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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Broadband, triple-play and advanced multimedia services – Content delivery and ubiquitous sensor network applications

Architecture for mobile/multi-access edge computing enabled content delivery networks

Recommendation ITU-T H.644.4

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Recommendation ITU-T H.644.4

Architecture for mobile/multi-access edge computing enabled content delivery networks

Summary

Recommendation ITU-T H.644.4 specifies a functional architecture for mobile/multi-access edge computing (MEC) enabled content delivery network (MEC-CDN). The functions and functional blocks within this functional architecture and the related reference points are specified in this Recommendation for matching the requirements in Recommendation ITU-T F.743.10. Particularly, this Recommendation also provides the deployment of virtualized content delivery network (CDN) service and the interworking between virtualized CDN functionalities and MEC management system, within a MEC-CDN ecosystem. In addition, a containerized solution of MEC-CDN is given in this Recommendation, followed by the basic information flows.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T H.644.4	2021-06-13	16	11.1002/1000/14686

Keywords

Architecture, CDN, framework, information flow, MEC, MEC enabled CDN, reference point.

* 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.

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1 Scope

This Recommendation specifies a fundamental functional architecture and the related components based on a mobile/multi-access edge computing (MEC) enabled content delivery network (CDN) scenario. The scope of this Recommendation consists of:

1 Logical framework and functional architecture.

2 Description of its functionalities and functional components within the MEC-CDN ecosystem.

3 Internal interfaces in the MEC-CDN node, interfaces between the MEC-CDN node and a conventional CDN node, and the interface between a MEC-CDN node and a MEC management system.

4 A containerized solution and the basic information flows.

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.743.10] Recommendation ITU-T F.743.10 (2019), *Requirements for mobile edge computing enabled content delivery networks*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 MEC enabled CDN [ITU-T F.743.10]: A content delivery network (CDN) enhanced by mobile edge computing (MEC), which is able to provide distribution and delivery service at the edge of the network. An MEC-enabled CDN can be composed of a conventional CDN node and a mobile edge CDN node.

3.1.2 mobile edge CDN [ITU-T F.743.10]: A group of content delivery network nodes, which is deployed locally on a mobile edge computing host, which can provide content delivery service to users on the edge of a mobile network.

3.1.3 mobile edge CDN instance [ITU-T F.743.10]: A mobile edge content delivery network node, which is instantiated in mobile edge computing system as an application.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API	Application Programming Interface
APP	Application
CDN	Content Delivery Network
CMS	Content Management System
CPU	Central Processing Unit
DC	Data Centre
DNS	Domain Name Service
FQDN	Fully Qualified Domain Name
FTP	File Transport Protocol
GSLB	Global Service Load Balance
HLS	HTTP Live Streaming
HPD	HTTP Progressive Download
IoV	Internet of Vehicles
MAN	Metropolitan Area Network
MANO	Management and Orchestration
MEC	Mobile/Multi-Access Edge Computing
MEC-APP	MEC application
MEC-CDN	MEC-enabled CDN
MEO	MEC Orchestrator
MEP	Mobile/Multi-Access Edge Platform
MNO	Mobile Network Operator
OS	Operating System
OSS	Operations Support System
QoS	Quality of Service
RAN	Radio Access Network
RNIF	Radio Network Information
RTSP	Real Time Streaming Protocol
SLB	Service Load Balance
SOAP	Simple Object Access Protocol
IPTV	Internet Protocol Television
vCDN	Virtualized Content Delivery Network
VI	Virtualized Infrastructure
VNF	Virtual Network Function
XML	Extensible Markup Language

5 Conventions

The following conventions are used in this Recommendation:

– 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.

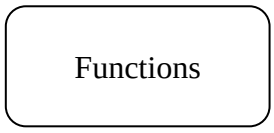
– The keywords "is prohibited from" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

– 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.

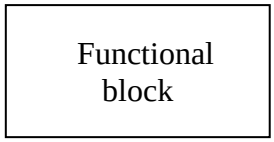
– The keywords "is not recommended" indicate a requirement which is not recommended but which is not specifically prohibited. Thus, conformance with this Recommendation can still be claimed even if this requirement is present.

– 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 this Recommendation.

– The keyword "functions" is defined as a collection of functionalities. It is represented by the following symbol in the context of MEC-CDN architecture (Figures 7-1, 7-2, 7-3, 7-4):



– The keyword "functional block" is defined as a group of functionalities that have not been further subdivided at the level of detail described in this Recommendation. It is represented by the following symbol in the context of MEC-CDN architecture (Figures 7-1, 7-2, 7-3, 7-4):



6 Introduction

6.1 Overview of MEC enabled CDN

A MEC-enabled CDN (MEC-CDN) can be composed of one or a number of virtualized/physical CDN nodes, which are recommended to be deployed in the edge of the transport network, usually within a metropolitan area network (MAN). In the traditional network architecture, the edge of a transport network where a CDN edge node is deployed is the core router devices or the service gateway in the mobile core network, which is the boundary between Internet and the operator network. The operator network also includes the aggregation network and access network (radio access network (RAN) in mobile networks). Such places are geographically nearer to the end-user than edge node in the core network and are also the places where the edge data centre (DC) or the operator's premises are established. Thus, MEC-enabled CDN (MEC-CDN) can be realized with a

centralized model or a distributed model utilizing the infrastructure resource provided by the DC or the operator's premises.

The use cases and scenarios for MEC-CDN can be found in [ITU-T F.743.10].

Generally, the geographical area, the number of connections and the number of end-users covered by MEC-CDN service may vary according to wherever the MEC-CDN node is deployed. Figure 6-1 shows possible MEC-CDN node deployments with the related information.

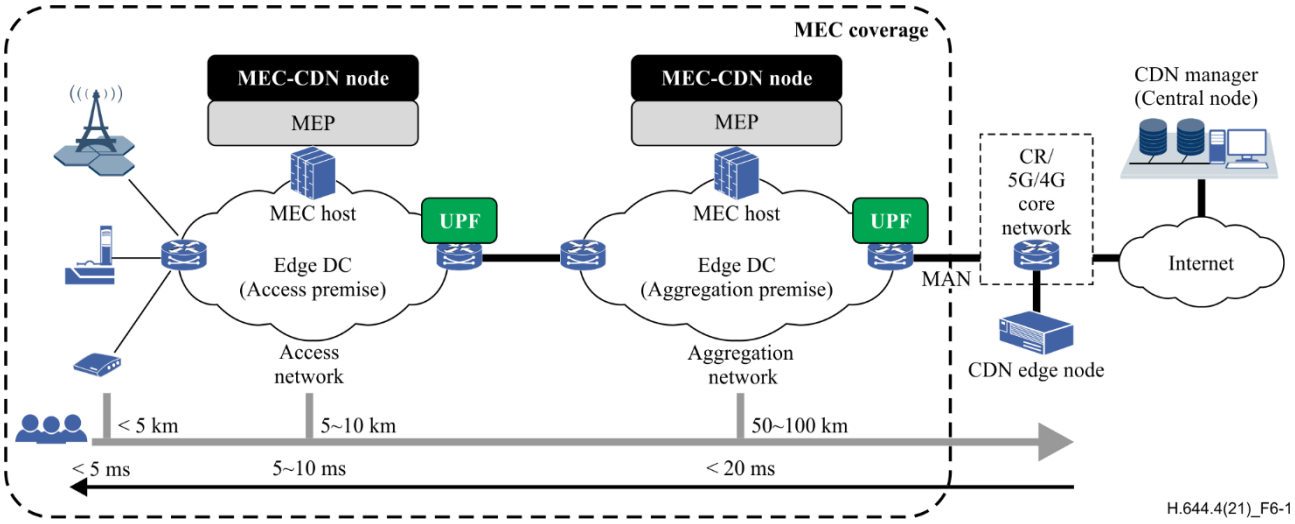


Figure 6-1 – Example of MEC-CDN node deployment

Figure 6-1 shows that there are three possible or optional places for providing the deployment of MEC-CDN nodes. All of them are expected to cover, for example, a large number of people in a city range:

1 The access premise of base, workplace and home, which are the nearest places to the end-user (less than 5 km), but the required number of premises is estimated as 1000.

