International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.2019

(09/2010)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Frameworks and functional architecture models

Content delivery functional architecture in NGN

Recommendation ITU-T Y.2019

International Telecommunication Union

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Recommendation ITU-T Y.2019

Content delivery functional architecture in NGN

Summary

Recommendation ITU-T Y.2019 describes the content delivery functional architecture in NGN. This detailed architecture is based on the IPTV functional architecture described in Recommendation ITU-T Y.1910. Only the NGN architecture options (IMS and non-IMS) are addressed.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2019	2010-09-06	13

FOREWORD

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CONTENTS

Introduction

The key aspects of content delivery are to locate content delivery instances in the NGN and to provide delivery of content to the end-users. Content delivery functions are described in [ITU-T Y.1910].

Content delivery functions interact with application functions, service control functions, network functions and end-user functions (e.g., functions in the home network, corporate network, etc.). Content delivery mechanisms are based on unicast and/or multicast.

This Recommendation describes the content delivery functional architecture, the related functional requirements and procedures.

In this Recommendation, only the NGN architecture options (IMS and non-IMS) are addressed.

Recommendation ITU-T Y.2019

Content delivery functional architecture in NGN

1 Scope

This Recommendation specifies the functional architecture of content delivery functions in NGN and the related procedures. This Recommendation builds upon the IPTV functional architecture described in [ITU-T Y.1910]. More specifically, this Recommendation provides:

- an overview of content delivery functions;
- a hierarchical architecture of content delivery functions and related reference points;
- requirements for content delivery;
- procedures related to content delivery functions.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

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

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks.*

[ITU-T Y.2014] Recommendation ITU-T Y.2014 (2010), *Network attachment control functions in next generation networks*.

[ITU-T Y.2111] Recommendation ITU-T Y.2111 (2008), *Resource and admission control functions in next generation networks.*

[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 functional architecture [ITU-T Y.2012]: A set of functional entities and the reference points between them used to describe the structure of an NGN. These functional entities are separated by reference points, and thus, they define the distribution of functions.

NOTE – The functional entities can be used to describe a set of reference configurations. These reference configurations identify which reference points are visible at the boundaries of equipment implementations and between administrative domains.

3.1.2 linear TV [ITU-T Y.1910]: A television service in which a continuous stream flows in real time from the service provider to the terminal device and where the user cannot control the temporal order in which contents are viewed.

3.1.3 reference point [ITU-T Y.2012]: A conceptual point at the conjunction of two non-overlapping functional entities that can be used to identify the type of information passing between these functional entities.

NOTE – A reference point may correspond to one or more physical interfaces between pieces of equipment.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 cluster: Cluster is a grouping of content delivery processing entities with their related control entity. Such grouping allows the sharing of resources (e.g., storage capacity) based on provider's policy (e.g., taking into account parameters such as user location).

3.2.2 content aging: The process to delete a content and related metadata from the content delivery functions.

3.2.3 content dispatching: The process to distribute a content and related metadata within different instances of content delivery functions.

3.2.4 content ingestion: The process of acquiring a content and related metadata by content delivery functions from content preparation functions.

3.2.5 content segment: To improve the efficiency of content dispatching, a complete media content is needed to be divided into several serial media content. One piece of the divided media content is called a content segment.

NOTE – The term content segment in this Recommendation includes non-continuous portion of content as well as continuous portion of content.

3.2.6 linear TV relay: Entity which receives stream from a linear TV source and delivers it to the end-user using multicast or unicast.

3.2.7 pull mode: A content delivery mode which provides delivery of content at the request of the end-user.

3.2.8 push mode: A content delivery mode which provides delivery of content at the request of the service provider.

4 Abbreviations and acronyms

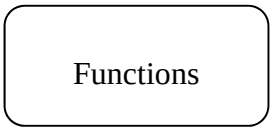
This Recommendation uses the following abbreviations and acronyms:

AF	Application Functions
CCF	Cluster Control Functions
CDCF	Content Delivery Control Functions
CDC-FE	Content Delivery Control Functional Entity
CDF	Content Delivery Functions
CDPF	Content Delivery Processing Functions
CDP-FE	Content Delivery Processing Functional Entity
CD&SF	Content Delivery & Storage Functions
CD&LCF	Content Distribution & Location Control Functions
CD&LC-FE	Content Distribution & Location Control Functional Entity
CPRF	Content Preparation Functions
FE	Functional Entity

IPTV	Internet Protocol TV
IPTV AF	IPTV Application Functions
LRU	Least Recently Used
McCP-FB	Multicast Control Point Functional Block
McR-FB	Multicast Replication Functional Block
MTF	Multicast Transport Functions
NACF	Network Attachment Control Functions
NGN	Next Generation Networks
QoS	Quality of Service
RACF	Resource and Admission Control Functions
RTSP	Real Time Streaming Protocol
SCF	Service Control Functions
SCP	Service and Content Protection
UCC	User Created Content
UE	User Equipment
VoD	Video on Demand

5 Conventions

Functions: In the context of this Recommendation, "functions" are defined as a collection of functionalities. It is represented by the following symbol:

