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Multimedia services

Framework and interfaces for multimedia content delivery network

Recommendation ITU-T F.743.5

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Recommendation ITU-T F.743.5

Framework and interfaces for multimedia content delivery network

Summary

Recommendation ITU-T F.743.5 describes the challenges of traditional Internet protocol television (IPTV), dedicated content delivery networks (CDNs) and the design goals of the multimedia CDN. It also defines the functional framework of multimedia CDN and the logical interfaces among its functional components.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Content delivery network (CDN), framework, interface, multimedia.

* 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 defines the functional framework and interfaces for multimedia content delivery networks (CDNs).

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.2019] Recommendation ITU-T Y.2019 (2010), *Content delivery functional architecture in NGN*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 content [b-ITU-T H.780]: A combination of audio, still image, graphic, video, or data.

3.1.2 content delivery network [b-ITU-T Y.2084]: A content delivery network (CDN) is a system of distributed servers that deliver content (e.g., web pages, files, videos and audios) to users based on pre-defined criteria such as the geographic locations of users, the status of the content delivery server and the IP network connection.

3.1.3 delivery [b-ITU-T X.609]: The procedures and means employed to provide a user with the required archived material for reuse.

3.1.4 overlay network [b-ITU-T X.1162]: An overlay network is a virtual network that runs on top of another network. Like any other network, the overlay network comprises a set of nodes and links between them. Because the links are logical ones, they may correspond to many physical links of the underlying network.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 content delivery network (CDN) provider: The special organization or company in charge of providing the infrastructure needed to deliver the content service provider's (CSP) contents to the end users in real time mode.

3.2.2 content delivery network (CDN) service: The service provided by service providers (SPs) or content delivery network (CDN) vendors/providers with the capability to distribute and deliver the content from content source to the destination by using CDN facilities.

3.2.3 distribution: The unidirectional flow of information from a given point in the network to other (multiple) locations.

3.2.4 dynamic content: Contents created on demand while a user dynamically operates a web application.

3.2.5 static content: Content that changes infrequently. This type of content is not changed with the requests of users.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CDN Content Delivery Network

CDNi CDN interconnection

CP Content Provider

CSP Content Service Provider

I/O Input/Output

IP Internet Protocol

IPTV Internet Protocol Television

NFV Network Function Virtualization

OTT Over The Top

QoS Quality of Service

SDN Software-Defined Networking

SLB Service Load Balance

SP Service Provider

URL Uniform Resource Locator

VCDN Virtual CDN

5 Conventions

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 document 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 document 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 specification 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 the specification.

6 Challenges in conventional CDNs

6.1 Multiple service adaptations

The conventional content delivery network (CDN) is usually designed for a dedicated service, such as Internet protocol television (IPTV) and web cache. Software features or hardware capabilities are designed to support dedicated service logic, the media content format, the business model and the terminal device type. Once the design goal is achieved, service deployment, configuration and maintenance are difficult to change. Usually, CDNs for different services are independent of each other, which results in poor interactivity between them.

Another problem related to multiple service adaptation is service deployment and promotion. Usually, the speed of service process in the conventional CDN relies on the capacity of the dedicated hardware/software. With the development of content formats, protocols and equipment lifecycles, the CDN providers or CDN vendors need to increase their investments to either replace or upgrade the hardware or software.

6.2 Multiple CPs/SPs management

From the perspective of the CDN providers, if they want to provide the service to multiple content providers (CPs) or service providers (SPs), they need to assign a specific CDN resource for each of them. However, different CP/SPs have their own service requirements, such as different network, storage and computing requirements. When the content is being distributed in the network, the management policy may also be different according to the specifics CP/SP requirements. Therefore, CDN providers should prepare the corresponding CDN software version to harmonize the purpose, which may also increase needed investments.

6.3 The efficiency of resource utilization

Clause 6.2 mentions that CDN resources are allocated to different CPs/SPs according to their demands. In fact, because of many factors, those resources cannot be used efficiently. For example, the device capability is typically designed for coping with the demands of peak time use, and those resources cannot then be used efficiently during normal times, nor can they be released for other uses. In multiple services scenarios, demands for resource utilization are varied, and the system capacity design should be able to match the demands, which increases the system complexity. Moreover, because the resources are running on dedicated hardware/software, resources migration and adjustments are not easy to implement and are limited by the dedicated system design.