2 The edge DC (access premise), which is 5~10 km to the end-user, and the number of premises is estimated as 100~300.

3 The edge DC (aggregation premise), which is 50~100 km to the end-user, and the number of premises is estimated as 10~20.

Therefore, it is better for the MEC-CDN service provider to deploy the MEC-CDN nodes by choosing the 2nd and/or 3rd option. Ideally, the aggregation premise is the best place to deploy the MEC-CDN node. However, if a service has an ultra-high bandwidth and ultra-low latency demand, e.g., Internet of vehicles (IoV) or industrial manufactory, the access premise is also an appropriate place.

In all cases, the orchestration and management of the MEC-CDN node and loading balance are deployed on the central content delivery network (CDN) node.

The detailed networking and deployment of MEC-CDN is described in clause 7.2.

6.2 Reference framework of MEC-CDN

Figure 6-2 shows the basic concept of a MEC-enabled CDN with a high-levelled reference framework.

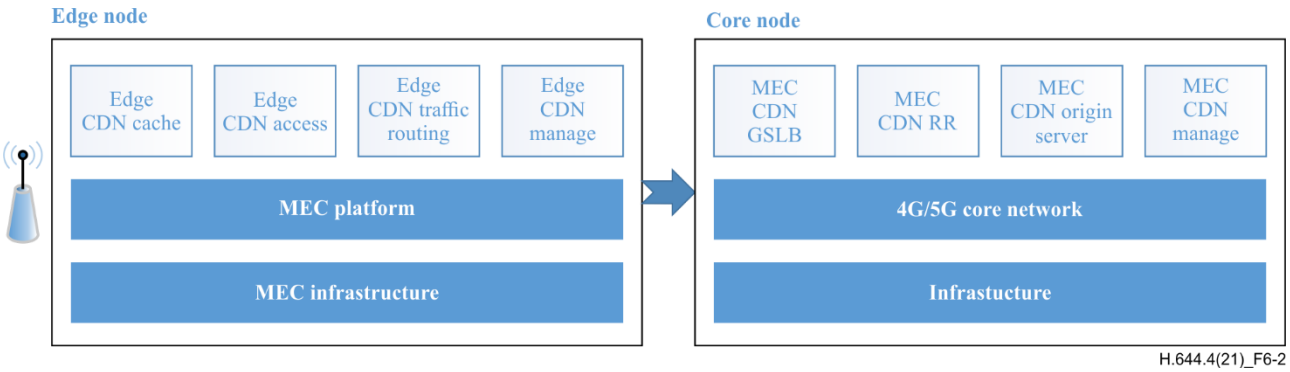


Figure 6-2 – The reference framework of MEC-CDN

A MEC-CDN, similar to the traditional CDN, consists of a set of functions such as CDN cache, CDN global service load balance (GSLB), and CDN origin server. However, since MEC-CDN will mainly focus on the deployment of a CDN service on the network edges, its framework is recommended to satisfy the following principles:

– MEC-CDN's edge node (or "edge node" in the following occurrences), as an application in a MEC platform, is recommended to have the ability to be deployed based on virtual machines or containers, which use a standard interface to utilize MEC-CDN.

– The architecture of the edge node is recommended to be lightweight, meaning it can dynamically expand or shrink its capacity based on the service requirement.

– The functional block of the edge node is recommended to have mobility/multi-access management and traffic management functionality.

– MEC-CDN's core node is recommended to possess the interface to interact with the mobile core network, distributing appropriate MEC-CDN service nodes to serve specific CDN throughput.

– MEC-CDN is recommended to cooperate with the traffic control functionality of a mobile/multi-access network to provide high quality of service.

More technical requirements for MEC-CDN can be found in [ITU-T F.743.10].

The design goal of the MEC-CDN framework is to provide a lightweight CDN solution for the multimedia service providers to extend their service to the network edge, but not affect the conventional CDN deployment and design. The following clauses in this Recommendation introduce the functional architecture and its functional components in detail.

7 Requirements and functional architecture of the MEC-CDN

The basic requirements for the MEC-enabled CDN, together with some application scenarios are defined in clause 8 of [ITU-T F.743.10]. Generally, the functional architecture of MEC-CDN and its related functions designed in this Recommendation are targeted to follow those requirements.

Moreover, clause 7.1 specifies the supplementary requirements to be considered in terms of MEC-CDN networking.

7.1 General requirements of MEC-enabled CDN networking

With flexible architecture, a MEC-CDN can satisfy service requirements for high-quality video applications in mobile or fixed networks. Meanwhile, by cooperating with a static CDN, it can guarantee quality of service (QoS) when users switch between a MEC-CDN and a static CDN. Therefore, a multimedia CDN service is recommended to integrate both MEC-CDN nodes and static CDN nodes by meeting the following networking requirements:

– MEC-CDN can optionally work as an independent network, by exposing content access and content control interfaces without leaking information about the MEC-CDN node.

– MEC-CDN is recommended to support the hierarchical networking and distributed networking of CDN nodes, including the function entities of distributed content storage, distributed streaming service, and distributed request routing. The detailed function requirements can be found in clause 8.1 of [ITU-T F.743.10].

– MEC-CDN is recommended to construct a standardized, open networking architecture to enable inter-communication between multiple types of CDN, such as virtualized CDN and static CDN.

– MEC-CDN can optionally support hybrid networks for both content serving service and resource rental service.

– MEC-CDN is recommended to support hybrid networking consisting of public networks and private networks, as well as supporting the coexistence of both IPv4 and IPv6 networking.

7.2 Functional architecture of MEC-CDN

Figure 7-1 shows the general functional architecture of MEC-CDN.