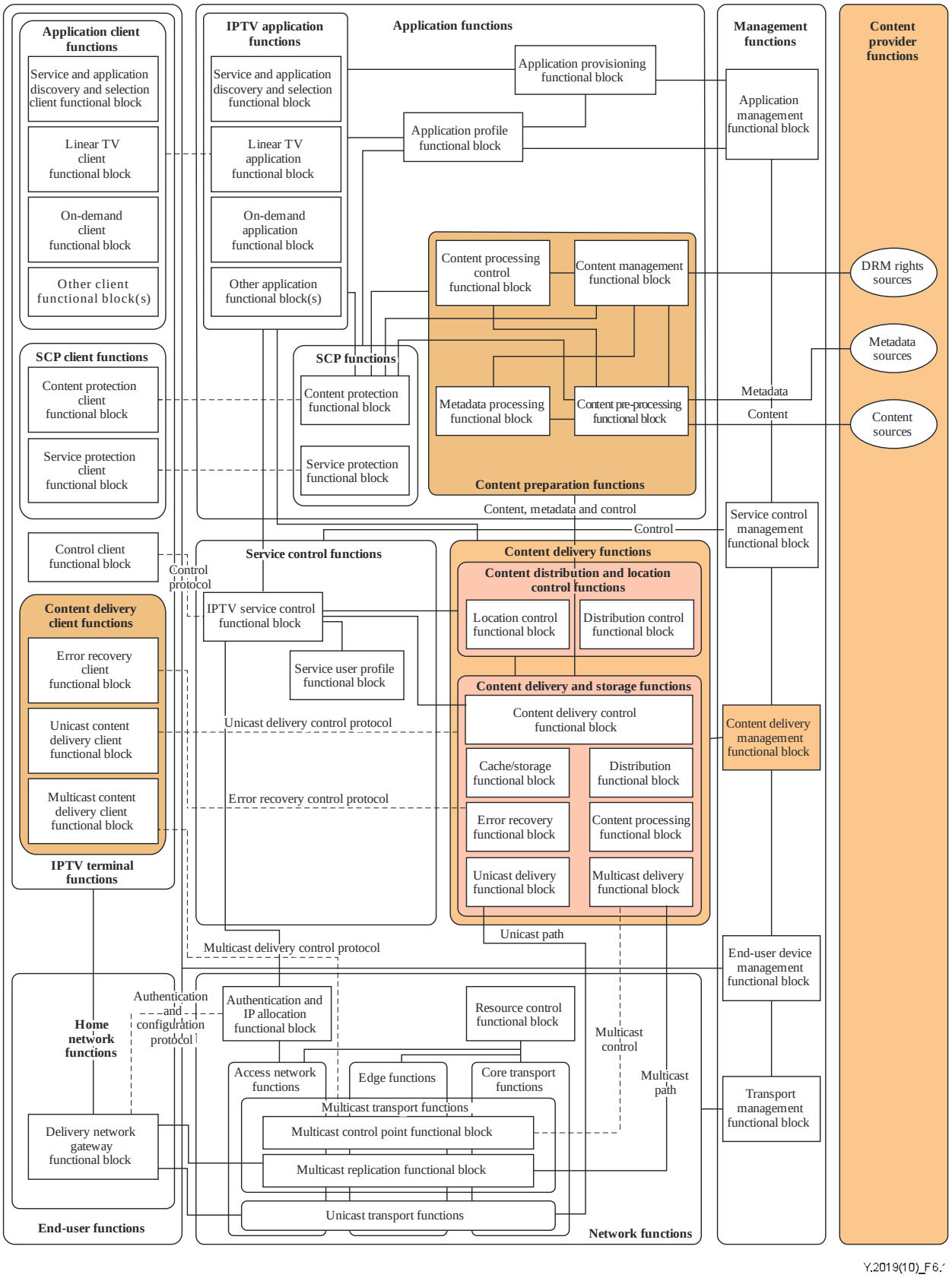


Functional block: In the context of this Recommendation, a "functional block" is defined as a group of functionalities that has not been further subdivided at the level of detail described in this Recommendation. It is represented by the following symbol:

6 Content delivery overview

6.1 Introduction

Based on Figure 10-4 of [ITU-T Y.1910], Figure 6-1 underlines the functions involved in content delivery.



NOTE 1 – For NGN IPTV architectures "Authentication & IP allocation functional block" is replaced by "Network attachment control functions (NACF)" [ITU-T Y.2014].
NOTE 2 – For NGN IPTV architectures, "Resource control functional block" is replaced by "Resource & admission control functions (RACF)" [ITU-T Y.2111].
NOTE 3 – For NGN IMS IPTV architecture, "IPTV service control functional block" is replaced by "Core IMS functions".
NOTE 4 – For NGN IMS IPTV architecture, "Client control functional block" is replaced by "Session client functional block".

Figure 6-1 – Detailed IPTV architecture – Content delivery

Content delivery involves the following functions described in [ITU-T Y.1910]:

- Content preparation functions (CPRF):
  - content management functional block;
  - metadata processing functional block;
  - content processing control functional block;
  - content pre-processing functional block.
- Content delivery functions (CDF):
  - content distribution and location control functions;
  - content delivery and storage functions.

In [ITU-T Y.1910], the functions involved in content delivery are in relationship with the management functions and the content provider functions.

Note that in some cases the SCP functions are involved in the content delivery process (e.g., for content encryption).

Content delivery includes the following:

- content ingestion: this process loads content received from CPRF for immediate or delayed delivery;
- content dispatching: this process distributes content within different instances of content delivery functions;
- content delivery: this process supplies content to the end-user.

6.2 Content ingestion

Content ingestion handles content and related metadata received from CPRF. CPRF control the preparation and aggregation of content received from the content provider functions.

The ingestion process can optionally be based on:

- push mechanism: once prepared, the content is sent by CPRF to the content delivery functions;
- pull mechanism: the content is fetched from CPRF only when needed by the content delivery functions.

The ingestion process can optionally include recording content. In this case, the content delivery functions perform functions that record linear content, either on demand or systematically depending on the end-user and/or service needs. This recording is for immediate or delayed delivery.

6.3 Content dispatching

After ingestion, content can optionally be duplicated through the content delivery functions depending on a predefined policy.

For example, popular content can optionally be duplicated on all content delivery functions, local content can optionally reside only in certain targeted areas and rare contents are less duplicated than the latter two.

The policy for duplication can optionally be defined on a static basis or dynamically updated, e.g., based on usage statistics.

6.4 Content delivery

Content delivery supplies content to the end-user under the control of the application functions. The related procedures are detailed in Appendix I of [ITU-T Y.1910].

7 Content delivery functions

Content delivery capabilities allow IPTV end-users to select, watch and/or listen to video or audio content. Content delivery capabilities either stream content through end-user functions, allowing viewing in real time, or download it to end-user functions with storage ability (e.g., personal computer, digital video recorder or portable media player) for viewing at any time.

By using the content delivery capabilities, a service provider delivers linear TV content to the IPTV terminal device with the optional capability to record, rewind, and pause, over the network. The content delivery capabilities allow the delivery of IPTV content to IPTV end-users by responding dynamically to IPTV user's requests.

The content delivery capabilities can optionally support two delivery modes towards IPTV end-users: multicast delivery and unicast delivery.

In the content delivery architecture, either download of the content from a single storage instance or download of the content in segments from multiple storage instances is supported.

7.1 Content delivery functions in the IPTV architecture

Figure 7-1 shows the content delivery functions in the IPTV architecture and the corresponding reference points (refer to [ITU-T Y.1910] for further details).

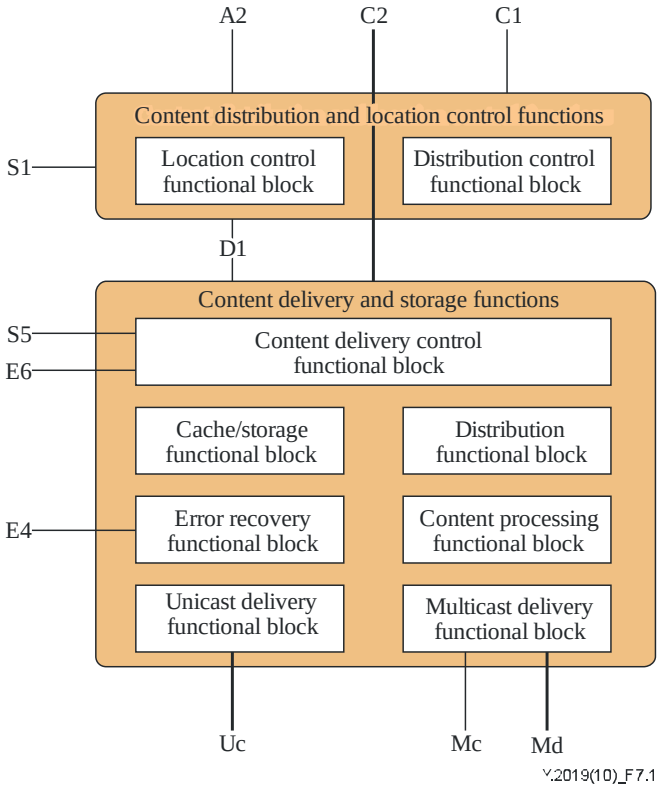


Figure 7-1 – Content delivery functions in [ITU-T Y.1910]

In [ITU-T Y.1910], the content delivery functions consist of two groups of functions:

- content distribution & location control functions (CD&LCF);
- content delivery & storage functions (CD&SF).