6.4 CDN over various networks

Conventional CDNs have different architectures and service logics that correspond to different networks, including mobile and fixed networks. Each network has its own regulation of routing, distribution and delivery. However, in the current market, a service, maybe with various content formats, is required to be able to be deployed over multiple types of networks. The interworking between networks is not performed well. Therefore, for different CDN providers, the CDN designed for each type of network has this weakness. The consequence is that content cannot be distributed in all types of CDNs unless the content is transformed into multi-types of content formats. As mentioned in clause 6.3, upgrades of this sort will require additional investments on the part of CDN service providers.

7 Design goals

Clause 6 describes the challenges of conventional CDNs developed with technical and marketing requirements. Correspondingly, a multimedia content delivery network should incorporate the following features into its design goals. Future CDN goals are summarized as follows:

7.1 The unified content/service management

Multimedia CDN may need to deal with various services, content formats and network capacities within different scenarios. To guarantee that all those services and content can be identified, located and managed appropriately, a unified service and content management platform is recommended. In addition, the related network topology, traffic monitoring and CDN nodes load balance are required to be managed in a unified management system.

7.2 Capability for flexible resource management

The development of flexible resource management will lead to the separation of software resources and hardware sources. The advantage of this separation could bring at least two benefits:

1) All resources can be centralized and located globally. The software does not need to be running on dedicated hardware. It can be reserved, utilized and reclaimed based on the requirements. This benefits greatly the software deployment, configuration and promotion.
2) The CDN node capability can be enhanced to support more content formats and service types by dynamically adjusting its resources. This is particularly good for operators wanting to reduce their investments.

The design objective for flexible resource management can be achieved by adopting network virtualization technology and software-defined network technology. The detailed information can be referenced from the related ITU-T Recommendations listed in the Bibliography.

7.3 Capability for interworking between networks

Currently, the dedicated CDN does not meet the requirements of comprehensive network integration. The CDN should be able to cover two or more network types. The interworking is the baseline for unified network management and interoperability between different networks. Also, it will guarantee content transmission across the different networks. From feedback offered by end-users, the CDN provides for the possibility of using different terminal devices and obtaining a better consumer experience.

8 Framework for multimedia content delivery network

This clause describes the functional framework for multimedia CDN and the functional blocks of multimedia CDN framework. [ITU-T Y.2019] is an important reference for this clause.

8.1 Overview

A CDN is an infrastructure of network elements operating at layer 4 through layer 7. Usually, a conventional CDN is a service-oriented overlay network built on the underlying transport network. According to requests made by users or content providers, the major service of CDN in the past years is to distribute and deliver digital content (web pages and images) to the place that is nearest to the end-point. With the development of multimedia services and network infrastructures, CDN is now widely used in dedicated networks for carrying Internet protocol (IP) based video/audio transportation. For example, IPTV is a quality of service (QoS) guaranteed service that takes great advantage from CDN.

In the real market, CDN is designed for varying purposes and is operated by different operators or service providers, which requires a dedicated CDN functional architecture. Those CDNs are usually isolated from each other, e.g., an IPTV CDN and an Internet CDN for over the top (OTT) service. Because of the different purposes such as the distribution of dynamic content or static content, CDNs may be designed by different architectures to support diverse media formats, transport protocols and receivers. More and more users expect to access various services using a single terminal device or expect to switch between different terminal devices with a high-speed service response and without

knowledge of the network infrastructure. The current CDN lacks interoperability, the ability to support multiple types of services and uses resources inefficiently.

Therefore, a CDN needs to be developed as an ideal solution for supporting various service types, content formats, transport protocols and interoperability.

Many emerging technologies can be applied in the multimedia CDN such as virtualized CDN, network function virtualization/software-defined networking (NVF/SDN), CDN interconnection (CDNi) and smart content/user request routing. But the basic concept of CDN still comes from the conventional CDN that can be found in [ITU-T Y.2019]. The basic CDN functions can be shown as four parts: Content distribution and control functions, content delivery functions, management functions and content routing/redirecting functions. Network function an infrastructure function that can affect the functional architecture in CDN but is outside the scope of this Recommendation.

8.2 The functional framework for multimedia CDN

Figure 8-1 shows the functional framework for multimedia CDN.