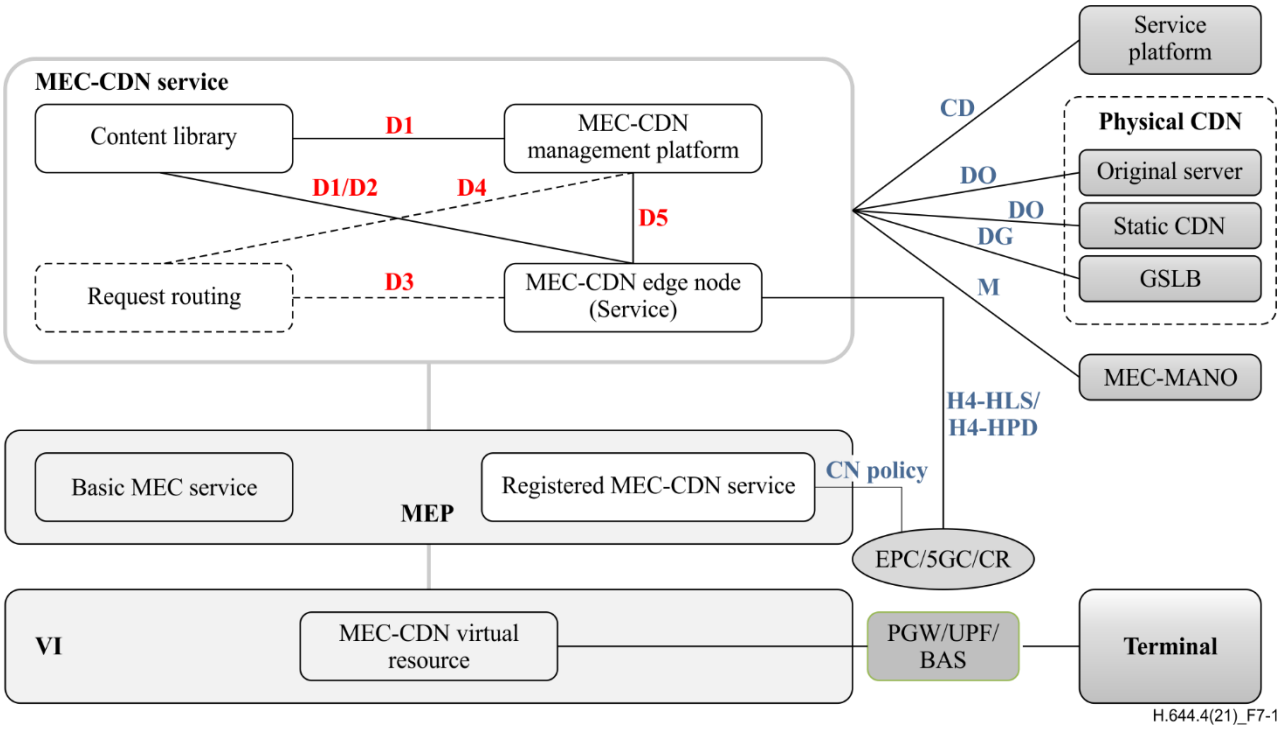


Figure 7-1 – Overview of MEC CDN functional architecture

NOTE – The blocks in grey are outside of the scope of this Recommendation.

The conventional CDN in this Recommendation refers a static or physical CDN. It is usually chosen to be deployed in a suitable network location according to business requirements. Once deployed, the CDN node will exist for a long time and the interconnection relationship between the CDN nodes is stable. MEC-CDN is generally designed to be deployed at the edge of the network and its service coverage is limited. Therefore, MEC-CDN is suitable for flexible deployment and recycling according to changes of network traffic, by using virtualized content delivery network (vCDN) technology.

The vCDN related solution can be referenced from [b-ITU-T H.644.1] and [b-ITU-T H.644.2] as background information.

The MEC-CDN and the static CDN are interconnected through a standard CDN interconnection interface. The coordination of the MEC-CDN and the static CDN can provide users with higher hit-rates and higher-quality services. Static CDNs can reroute a part of service requests to MEC-CDN based on the content hit-rate and content service level requirements, and then MEC-CDN can handle the CDN services to those users. Reversely, the MEC-CDN can reroute the service requests back to the static CDN when the service load on MEC-CDN node is too high or a cache-miss occurs.

MEC-CDN, by representing as an APP of the MEC capability platform, can call mobile/multi-access edge platform (MEP) service capabilities, including domain name service (DNS), resource request, and policy control capabilities, through its interface with the MEP.

Basically, a logical MEC-CDN service is composed of four essential functions: content library functions, MEC-CDN edge node functions, request routing functions (optional), and MEC-CDN management platform functions. With those functions, MEC-CDN is able to provide the same service as the conventional CDN. In a real implementation, for the purpose of a lightweight deployment, only the MEC-CDN edge node functions will be instantiated within the MEC system. The other three functions can be merged into conventional CDN function entities, such as a CDN central node.

In terms of MEC features, MEC-CDN can also register its capabilities on MEP so that other MEC APPs can discover and use those capabilities, as an open CDN service.

The detailed description of the reference point between the conventional CDN and MEC-CDN is specified in clause 8.

7.3 The essential functional components of MEC-CDN

Figure 7-2 shows the functions and functional blocks within MEC-CDN service scope:

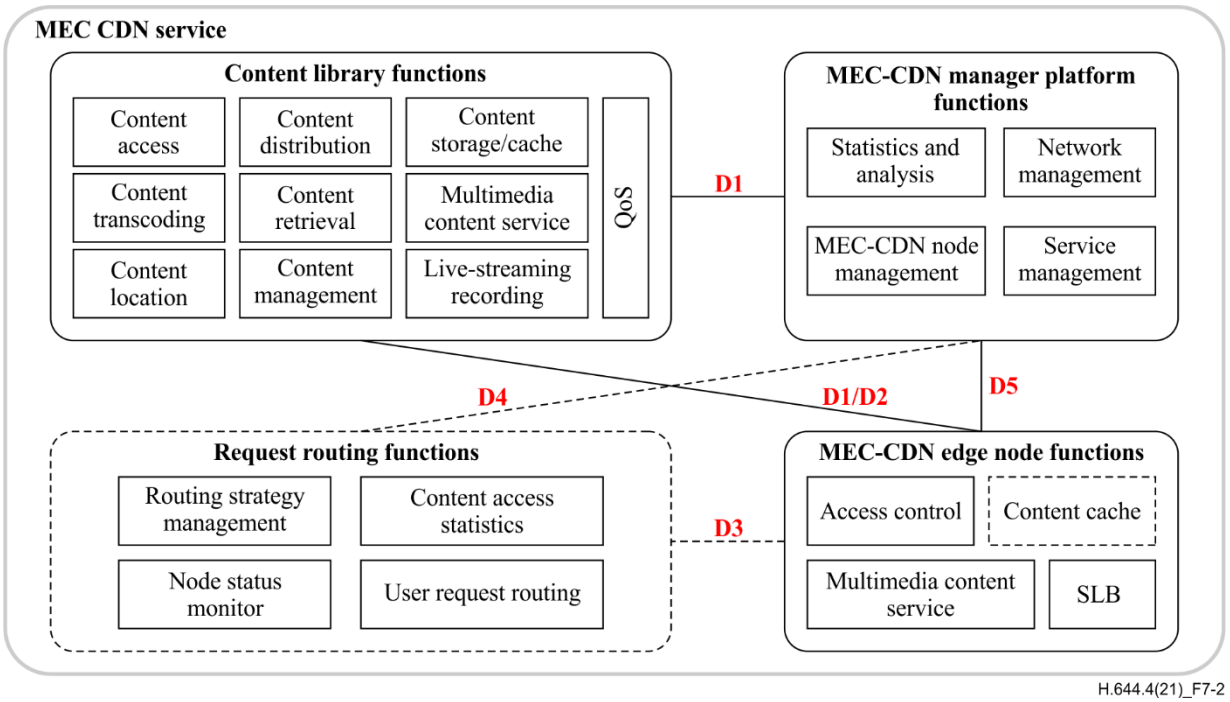


Figure 7-2 – Functions and functional blocks within MEC-CDN service domain

NOTE – The functions with dash-line border refer to the optional functions.