In the context of this Recommendation, the CD&SF, as defined in [ITU-T Y.1910], is split into two parts as shown in Figure 7-2:

- content delivery control functions (CDCF) including the following functional block:
  - content delivery control;
- content delivery processing functions (CDPF) including the following functional blocks:
  - cache/storage;
  - distribution;
  - content processing;
  - unicast delivery;
  - error recovery;
  - multicast delivery.

NOTE – Error recovery and multicast delivery functional blocks are optional.

A new reference point, i.e., the D2 reference point, is added between CDCF and CDPF.

Such functional split allows the support of the deployment scenarios described in this Recommendation.

The functional architecture shown in Figure 7-2 is compatible with the NGN functional architecture, as described in clause 9.3.4 of [ITU-T Y.2012]. More specifically:

- The CD&LCF correspond to the CD&LC-FE as per clause 9.3.4.1 of [ITU-T Y.2012];
- The CDCF correspond to the CDC-FE as per clause 9.3.4.2 of [ITU-T Y.2012];
- The CDPF correspond to the CDP-FE as per clause 9.3.4.3 of [ITU-T Y.2012].

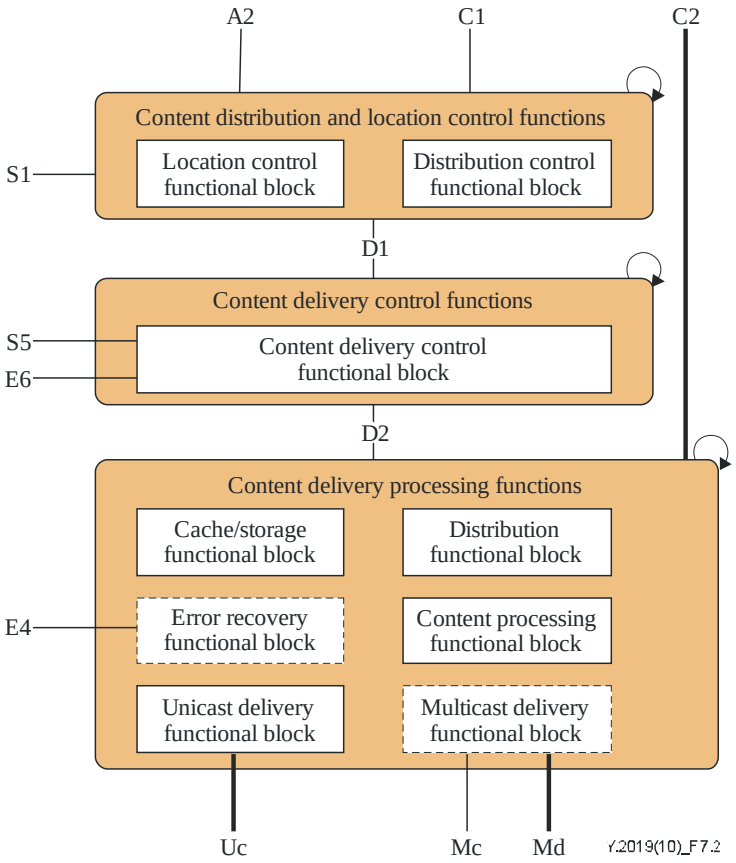


Figure 7-2 – Content delivery functional architecture

7.2 Hierarchical content delivery architecture

The content delivery functional architecture shown in Figure 7-2 is flexible and can be deployed in different ways depending on the delivery constraints.

This clause describes a hierarchical model based on the use of the following three types of functions:

- content distribution & location control functions (CD&LCF);
- cluster control functions (CCF) which groups content distribution & location control functions (CD&LCF) and content delivery control functions (CDCF);
- content delivery processing functions (CDPF).

A given instance of the CD&LCF manages one or multiple instances of CCF.

A given instance of CCF manages one or multiples instances of CDPF.

This hierarchical architecture can optionally involve more than two levels of control (CD&LCF and CCF) depending on scalability constraints.

Figure 7-3 shows the hierarchical content delivery architecture.

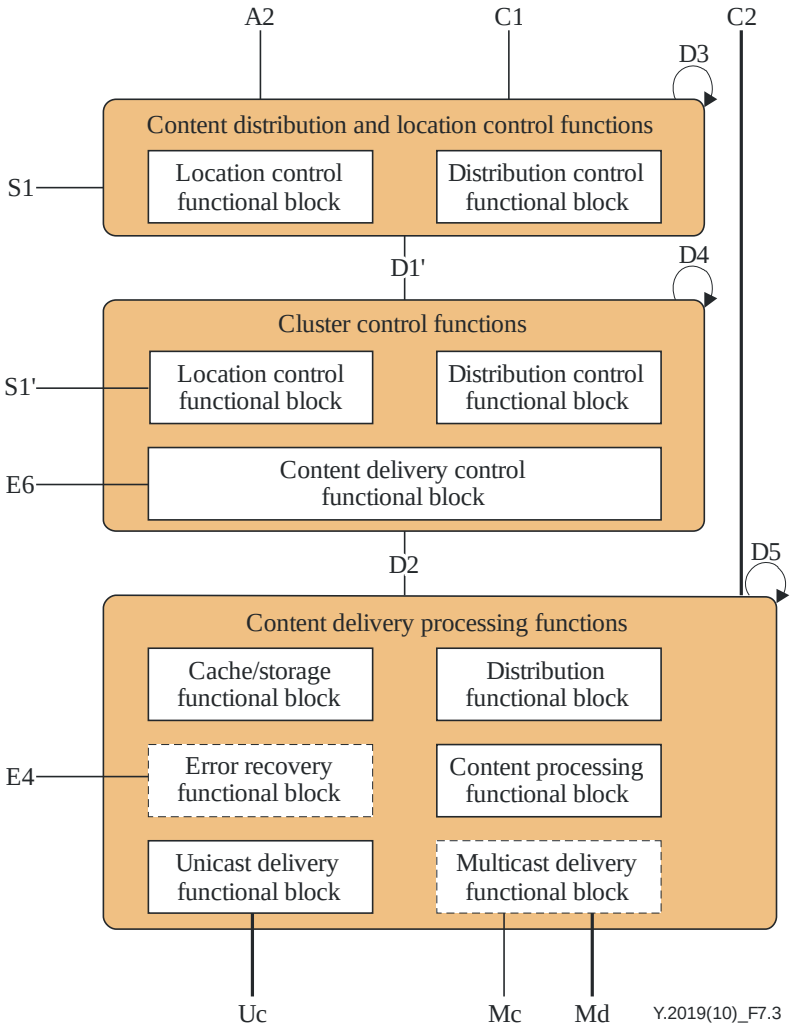


Figure 7-3 – Hierarchical content delivery architecture

Figure 7-3 shows the reference points between different instances of the content delivery functions.

The D3 reference point is between different CD&LCF instances, allowing the selection on the optimal CD&LCF instance.

The D4 reference point is between different CCF instances, allowing content distribution control and content location control signalling transfer.

The D5 reference point is between different instances of CDPF allowing content distribution.

The D3, D4 and D5 reference points are optional.