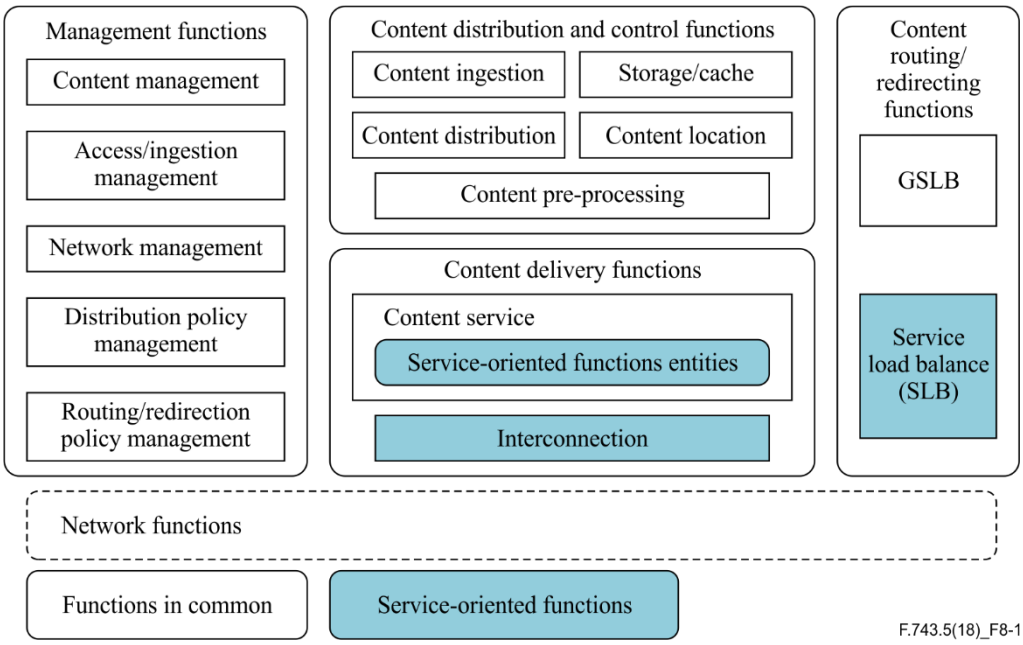

Figure 8-1 – Functional framework of multimedia CDN

In essence, the functional framework for multimedia CDN consists of functions in common, and service-oriented functions. The functions in common include the basic functions that all types of CDN services are required to implement, e.g., content distribution, ingestion, storage, etc. The service-oriented functions include the specific functions that implement the service logic specifically for the target service. For example, as a service provided by CDN, the media transcoding function may not be required for web service, but may be required for IPTV service to provide various qualities of media streams.

The functions in the framework are described in the following clauses.

8.2.1 Management functions

Several specific functions blocks are involved in this function. The blocks are specified as content management, network management, access/ingestion management, distribution policy management, and routing/redirection policy management. The major role of this function is to manage the content, policy and node server to guarantee that the CDN is running in a highly efficient and secure environment.

8.2.2 Content distribution and control functions

Several specific functional blocks are involved in this function such as user request routing/redirection, content location, content distribution/delivery routing, content distribution and storage/cache. The major role of this function is to control the content distribution in the network with quick response, high efficiency and security.

8.2.3 Content delivery functions

Several specific functional blocks are involved in this function such as load balance, interconnection and content service (including, but not limited to, web and streaming media service). The major role of this function is to deliver the related content to the end-user based on the user's request, the adapted transport protocols and the server nodes' status. The functions can be designed for different architectures according to the service which a service provider wants to provide.

8.2.4 Content routing/redirecting functions

The content routing/redirecting functions are responsible for selecting the request content resource for users. The content resource may be the content location uniform resource locator (URL) or the media server address. If there is not any content hinted, the original content source location should be provided. Typically, a load balance system is designed to optimize the content selection. The load balance algorithm may have many priorities, such as current server load status, service type, input/output (I/O) states, etc. It is worth noting that the service load balance (SLB) can be optionally implemented inside a CDN node as a service-oriented function.

8.2.5 Network functions

The network functions provides the network resource for data transmission and processing for the above-mentioned functions, which are the infrastructure functions in the CDN framework. Network functions can be changed because of technology evolution. The functional framework for the CDN may be affected. For example, the network resource reservation and allocation may be different when CDN is running on a SDN-based network instead of a conventional network, thereby affecting the functions in CDN.

9 High-level interfaces

Figure 8-1 presents the framework for a multimedia CDN. Figure 9-1 provides the possible high-level interfaces based on Figure 8-1, through the consideration of the content source stratum, service stratum, network stratum and end-user stratum. The current CDN equipment used in IPTV service, as the implementation of content delivery functions, can be referenced from [b-ITU-T Y.1910].