7.3.1 Content library functions

The content library functions can connect to the service system via an interface to perform functions such as content access, content management, content storage, and content distribution in service nodes. Specifically, it is recommended to have the following functional blocks:

1) **Content location:** It can receive content distribution requests from subordinate multimedia service nodes, locate the requested contents, and designate proper service devices to serve the requests based on load balancing strategy.
2) **QoS:** Based on the popularity value defined by a content injection interface, it can determine the priorities of the access and distribution of different contents, mark high-priority contents, and prioritize their processing. The marked contents can be distinguished in subsequent services.
3) **Content access:** It can acquire designated content according to the content ingesting instruction from a content management system (CMS), store it on content storage module, and register it on content management functions.
4) **Live-streaming recording:** It can perform time-shift, recording, and management on live channels according to instructions from a content management platform.
5) **Content management:** It can manage content attributes registered in a CDN including UniContentID, metadata, lifetime, and status, and can also change their status with content push strategy, content deletion, content update, and other functions.
6) **Content distribution:** It can deliver contents based on routing strategy in content management functions or according to the request from subordinate multimedia service nodes.
7) **Content retrieval:** When requested content is not stored in content library functions, it can download the required content from the original server based on the content retrieval strategy.
8) **Content transcoding:** It can decode/decapsulate files of some formats and re-encode/re-encapsulate them to different formats as the content management platform requires. For group streaming, it should support forward error correction using redundancy information to improve QoS.
9) **Content storage:** It can store and manage ingested multimedia contents according to the content management strategy in content management functions, until the content management platform deletes or updates them explicitly.
10) **Content caching:** It can store and manage pre-ingested multimedia content according to caching strategy, which includes updating, caching, or deleting multimedia contents based on their access frequencies.
11) **Multimedia content service:** It can provide streaming media service to end users if the MEC-CDN edge node cannot provide the multimedia content service. It is usually used to provide Internet protocol television (IPTV) service based on real-time streaming protocol (RTSP) upon a cache miss on subordinate service nodes.

7.3.2 MEC-CDN edge node (service) functions

As the principal entity of MEC CDN service, MEC-CDN Edge service is responsible for receiving end-to-end requests, authenticating and serving local cached content.

MEC-CDN service nodes are recommended to have following functions:

1) **Access control:** It can use security-chain or other techniques to authenticate user access.
2) **Multimedia content service:** It can serve multimedia contents for all service requests.

3) **Content cache (optional):** The content streaming could be temporally stored in the MEC-CDN edge node and served for a multimedia content service locally. If the content is not hinted in the cache, the content request will be transferred to the content library functions for retrieving the media content or to be served directly by content library functions. The realization of content cache functions depends on the resource provided by MEC host.

4) **Service load balance (SLB):** Based on the service loading condition, the SLB selects the most appropriate media server node (or a MEC-APP for a dedicated functionality) within the MEC-CDN edge node to provide multimedia content service. It is noted that the media server or MEC-APP may be deployed in the different MEC hosts or MEPs.

7.3.3 Request routing functions

As the entrance of MEC-CDN service, the request routing functions process the routing of user requests based on routing strategy. It is noted that, for some special situations such as the MEC service coverage is limited, the RR may not be applied. The selection of MEC-CDN edge node will be processed directly at the GSLB or upstream RR, which is out of the MEC service coverage.

The implantation of RR is optional. But if RR is deployed conditionally, it is recommended to have the following functions:

1) **User request routing:** It can use request redirection to realize user request routing in the application layer.

2) **Routing strategy management:** It can define the routing strategy for a user request.

3) **Node status monitor:** It can query and monitor traffic load information of each of the CDN nodes, which will be used in service routing.

4) **Content access statistics:** It records access information of all contents and reports the information to the content library functions.

7.3.4 MEC-CDN management platform functions

The MEC-CDN management platform is in charge of managing internal network, service, statistics, and other functions. It can also receive and parse commands from a service management system into operations on a CDN internal network. It is recommended to have the following functions:

1) **Network management:** It can manage information and settings including CDN network performance, service warning, topology, etc.

2) **Service management:** It can configure a CDN service to achieve centralized management on content ingestion, content distribution, content routing, routing strategy, etc.

3) **MEC-CDN node management:** It manages the creation, maintenance and termination of the MEC-CDN node. It can also monitor the performance status of each MEC-CDN node by interworking with a mobile edge computing management and orchestration (MEC MANO) system. With such information, it is able to adjust the MEC-CDN node performance by modifying the related virtualized resource, e.g., to enlarge the storage, improve the central processing unit (CPU) capacity, etc. In addition, it also maintains the configuration template of the MEC-CDN node.

4) **Statistics and analysis:** It can generate statistical reports by analysing the content access information.

7.4 The functional components and the related interfaces of the MEC-CDN ecosystem

7.4.1 Deployment of vCDN service within MEC system

According to the description of the entities of the MEC-CDN deployment scenario in Figure 6-1, the implementation of a MEC-CDN ecosystem is recommended to be reliant on the deployment of a vCDN service within the MEC system as shown in Figure 7-3.

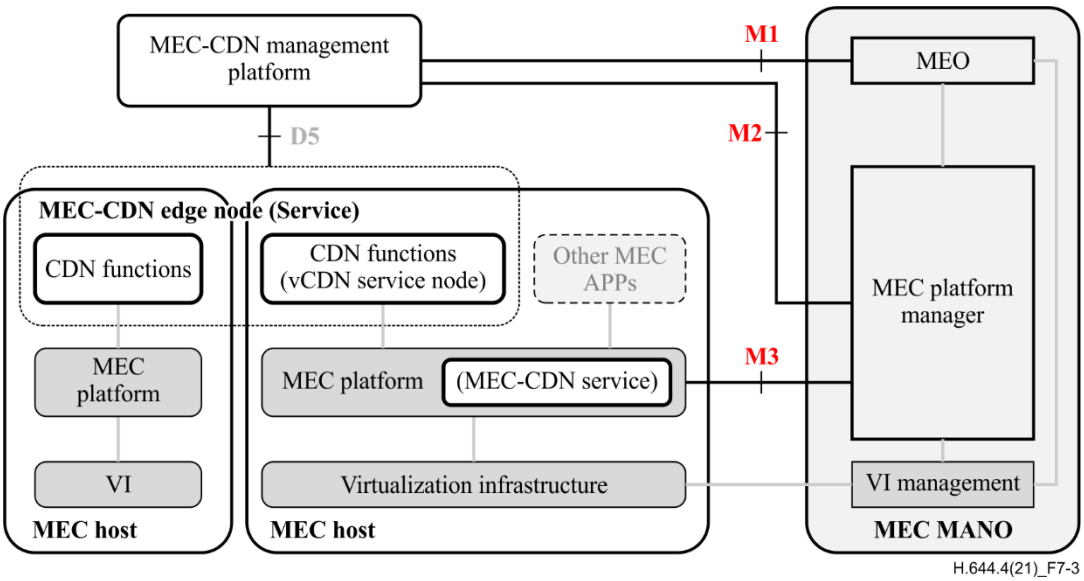


Figure 7-3 – vCDN functions deployed within MEC system

NOTE 1 – The blocks with the black bold border refer to the MEC-CDN functionalities deployed within the MEC ecosystem. The blocks in grey are out of this Recommendation's scope.

The MEC-CDN ecosystem can be composed of three core parts: MEC-CDN management platform, MEC-MANO and MEC-CDN edge node (service). In addition, there are four interfaces among those components and information can be exchanged for the creation, configuration and management of MEC-CDN edge node. These interfaces, labelled in Figure 7-3 as M1, M2 and M3, are categorized as MEC-CDN networking interfaces, which are different from the server interfaces defined in the Figure 7-2 (see Table 1 in clause 8.1 for more information on these interfaces).