The hierarchical architecture supports two sub-models:

- hierarchical architecture with functions of the same level that are not connected to each other;
- hierarchical architecture with functions of the same level that can optionally be connected to each other. In this case, the D3, D4, D5 reference points can optionally be used.

7.2.1 Content distribution & location control functions (CD&LCF)

The CD&LCF include two functional blocks: the location control functional block and the distribution control functional block which are defined in [ITU-T Y.1910].

The CD&LCF are used for overall control of the content delivery process. The CD&LCF are used as the main entry for service requests from IPTV application functions through the A2 reference point or from service control functions through the S1 reference point. The CD&LCF control one or multiple instances of cluster control functions (CCF).

7.2.2 Cluster control functions (CCF)

The CCF include three functional blocks: location control, distribution control and content delivery control functional blocks which are defined in [ITU-T Y.1910].

The CCF are used as the entry for service request from IPTV application functions through the S1' reference point. The CCF are also used for media content control (e.g., for RTSP control) through the E6 reference point. The CCF control one or multiple instances of CDPF.

7.2.3 Content delivery processing functions (CDPF)

The CDPF include six functional blocks: cache/storage, distribution, error recovery, content processing, unicast delivery and multicast delivery defined in [ITU-T Y.1910].

Error recovery and multicast delivery functional blocks are optional.

The CDPF are used for content delivery (unicast or multicast) and content distribution (content ingestion, content dispatching and content aging) under the control of CCF.

8 Content delivery requirements

Note that this Recommendation follows also requirements provided in [ITU-T Y.1910], and these requirements are additional requirements to [ITU-T Y.1910].

8.1 Mandatory requirements

The requirements provided in this clause are mandatory.

R1: The content delivery functions are required to support mechanisms to select the content delivery processing functions (CDPF) instance for a specific end-user or set of end-users based on provider policies (e.g., end-user location, content availability, load of the content delivery processing functions, etc.).

R2: The content delivery functions are required to support delivery of the content through streaming and download.

R3: The content delivery functions are required to support content ingesting, dispatching, aging and delivery.

R4: The content delivery functions are required to provide mechanisms to collect and maintain the data related to the content distribution in order to allocate end-user's requests to the appropriate content delivery processing functions (CDPF) instance.

R5: The content delivery functions are required to provide mechanisms to collect data related to the content popularity (e.g., the number of end-user's requests, etc.).

R6: The content delivery functions are required to provide reporting abilities between the different functions (e.g., availability of content delivery processing functions instances, unexpected signalling from the end-user functions, etc.).

R7: In case of hierarchical architecture, the content delivery functions are required to support dispatching of content between different instances of content delivery processing functions.

8.2 Optional requirements

The requirements provided in this clause are optional.

R8: The content delivery functions can optionally provide different priority levels for content and/or services.

R9: The content delivery functions are recommended to support content segmentation mechanism (i.e., divide the content in smaller pieces) for efficient content dispatching.

R10: The content delivery functions can optionally support distribution and delivery of user created content (UCC).

R11: The content delivery functions can optionally support multicast content delivery mechanisms.

R12: The content delivery functions can optionally support FEC or retransmission mechanisms.

R13: The content delivery functions can optionally support seamless content serving transfer from one content delivery function instance to another content delivery function instance when the end-user moves from one geographical area to another area.

R14: The content delivery functions can optionally provide a mechanism to support advertisement insertion for unicast streaming.

9 Reference points

This Recommendation uses the existing A2, C1, C2, S1, E4, E6, Uc, Mc and Md reference points defined in [ITU-T Y.1910] and defines new reference points as follows.

9.1 Reference point D1' between CD&LCF and CCF

The D1' reference point between CD&LCF and CCF allows CD&LCF to get status information from CCF such as load status on each instance of content delivery functions. It can optionally be used to locate the appropriate CCF instance for controlling the delivery of the content to the end-user. The D1' reference point serves for controlling content ingestion and optionally for performing content dispatching or content aging to and within the content delivery functions.

9.2 Reference point D2 between CCF and CDPF

The D2 reference point between CCF and CDPF allows CD&LCF to get status information from CDPF instances such as load status on each instance that the CCF controls. The D2 reference point is used to locate the appropriate CDPF instance for controlling the delivery of the content to the end-user. The D2 reference point serves for performing content dispatching and content aging within the content delivery functions.

9.3 Reference point D3 between different CD&LCF

The D3 reference point between different CD&LCF instances allows caching content distribution and content delivery control-related signalling between CD&LCF to locate the appropriate CD&LCF instance.

9.4 Reference point D4 between different CCF

The D4 reference point between different CCF instances allows CCF to transfer the session establishment, modification, or termination request to other CCF instances. Additionally, the D4 reference point is also used for the transfer of content dispatching requests and content aging requests.

9.5 Reference point D5 between different CDPF

The D5 reference point between different CDPF instances allows the content to be distributed among different CDPF under the control of CCF.

9.6 Reference point S1' between SCF and CCF

The S1' reference point between SCF and CCF is identical to the S1 reference point as defined in [ITU-T Y.1910]. Unicast content control signalling request (e.g., VoD content request) is directly coming from SCF to the specified CCF.

10 Hierarchical model deployment principles

10.1 General principles

This clause describes general principles that can optionally be applied to hierarchical architecture regarding content delivery functions.

The hierarchical architecture described in this clause allows the optimization of the network use through a distribution of the media servers in the network, and the optimization of the storage resources of the content on the media servers, based on provider criteria. For example, if the criterion is the popularity of the content, popular content is distributed on media servers at the edge of the network (as close as possible to the customer), while less popular content is distributed on a reduced number of media servers.

Figure 10-1 describes an example of hierarchical architecture deployment involving different instances of functions related to content delivery.