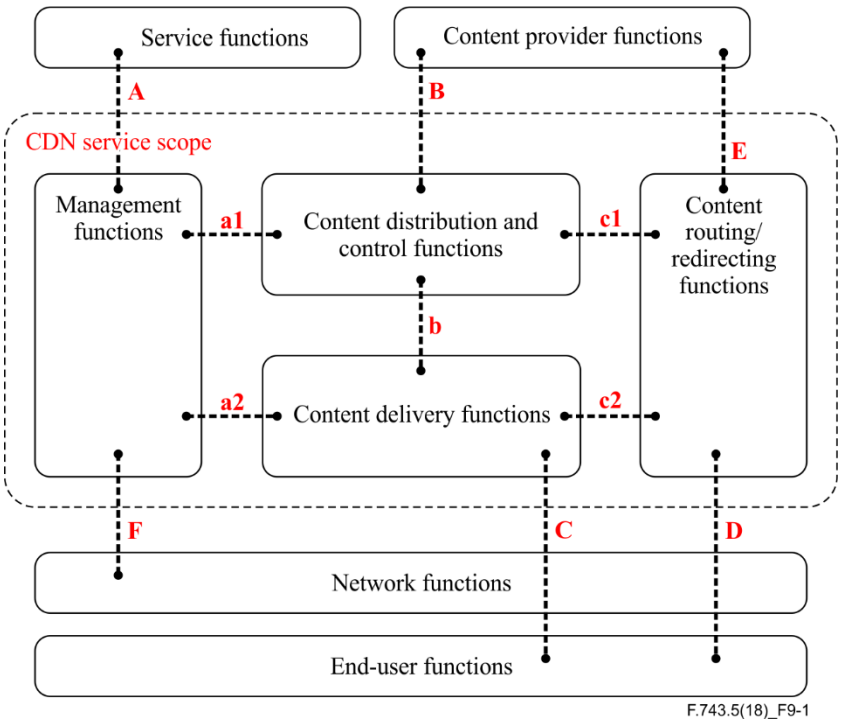

Figure 9-1 – High-level interfaces between functions in multimedia CDN

From Figure 9-1, all interfaces can be categorized into two types:

1) Interface between CDN service scope and other service scope.

2) An inner interface between CDN Functions

The high-level interfaces shown in Figure 9-1 are not the logical reference points of the CDN functional architecture. The reference points should be defined in other future ITU-T Recommendations.

The above interfaces are meant to realize the functions described in clause 9.1.

9.1 Interfaces between CDN service scope and other service scope

– **Interface A**: between management functions and service functions. It is used to receive the service request from service providers and to manage the CDN nodes and service according to those requests.

– **Interface B**: between content distribution and control functions and content provider functions. It is used to ingest content from the content source.

– **Interface C**: between content delivery functions and end-user functions. It is used to deliver the content to end users and to manage the media and control connection session.

– **Interface D**: between content routing/redirecting functions and end-user functions. It is used to receive the content request from an end user and return the content URL or redirect the end user to the right media server after loading balance.

– **Interface E**: between content routing/redirecting functions and content provider functions. It is used to translate the original content address to a new URL that can be mapped to the CDN address.

– **Interface F**: between management functions and network functions. It is used to detect the network status and to modify its network control policy.

9.2 Inner interfaces between CDN functions

– **Interface a1**: between management functions and content distribution and control functions. It is used to exchange the management request, such as content process policy, content distribution policy, etc., between those two functions. This interface is mainly used for CDN central node.

– **Interface a2**: between management functions and content delivery functions. It is used to exchange the management request, such as node configuration, content delivery policy, etc., between those two functions. This interface is mainly used for CDN edge node.

– **Interface b**: between content distribution and control functions and content delivery functions. It is used to implement the distribution, content track and other distribution functions.

– **Interface c1**: between content routing/redirecting functions and content distribution and control functions. It is used to collect the entire CDN servers' status and to implement global load balance.

– **Interface c2**: between content routing/redirecting functions and content delivery functions. It is used to locate the right content URL or redirect user request to a CDN edge node. In addition, it can implement inner node loading balance.

Bibliography

[b-ITU-T H.780] Recommendation ITU-T H.780, *Digital signage: Service requirements and IPTV-based architecture*.

[b-ITU-T X.609] Recommendation ITU-T X.609, *Managed peer-to-peer (P2P) communications: Functional architecture*.

[b-ITU-T X.1162] Recommendation ITU-T X.1162, *Security architecture and operations for peer-to-peer networks*.

[b-ITU-T Y.1910] Recommendation ITU-T Y.1910 (2008), *IPTV functional architecture*.

[b-ITU-T Y.2084] Recommendation ITU-T Y.2084, *Distributed service networking content distribution functions*.

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