The utilities of vCDN are defined as the following:

– **MEC-CDN management platform**

The MEC-CDN management platform is responsible for the creation, maintenance and termination of one or more MEC-CDN edge nodes, by cooperating with the MEC-MANO system. It also maintains the template of MEC-CDN edge node. A logical MEC-CDN node can be created according to a specific performance demand. Therefore, the various pre-designed resource allocation information and the instantiating instruction for a customized MEC-CDN node will be stored into multiple MEC-CDN node templates separately. These templates will be selected and used by MEC MANO to create or adjust a MEC-CDN node by following the request from the MEC-CDN management platform.

NOTE 2 –The implementation of MEC-CDN management platform may have many options. For example, it could be co-set with a physical CDN manager or work in a dedicated equipment, but this is out of the scope of this Recommendation.

– **MEC MANO**

MEC MANO implements the required resource reservation and allocation based on the hardware/software resource provided by the (virtualized) infrastructure manager. It also manages the elements, rules and lifecycle of the MEP and MEC-CDN edge node (MEC APPs).

A MANO system can be logically composed of three functions:

1 MEC orchestrator (MEO): It orchestrates and reserves the virtual resource for instantiating a MEC-CDN node and selects the most appropriate MEC host.

2 MEC platform (MEP) manager: It keeps tracking the event and status of the MEP and MEC APP and reports to MEO. It also manages the application rules and requirements.

3 VI (virtualized infrastructure) manager: It provides and manages the virtualized resource and keeps monitoring the performance.

NOTE 3 – The definition and implementation of MEC MANO is out of scope of this Recommendation. This part could be referenced from [b-ETSI GS MEC 003].

– **MEC-CDN edge node (service)**

A MEC-CDN node is a logical CDN node composed of one or more virtualized CDN service nodes in a cluster, similar to a physical CDN node, and running on a MEC host. A virtualized CDN service node is composed of many virtualized CDN functions, at least one, which can be encapsulated into one or more MEC APPs. Moreover, the virtualized CDN functions, as for the different MEC-CDN apps, can be deployed into one or more MEPs. A service loading balance measure (e.g., network layer-4/7 SLB or a dedicated request routing service) is recommended to be used for selecting the most appropriate CDN service node.

Typically, to create a MEC-CDN edge node, the MEC-CDN management platform sends the node creation request to MANO. MANO can either follow the instruction in the request directly or obtain a MEC-CDN node configuration template from the MEC-CDN management platform and then control the MEP to instantiate the MEC-CDN edge node based on the instructions in that template. Once the new MEC-CDN edge node is created, it will be connected to the entire CDN system and act as a special CDN edge node under the MEC service coverage. After that, the allocated resource for the MEC-CDN node can be adjusted by following the change requirements dynamically.

The MEC-CDN node, as can the virtualized CDN (vCDN) node, can be implemented by using different solutions:

1 **Virtual machine (host) mode:** The CDN applications can be run on the specific runtime environment based on its own virtualized OS. The hardware and software resource provided by the common host machine cannot be shared by different vCDN applications. In this mode, the vCDN performance may be restricted by its allocated resource.

2 **Container mode:** The CDN applications can be encapsulated as many images to be deployed based on a virtualized container engine/runtime such as Docker. The hardware and software resource can be shared by different vCDN applications. In this mode, the vCDN performance is very similar to the original CDN but has the advantages of quick start, lightweight deployment, dynamical scaling, grey updating and so on.

By considering the MEC service requirements, it is recommended to adopt the container solution to realize MEC-CDN functionality in most situations. The detailed solution will be introduced in clause 7.4.2.

NOTE – The infrastructure resource provided by the MEC host can be a number of virtual machines or dedicated hardware/software.

The reference points between these components are defined in clause 8.1.

7.4.2 The solution of the containerized MEC-CDN edge node (service)

The basic concept of this solution is to encapsulate the vCDN functions into a number of containers and run on a common host with a container runtime environment, as the MEC-APPs.

The following Figure 7-4 shows the functions that support the containerized MEC-CDN solution within a MEC host level.

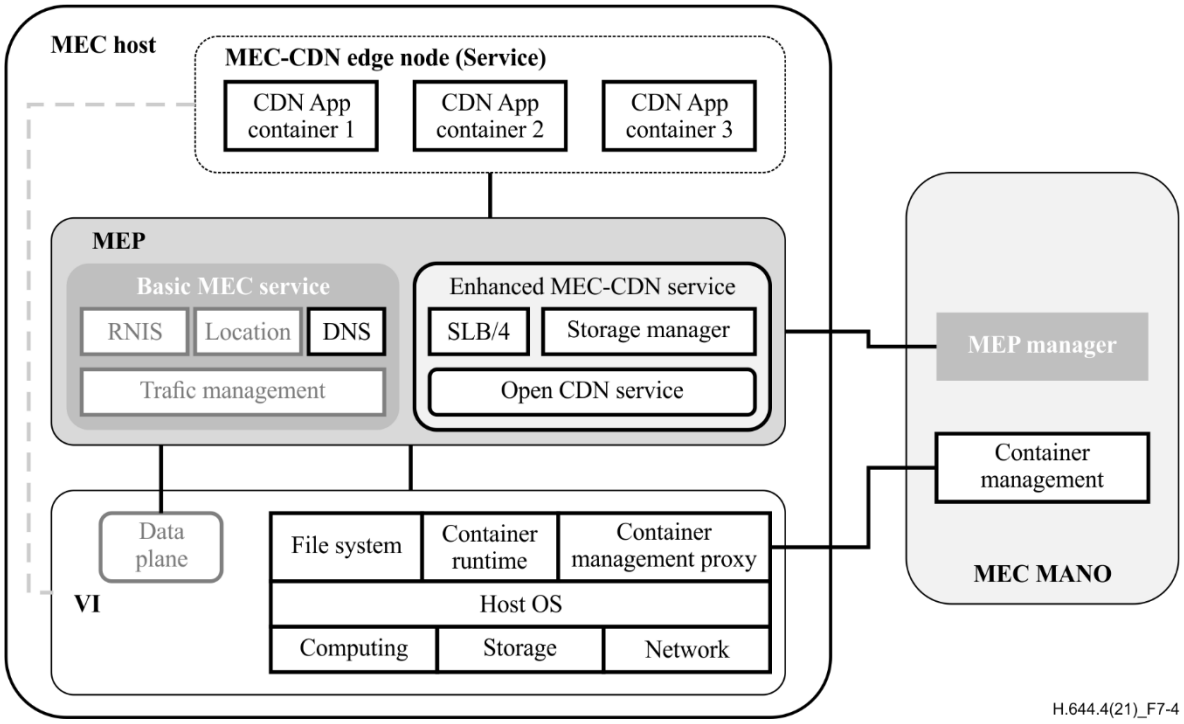


Figure 7-4 – Containerized MEC-CDN functions in MEC host level

NOTE 1 – The function of the interface between MANO and MEC host has been defined as "Reference Point M3" in clause 8.1. The implementation of this interface is not included in the scope of this Recommendation.

NOTE 2 – The blocks with the black bold border refer to the MEC-CDN functionalities deployed on MEC ecosystem. The blocks in grey are out of this Recommendation's scope.