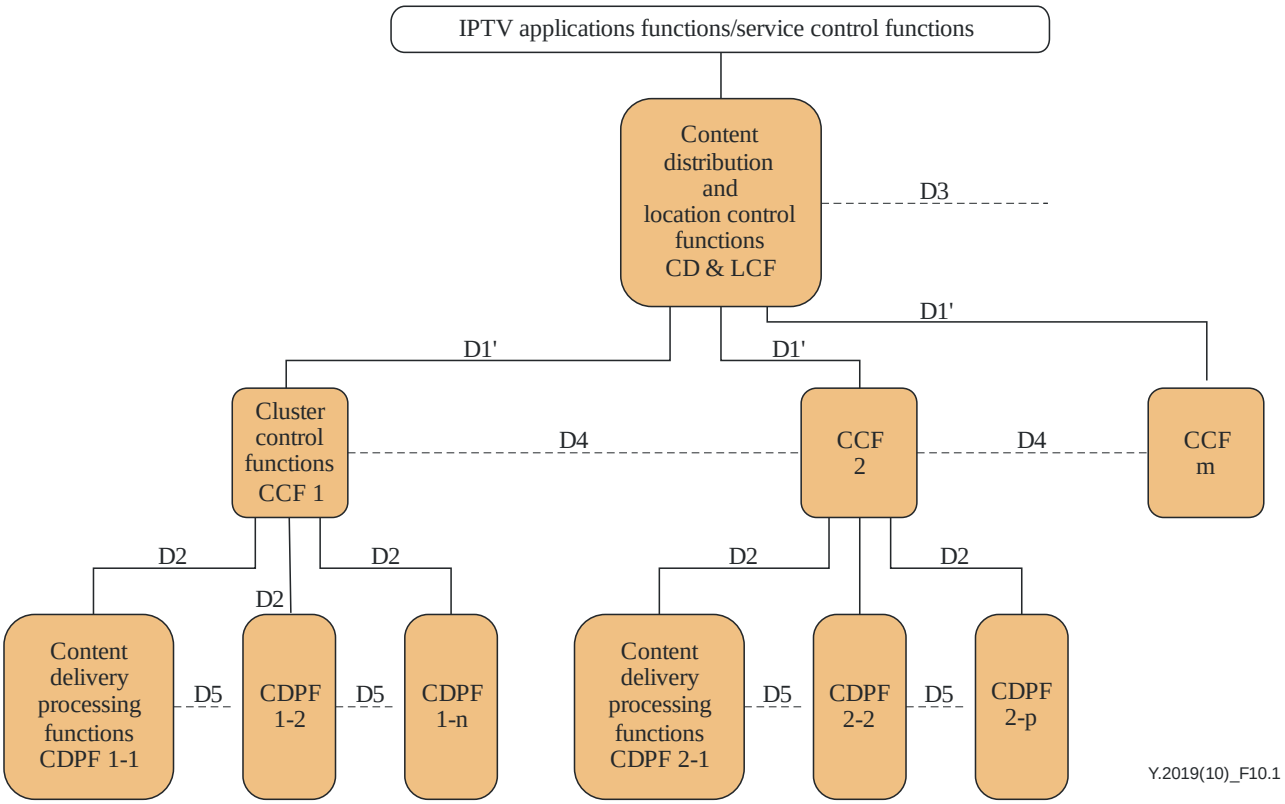


Figure 10-1 – Example of hierarchical architecture deployment

The deployment of CDPF can optionally be based on the following criteria:

- one CDPF is managed by only one CCF, so one CDPF belongs to only one cluster;
- content available to customers is not necessarily distributed uniformly among the CDPF;
- a content can optionally be available in some CDPF within a given cluster and absent in other CDPF within the same cluster.

Depending on the context, functions of the same level (i.e., different instances of CD&LCF, CCF or CDPF) can optionally be interconnected (using the D3, D4 or D5 reference points).

10.2 Selection

10.2.1 CD&LCF selection

If there are more than one CD&LCF, IPTV AF select one CD&LCF for UE, based on some criteria, for example:

- geographical location of the UE: CD&LCF is selected based on the UE location, such as the parameter of the IP address in the service request;
- service capability: The service capability includes the CD&LCF own service capability and the capability of the CCF under it.

10.2.2 CCF selection

The CCF instance is selected by CD&LCF based on some criteria, for example:

- geographical location of the UE: CCF is selected based on the UE location, such as the parameter of the IP address in the service request;
- content availability: CCF is selected according to the content availability of the UE's request;

- service capability: The service capability includes the CCF's service capability and the streaming capability of the CDF organized by the CCF.

10.2.3 CDPF selection

The CDPF instance is selected by CCF based on some criteria, for example:

- geographical location of the UE: The CDPF is selected according to geographical location of the UE, and selects a nearest CDPF to service for UE;
- content availability: The CDPF is selected according to the content availability of the UE's request.

11 Content delivery procedures

The following clauses describe basic procedures for content delivery.

11.1 Generic content delivery procedures

Generic procedures related to content delivery functions are described in [ITU-T Y.1910].

11.2 Hierarchical content delivery procedures

This clause provides procedures related to the hierarchical content delivery architecture described in clause 7.2 in line with the requirements identified in clause 8.

11.2.1 Content ingestion procedure

This procedure covers the mandatory requirement R3 (see clause 8.1).

Figure 11-1 describes the content ingestion procedure, i.e., how content is ingested from CPRF to different CDPF.

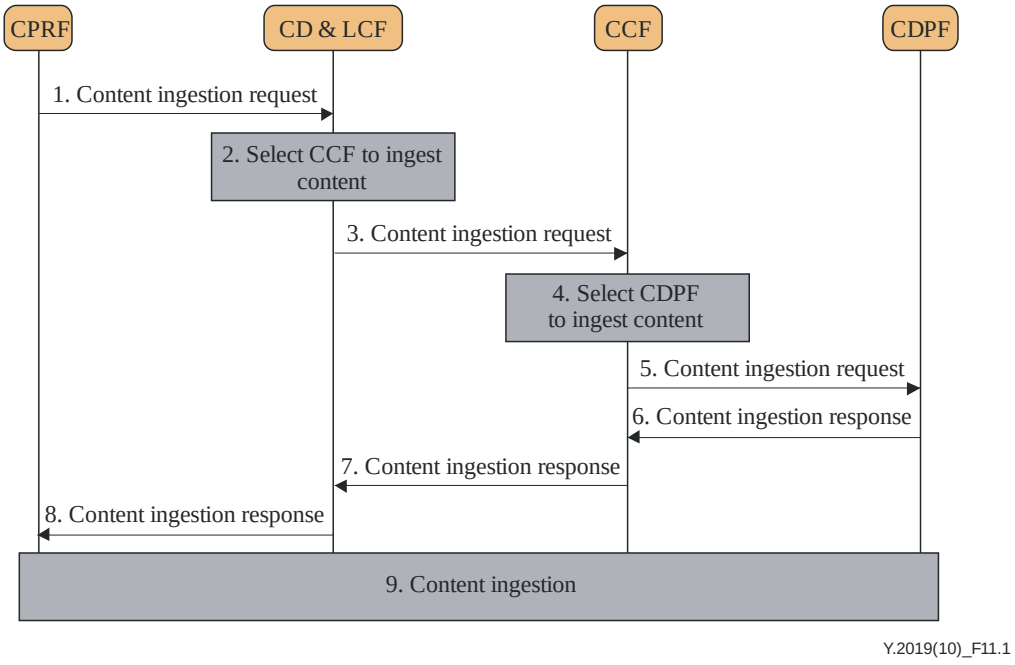


Figure 11-1 – Content ingestion procedure

Pre-conditions:

It is assumed that:

- content metadata and content protection rights information have been delivered from the content provider functions to content preparation functions (CPRF);
- content preparation procedures are completed.

NOTE 1 – Content preparation procedures include content aggregation, content management, metadata processing, content processing and content encryption as defined in [ITU-T Y.1910].

The procedure shown in Figure 11-1 includes the following steps:

1) the CPRF identify the CD&LCF and send a content ingestion request to the selected CD&LCF;
2) the CD&LCF enforce specific ingestion policy and select one or multiple clusters to receive the content;
3) the CD&LCF send a content ingestion request to the CCF of the selected clusters;
4) the CCF select one or multiple CDPF according to a specific ingestion policy to receive the content;
5) the CCF send a content ingestion request to the selected CDPF;
6) the selected CDPF provide an acknowledgement to the CCF that the content can be ingested;
7) the selected CCF provide an acknowledgement to the CD&LCF that the content can be ingested;
8) the CD&LCF provide an acknowledgement to the CPRF that the content can be ingested;
9) the CPRF transfer the content to the selected CDPF.
    a) the content transport method can optionally be pull mode, i.e., the CDPF initiate the download of the content from the CPRF;
    b) the content transport method can optionally be push mode, i.e., the CPRF initiate the delivery of the content to CDPF.