As the virtual infrastructure provider, the MEC host is recommended to provide the necessary hardware/software resource for running the MEP (may be as a VNF) and containerized MEC applications.

1) The MEC-APP provides:
   - The containerized vCDN functions which may be the lightweight CDN node functions. They provide the CDN service for both content provider and end-user.

2) The MEP provides:
   - The basic MEC service, which may include Radio Network Information (RNIF), location and traffic management service (detailed description of those services can be found in clause 8, [b-ETSI GS MEC 003]), etc. However, DNS service is recommended to be implemented together with other basic MEC services and enhanced MEC-CDN service, especially in this Recommendation.
     - DNS: The MEC platform provides access to DNS, which includes a name server and a proxy/cache function. The MEC platform receives the application DNS rules from the MEC management. Based on the configuration or following an activation request from the MEC-CDN application, the MEC platform configures the mapping between an MEC-CDN node or SLB IP address and its fully qualified domain name (FQDN) into the DNS based on these rules.
   - The enhanced MEC service related to MEC-CDN such as (Layer-4) SLB, Open CDN service and storage access:
     - (Network Layer-4) SLB: The SLB provided by MEP selects the most appropriate vCDN service node for redirecting the user request based on the load balance mechanism working at Layer-4 network protocol.

- Open CDN service: the open CDN service is a set of CDN capabilities which are registered by MEC-CDN applications. It can be discovered and consumed by other MEC APPs or the 3rd party APPs which is out of the MEC platform.
- Storage management: By coordinating with the file system, the storage management is able to provide the unified access interface for the MEC-CDN APPs to access the storage resource. In addition, the storage management also provides a capability for the MEC-CDN APPs to adjust the related allocated storage resource followed by the storage resource change request, e.g., adjusting the storage size, I/O performance, etc., by taking advantage of storage virtualization technology. Moreover, the storage adjusting can be done by a pre-defined resource management policy. The policy can also be adjusted dynamically according to the received policy change request.

3) The virtual infrastructure functions provide:

– The essential virtualized resources such as computing resources, storage resources and network resources for running the up-level software applications.

– The host OS, e.g., Linux OS, to run the basic application engine.

– The application engine to present the necessary container runtime or application library. It can be composed of:

- The file system, which provides the capability to access the local storage.
- Container runtime, which provides the software engine to run the containerized APPs.
- The container manager proxy, which implements the container operation based on the instruction sent from container management.

4) The MEC MANO provides:

– Container management, which controls the container APPs running status. It receives the request from MEC-CDN management, bypasses MEO and controls the containerized MEC-CDN Apps realization via container manager proxy.

– Other general MEC management functions are defined in [b-ETSI GS MEC 003], which is out of this Recommendation's scope.

8 Reference points

Different reference points in the MEC-CDN are defined to connect different systems. Interfaces can be categorized into external interfaces and internal interfaces according to the system that MEC-CDN communicates to.

8.1 Reference point between MEC-CDN management platform and mobile/multi-access edge system

The reference points defined in this clause are recommended to be used for implementing the MEC-CDN edge node instantiation and activation.

Table 1 lists MEC-CDN networking interfaces.

Table 1 – MEC-CDN networking interfaces

Reference point	Directions	Protocol	Remarks
M1	Interface between MEC-CDN management platform and MEC MANO – MEO	HTTP 1.1	This interface is used for MEC-CDN management platform to trigger the MEC-CDN edge node (MEC APPs) instantiation and termination. NOTE – M1 will be further implemented as the collection of sub-interfaces or APIs for each specific command, such as create, terminate, upgrade, etc.
M2	Interface between MEC-CDN management platform and MEC MANO – MEC platform manager	HTTP 1.1	This interface is used by the MEC-CDN management platform for the MEP configuration and performance management.
M3	Interface between MEP and MEC MANO – MEC platform manager	HTTP 1.1	The M3 reference point is used to perform platform configuration, configuration of the application rules and requirements, application lifecycle support procedures, management of application relocation, etc.

NOTE 1 – Reference point D5 is defined in Table 3.

NOTE 2 – There are many interfaces among the functions within MEC system but most of them are the common inner interface and not recommended to be specified in this Recommendation. Those interfaces can be realized by MEC system provider. The selected four interfaces in Figure 7-2 will be used specifically by conventional CDN service providers and manufacturers.

8.2 Reference point between MEC-CDN and external service platform

Regarding systems and network architectures that interfaces communicate with, the external interfaces in CDN are defined in Table 2.

Table 2 – MEC-CDN external interfaces

Reference point	Directions	Protocol	Remarks
CD	Content ingestion interface between CMS and CDN	SOAP+XML	Interface used for sending metadata and content data of ingestion and pre-ingestion process
DO	Interface between original server and CDN for backhaul traffic	HTTP1.1	Interface used to retrieve content from original server. IPTV CDN can also become original server to provide source content to other CDN.
H4-HLS	Interface between terminal device and CDN	HTTP 1.1	HLS interface between CDN and terminal devices (including digital media player, mobile phone, pads, etc.)
H4-HPD		HTTP 1.1	Interface for progressive download between Internet terminal and CDN
DG	Interface between GSLB and RR	HTTP+XML	Interface for GSLB/RR to inquire CDN capability
ND	Interface between external management system and CDN management system	HTTP1.1 and FTP	Interface between general management system and CDN management system

8.3 Reference point between MEC-CDN internal functions

The internal interfaces in MEC-CDN are defined in Table 3.

Table 3 – MEC-CDN internal interfaces

Reference point	Direction	Protocol	Remarks
D1.2-H	Interface between multiple CDNs	HTTP1.1	Interface to locate cascaded contents based on HTTP, applicable to internet video service on cascaded CDN.
D2	Cascade content management interface	SOAP+XML	Interface for content library CDN to send ingestion information to other CDN
D3	Optional interface between RR and subordinate RR/CDN nodes	HTTP+XML	Interface for traffic routing system to probe CDN capacities, or for CDN to report its capacities.

Table 3 – MEC-CDN internal interfaces

Reference point	Direction	Protocol	Remarks
D4	Optional interface between CDN management platform and RR	Restful+Json	Interface for MEC CDN management platform to manage and update content distribution and address information in RR.
D5	Interface between MEC-CDN management platform and MEC-CDN edge node	Restful+Json	Interface for MEC CDN edge nodes to report service records. It is also used for MEC-CDN management platform to configure the MEC-CDN node with the pre-defined service parameters. Once the MEC-CDN edge node is activated, it can also be used for performing the common CDN service operation, such as content streaming, cache, etc.
NOTE – For some special occasions, such as the limited service coverage, there may not exist many MEC-CDN nodes. Thus the routing of request to MEC-CDN node may be directly under the control of central GSLB. Then the reference point "DG" may be reused to replace the functionality of "D3". "D4" will be not implemented as its functionality has been covered by the interface between CDN manager and GSLB.			

9 Information flows

This clause describes the high-levelled information flows which are related to the basic operations of MEC-CDN node. The following sub-clauses present the MEC-CDN node creation, scaling and termination with the brief procedural steps.

9.1 Procedure for creating a MEC-CDN node

Figure 9-1 describes the creation of a MEC-CDN node.