NOTE 2 – In case the content needs to be segmented, the corresponding procedure for content dispatching is described in clause 11.2.2.

11.2.2 Content dispatching procedure

11.2.2.1 Content dispatching procedure with unicast

This procedure covers mandatory requirement R7 (see clause 8.1).

Figure 11-2 describes the content dispatching procedure, i.e., how content is distributed among different CDPF.

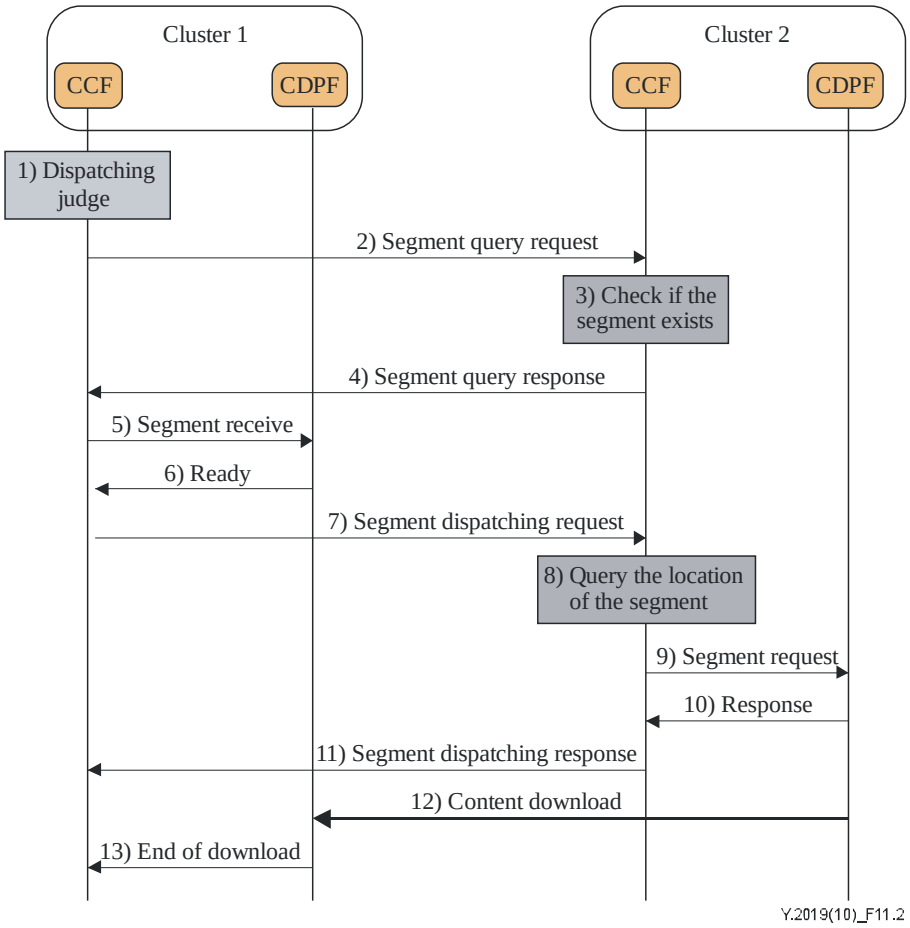


Figure 11-2 – Content dispatching procedure

The procedure shown in Figure 11-2 includes the following steps:

1) when the CCF of cluster 1 receive a content request from the end-user functions, the CCF discover that some content segments are not available in cluster 1;
2) the CCF of cluster 1 send a segment request to the CCF of other clusters to query if they can supply the content segment;
3) the CCF of cluster 2 check if the content segment is available in cluster 2. The assumption is that the content segment is available in cluster 2;
4) the CCF of cluster 2 send a segment query response to the CCF of cluster 1 indicating that the content segment is available in cluster 2;
5) the CCF of cluster 1 send a segment receiving notification to the CDPF of cluster 1;
6) the CDPF of cluster 1 confirm to the CCF of cluster 1 that it can receive the content segment;
7) the CCF of cluster 1 send a segment dispatching request to the CCF of cluster 2;
8) the CCF of cluster 2 query the location of the content segment in the CDPF of cluster 2;
9) the CCF of cluster 2 send a segment request to the selected CDPF of cluster 2 to distribute the requested content segment;
10) the CDPF of cluster 2 confirm the received segment request to the CCF of cluster 2;
11) the CCF of cluster 2 send a segment dispatching response to the CCF of cluster 1 to confirm the segment dispatching;
12) the CDPF of cluster 2 download the content segment to the CDPF of cluster 1;

13) when the content download is achieved, the CDPF of cluster 1 notify the segment dispatching result to the CCF of cluster 1.

11.2.2.2 Content dispatching procedure with multicast

This procedure covers optional requirement R11 (see clause 8.2).

Figure 11-3 describes the content dispatching procedure with multicast mode.