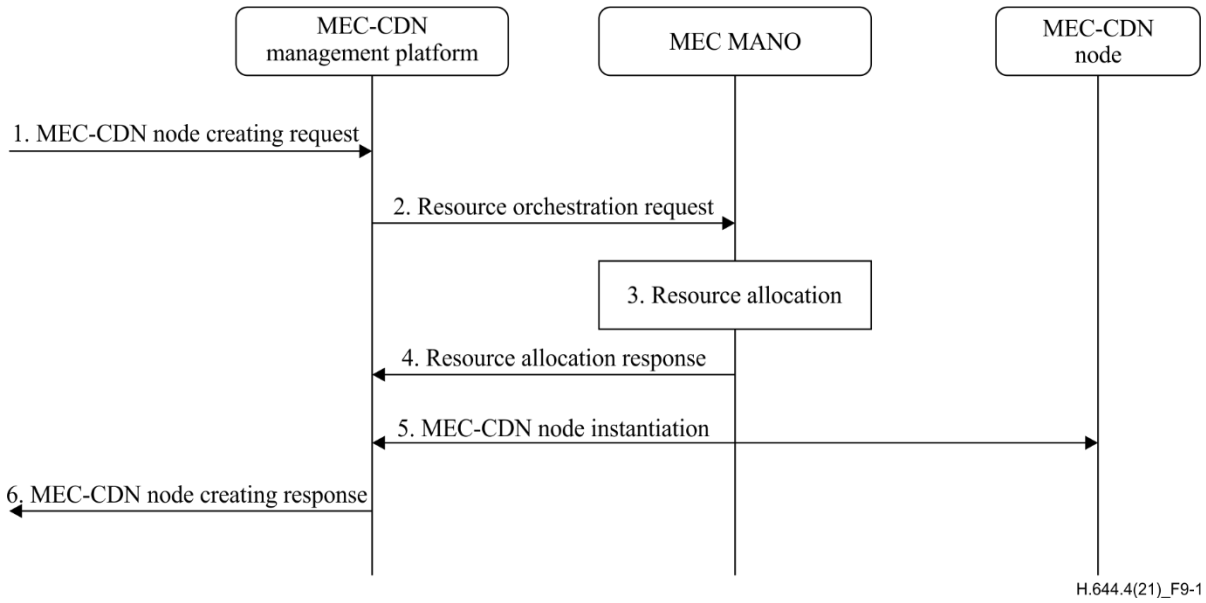


Figure 9-1 – Procedure for creating a MEC-CDN node

In this procedure:

1) MEC-CDN management platform receives a request for creating a MEC-CDN node. It is noted that the request may be from an external CDN operations support system (OSS) or from an operator manually.

2) MEC-CDN management platform starts the MEC-CDN node creation procedure. It estimates the essential resource based on the request and sends the resource orchestration request to the MEC MANO system. The required resource comes from the information in the MEC-CDN creating request, which may include CDN node type, scale of virtual resource, location, numbers of node, etc.

3) MEC-MANO prepares the resource allocation by searching and reserving the resource from the resource pool, according to the resource orchestration request.

4) MEC-MANO sends the resource allocation response back to the MEC-CDN management platform.

5) MEC-CDN management platform performs the instantiation of the MEC-CDN node based on the reserved resource, for example to allocate an IP address and ID to a certain MEC-CDN node.

6) MEC-CDN management platform returns the result of the MEC-CDN node creation to the request sender.

9.2 Procedure for MEC-CDN node scaling

Figure 9-2 describes the scaling of a MEC-CDN node.

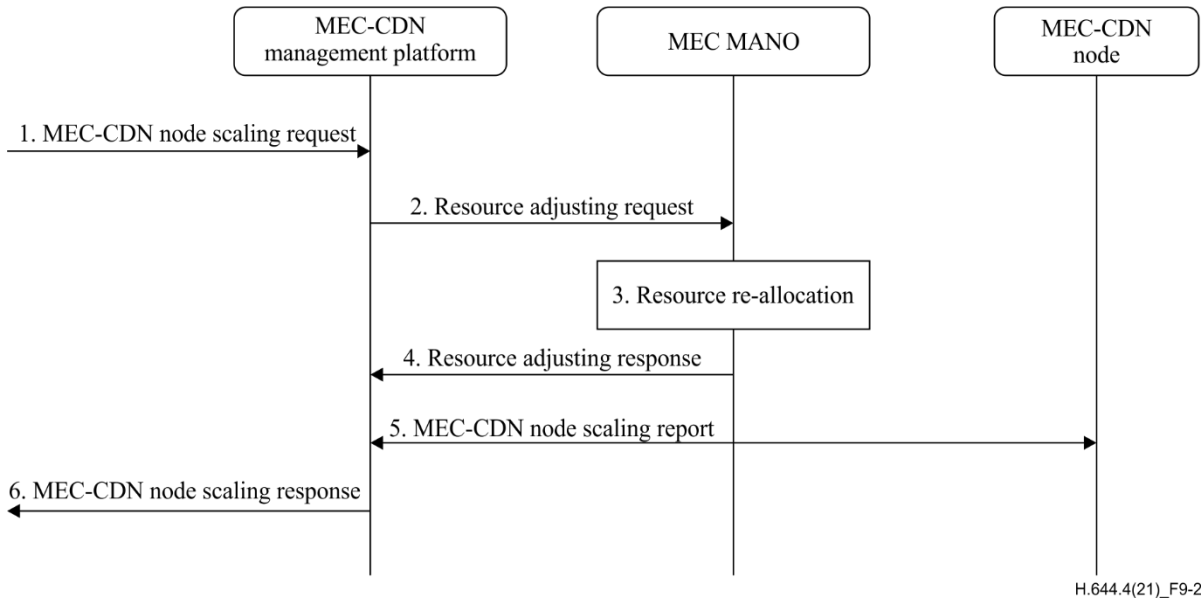


Figure 9-2 – Procedure for scaling a MEC-CDN node

In this procedure:

1) MEC-CDN management platform receives a request for scaling a MEC-CDN node. It is noted that the request may be from external CDN OSS or from an operator manually.

2) MEC-CDN management platform starts the MEC-CDN node scaling procedure. It calculates the resource that needs to be reserved or released and sends the adjusting request to the MEC-MANO.

3) MEC-MANO performs the resource re-allocation by reserving or releasing the resource from the resource pool.

4) MEC-MANO sends the resource adjusting response back to the MEC-CDN management platform.

5) MEC-CDN management platform obtains the report of the MEC-CDN node resource adjusting result.

6) MEC-CDN management platform returns the result of MEC-CDN node scaling to the request sender.

NOTE – The scaling of a MEC-CDN node may be performed automatically by MEC-CDN service itself if there is a predefined scaling policy. That policy may contain the specific threshold and command which can activate the node scaling. For example, when the resource consumption reaches its predefined threshold, such as 80% CPU usage or 80% disk space, it may send the scale-out notification to the MEC-CDN management platform.

9.3 Procedure for terminating a MEC-CDN node

Figure 9-3 describes the termination of a MEC-CDN node.