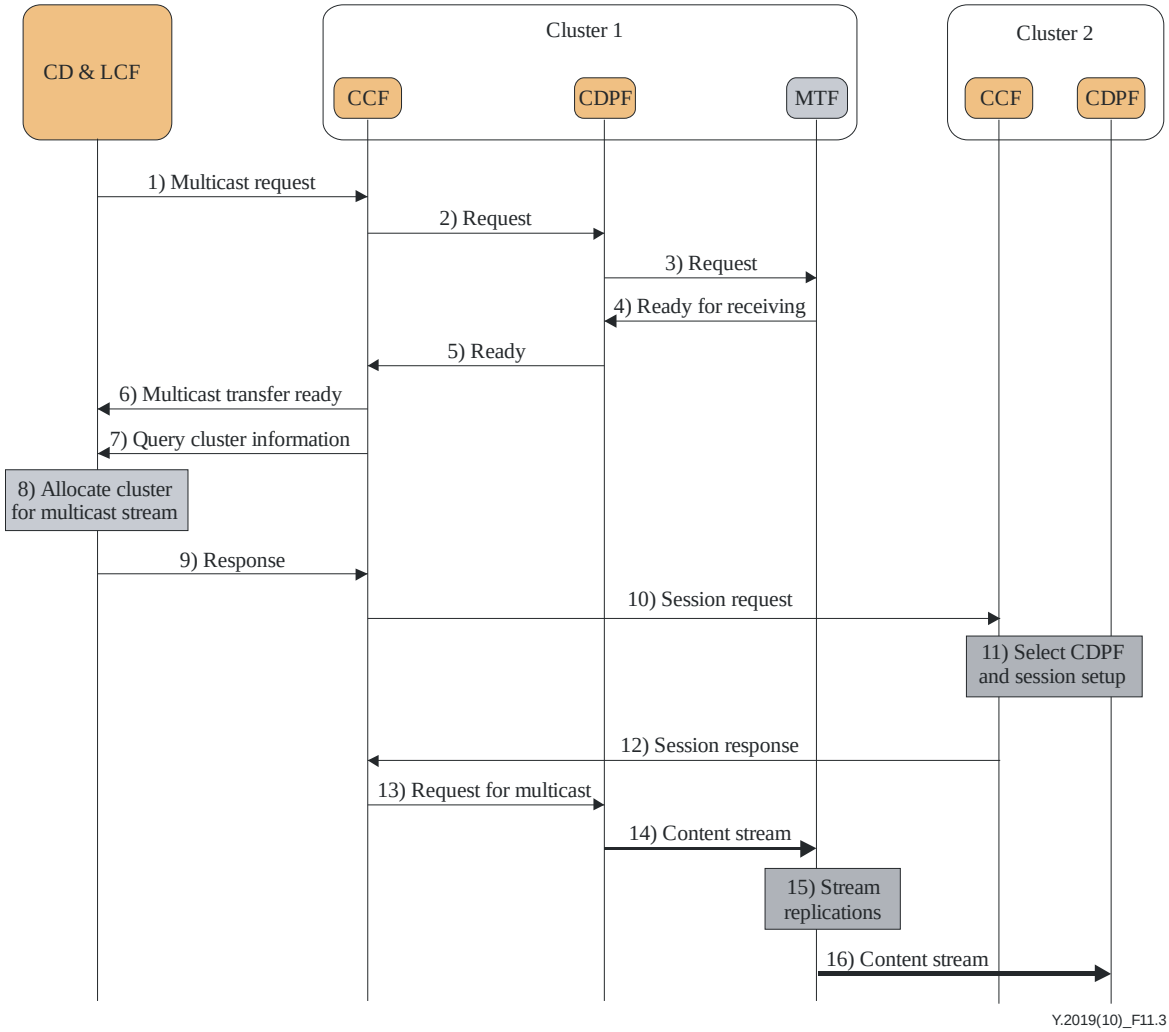


Figure 11-3 – Content dispatching procedure with multicast

NOTE 1 – It is assumed that the multicast transport functions (MTF) are located in cluster 1. MTF are functions in the NGN transport stratum which can optionally be located inside or outside of cluster 1 depending on the implementation. MTF include a multicast control point functional block (McCP-FB) and a multicast replication functional block (McR-FB) as defined in [ITU-T Y.1910].

NOTE 2 – CD&LCF maintain information about content availability in clusters.

NOTE 3 – It is assumed that the content is available in cluster 1 and will be delivered to cluster 2 by means of multicast mechanisms.

The procedure shown in Figure 11-3 includes the following steps:

1) the CD&LCF trigger a multicast request to the CCF of cluster 1;
2) the CCF forward the multicast request to the appropriate CDPF;
3) the selected CDPF send a multicast request to the MTF;
4) the MTF send an acknowledgement to the CDPF;

5) the CDPF forward the acknowledgement;

6) the CCF forward the acknowledgement and inform that multicast transfer is ready;

7) the CCF send a cluster information query to the CD&LCF;

8) the CD&LCF select a cluster to be used for content delivery;

9) the corresponding cluster information is returned to the CCF;

10) the CCF of cluster 1 send a session request to the selected CCF of cluster 2;

11) the CCF of cluster 2 send a session request to the appropriate CDPF of cluster 2 and set up the content delivery session;

12) the content delivery session identification is returned, through the service session setup response, to the CCF of cluster 1;

13) the CCF of cluster 1 send a request for multicast delivery to the CDPF;

14) the CDPF of cluster 1 stream the media to the MTF;

15) the MTF replicate the received media;

16) the MTF stream the replicated media to the CDPF of cluster 2.

11.2.3 Content aging procedure

The procedures in this clause cover mandatory requirement R3 (see clause 8.1).

For content aging, the following methods can optionally be used:

- Cluster controlled content aging

  For this content aging method, the CD&LCF is not required to know which content is stored in the clusters. The CCF within the cluster manages its own content. The cluster only needs to know the topology of the network. This method is mainly used for the case where content is required to be segmented, given that it may be difficult for the CD&LCF to manage several content segments distributed throughout the network. The detailed procedure is described in clause 11.2.3.1.

- CD&LCF and cluster controlled content aging

  For this content aging method, the CD&LCF is required to know which content is stored in the clusters of the network. This method is mainly used for the case where content is not required to be segmented. Since the CCF initiate the content aging process, it is called pull mode-based content aging. The detailed procedure is described in clause 11.2.3.2.

- CD&LCF controlled content aging

  For this content aging method, the CD&LCF need to know which content is stored in the clusters of the network. This method is used for the case where content is not required to be segmented. Since the CD&LCF initiate the content aging process, it is called push mode-based content aging. The detailed procedure is described in clause 11.2.3.3.

  For content aging policy, some algorithms, such as least recently used (LRU) algorithm can optionally be used to decide which content (segment or complete content) will be aged.

11.2.3.1 Cluster controlled content aging procedure

Figure 11-4 describes the cluster controlled content aging procedure.

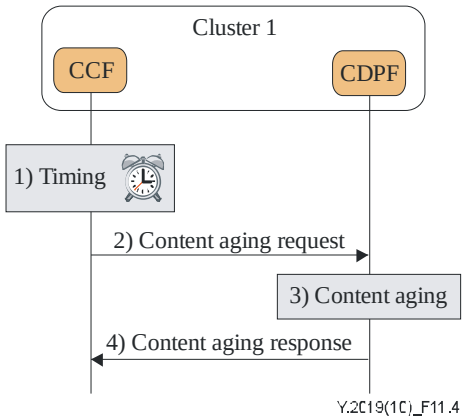


Figure 11-4 – Cluster controlled content aging procedure

The procedure shown in Figure 11-4 contains the following steps:

1) the CCF is assumed to perform a content aging task periodically. A timer is used to control the execution of the content aging task;
2) each time the timer expires, the CCF check whether the content is aged and in case the content is aged, the CCF send a content aging request to the CDPF to indicate to the CDPF which content is required to be aged;
3) the CDPF execute content aging (i.e., delete the content) according to the indication of the CCF;
4) when the content aging is successfully achieved, the CDPF confirm the content aging result to the CCF.

11.2.3.2 CD&LCF and cluster controlled content aging procedure

Figure 11-5 describes the CD&LCF and cluster controlled content aging procedure.

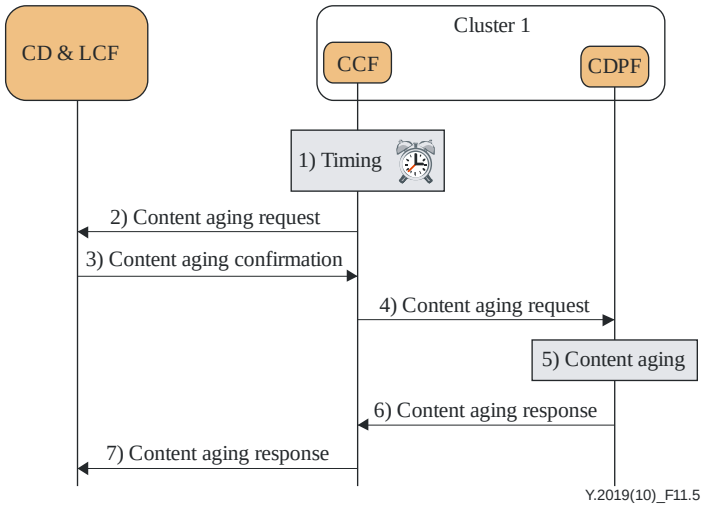


Figure 11-5 – CD&LCF and cluster controlled content aging procedure

The procedure shown in Figure 11-5 contains the following steps:

1) the CCF is assumed to perform a content aging task periodically. A timer is used to control the execution of the content aging task;
2) each time the timer expires, the CCF send a content aging request to the CD&LCF to indicate which content is required to be aged;
3) the CD&LCF judge if the content can be aged. If the content is aged, the CD&LCF send a content aging confirmation to the CCF to indicate that the content can be aged;
4) the CCF send a content aging request to the CDPF to indicate to the CDPF which content needs to be aged;
5) the CDPF execute content aging (i.e., delete the content) according to the indication of the CCF;
6) when the content aging is successfully achieved, the CDPF confirm the content aging result to the CCF;
7) the CCF send a content aging confirmation notification to the CD&LCF.