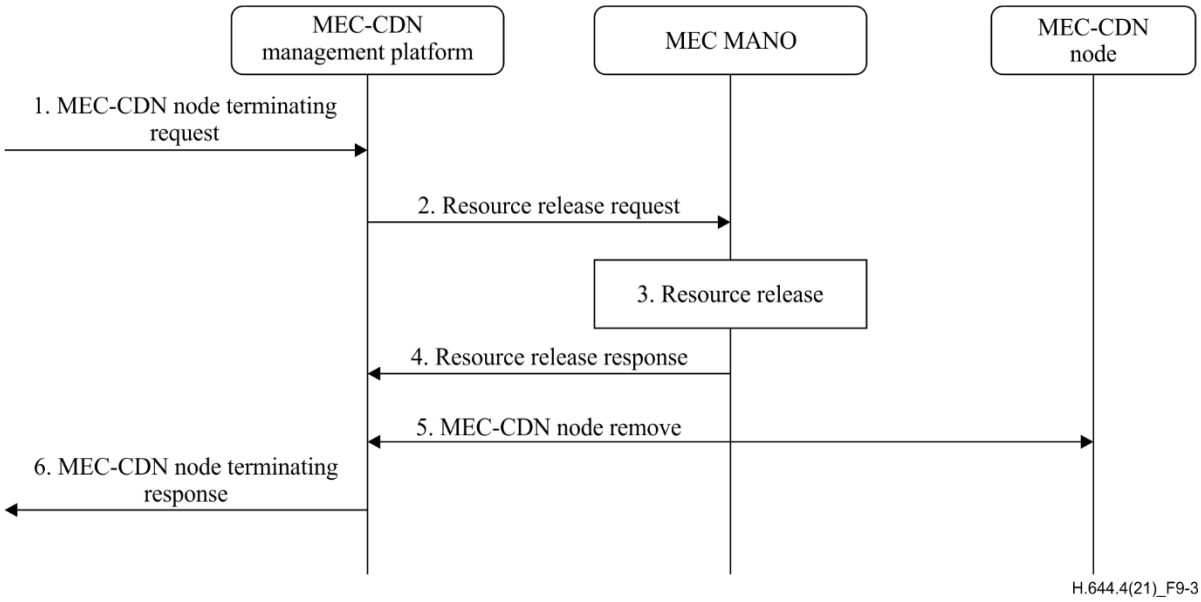


Figure 9-3 – Procedure for terminating a MEC-CDN node

In this procedure:

1) MEC-CDN management platform receives a request for terminating a MEC-CDN node. It is noted that the request may be from external CDN OSS or from an operator manually.
2) MEC-CDN management platform starts the MEC-CDN node termination procedure. It sends the resource release request to the MEC MANO system.
3) MEC-MANO performs the releasing of resource from the resource pool.
4) MEC-MANO sends the resource release response back to the MEC-CDN management platform.
5) MEC-CDN management platform removes the MEC-CDN node from its node list. It is noted that the IP address and node ID may be recycled and reused in future.
6) MEC-CDN management platform returns the result of the MEC-CDN node termination to the request sender.

NOTE – In a real implementation, to avoid the interruption of CDN service, the MEC-CDN management platform may try scaling-in the MEC-CDN node resource gradually to null before shutting down the MEC-CDN service. Then the MEC-CDN node can be terminated safely.

Appendix I

Use case of hierarchical MEC-CDN networking

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

MEC-CDN should use hierarchical deployment, which means that the MEC-CDN management platform, multimedia content library, and load balancing server should be deployed on core nodes, while MEC-CDN edge service nodes can be distributed and deployed on core or edge nodes of the metropolitan area network according to the user scale and QoS requirement.

In clause 6.1, Figure 6-1 shows the possible places where the MEC-CDN nodes are deployed. Actually, an entire MEC-CDN may be composed of many CDN nodes, which include a central node, edge node, including MEC enabled node, and the related management system.

Figure I.1 shows the high-level networking architecture of the MEC-CDN.

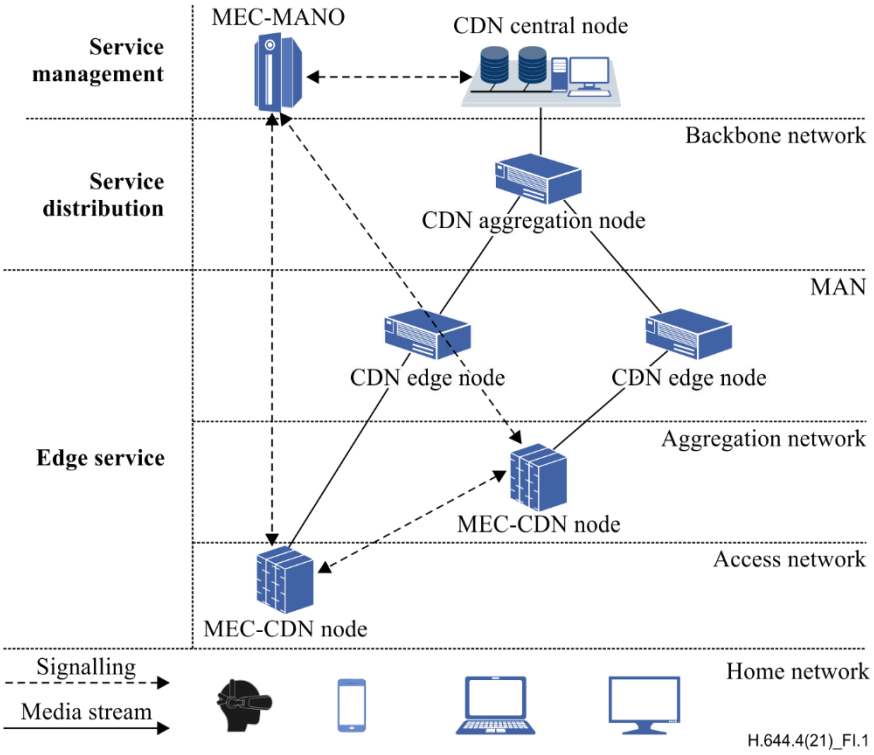


Figure I.1 – High-level hierarchical networking of the MEC-CDN

The entire MEC-CDN system can be categorized into the following three levels:

1) Service management

The CDN central node, also could be a CDN management system, is built together or connected with the MEC MANO (or MEC management platform). The MEC MANO system receives the service orchestration request from the CDN management system to reserve the required resource for creating the MEC-CDN nodes. The CDN management system maintains all the CDN nodes running in the network, including MEC-CDN nodes. In addition, a GSLB is used to redirect the content request and to select the most appropriate CDN edge nodes, including a MEC-CDN node, for the end-user.

2) Service distribution

The CDN aggregation node helps to distribute the content from the central node to the edge node. In some implementations, there is no aggregation node if the CDN service covers a limited small area.

3) Edge service

Typically, the CDN edge node receives the content request from the end-user and delivers the related media stream to the end-user. Usually, the conventional CDN edge node is deployed in the edge of a network, such as MAN. But the MEC-CDN node can be deployed in the place nearer to the end-user, such as aggregation network or access network. Thus, the conventional CDN edge node can be regarded as the upper node of the MEC-CDN node. The lifecycle of MEC-CDN node is handled by the MEC MANO, according to the request of the CDN management system.

Bibliography

[b-ITU-T H.644.1] Recommendation ITU-T H.644.1 (2019), *Functional architecture for virtual content delivery networks*.

[b-ITU-T H.644.2] Recommendation ITU-T H.644.2 (2019), *Virtual content delivery network – Network virtualization*.

[b-ETSI GS MEC 003] Industry Specification Group (ISG) on multi-access edge computing (MEC), ETSI GS MEC 003 V22.2 (2020), *Multi-Access Edge Computing (MEC); Framework and Reference Architecture*. https://www.etsi.org/deliver/etsi_gs/MEC/001_099/003/02.02.01_60/gs_MEC003v020201p.pdf.

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