11.2.3.3 CD&LCF controlled content aging procedure

Figure 11-6 describes the CD&LCF controlled content aging procedure.

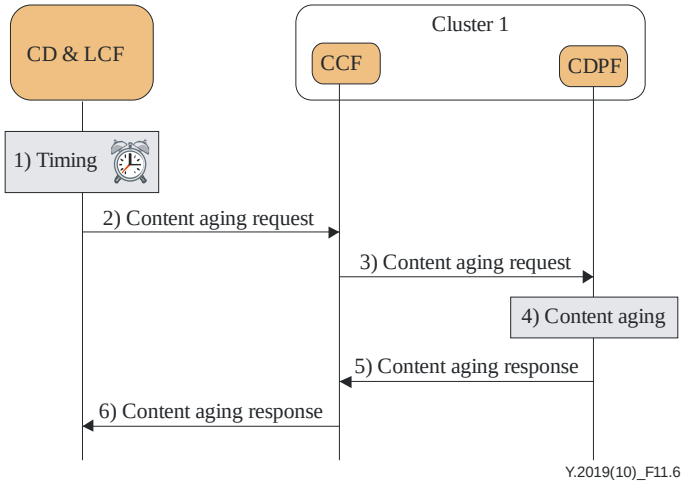


Figure 11-6 – CD&LCF controlled content aging procedure

The procedure shown in Figure 11-6 contains the following steps:

1) the CD&LCF is assumed to perform a content aging task periodically. A timer is used to control the execution of the content aging task;
2) each time the timer expires, the CD&LCF check whether the content is aged and in case the content has aged, the CD&LCF send a content aging request to the CCF to indicate which content is required to be aged;
3) the CCF send a content aging request to the CDPF to indicate which content is required to be aged;
4) the CDPF execute content aging (i.e., delete the content) according to the indication of the CCF;
5) when the content aging is successfully achieved, the CDPF confirm the content aging result to the CCF;

6) the CCF send a content aging confirmation notification to the CD&LCF.

11.2.4 Content delivery procedure

11.2.4.1 Procedure of content delivery with unicast

The procedures in this clause cover mandatory requirement R2 (see clause 8.1).

SCF/IPTV AF requests the content from CCF in a specific cluster. The choice of this cluster is based on some criteria (see clause 10.2.2, for example, geographical criteria, QoS criteria, etc.). After selection of a cluster, three cases could appear:

- Case 1: The selected cluster (referred to as cluster 1) has serving capability.
- Case 2: Cluster 1 has no serving capability, so cluster 1 relays the request to CD&LCF, which selects a new candidate cluster (referred to as cluster 2) which has serving capability.
  - Case 2-1: Cluster 2 streams directly the content to the end-user functions.
  - Case 2-2: Cluster 1 fetches the content from cluster 2, and delivers the content to the end-user functions.

Procedures described in this clause are related to the upper cases.

11.2.4.1.1 Case 1: Content available in cluster 1

Figure 11-7 describes the procedure where cluster 1 can serve the end-user functions.

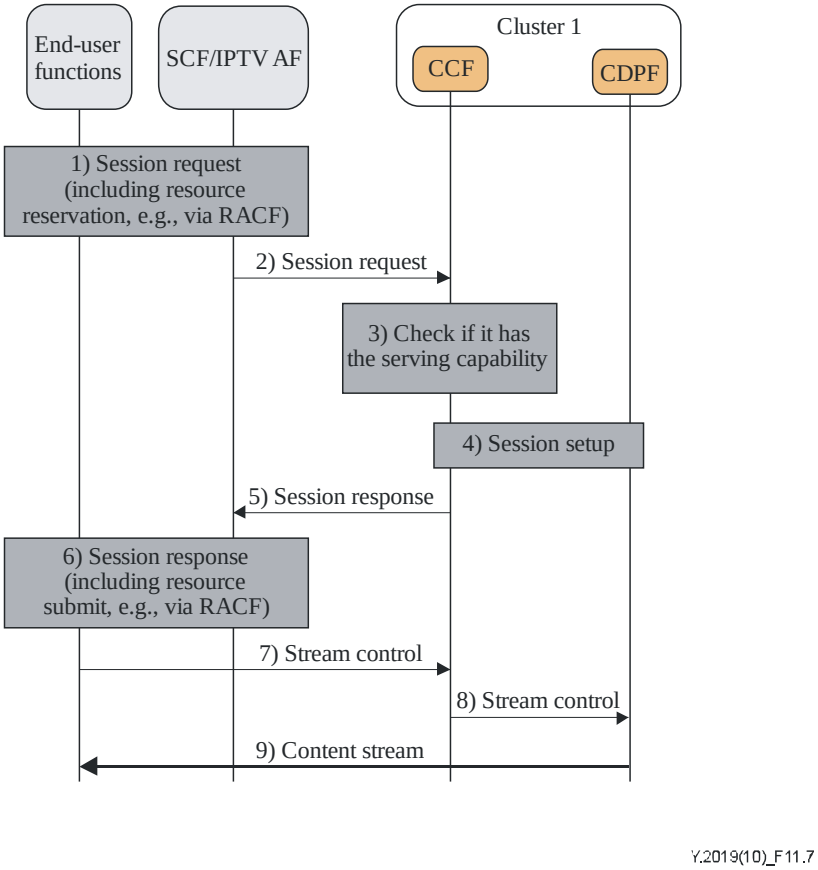


Figure 11-7 – Case 1, Content available in cluster 1

The procedure shown in Figure 11-7 contains the following steps:

1) the procedure is triggered by an action from the end-user. The end-user requests content from the IPTV AF which results in a unicast session request from end-user functions to the SCF;
2) the SCF forward the service session request to the CCF of cluster 1;
3) the CCF of cluster 1 check if they have the serving capability (e.g., if the requested content is available in the cluster, if the load in cluster 1 is below a given threshold, etc.);
4) if cluster 1 can supply the content, the CCF send a session request to the appropriate CDPF and establish a content delivery session;
5) the content delivery session identification is returned through the service session setup response to the SCF;
6) the SCF forward the service session response to the end-user functions. Reserved resources are allocated in this step (e.g., via RACF as specified in [ITU-T Y.2111]);
7) stream control requests generated by the end-user functions are sent to the CCF of cluster 1;
8) the CCF of cluster 1 cache the stream control requests to the appropriate CDPF;
9) the CDPF stream the media directly to the end-user functions.

11.2.4.1.2 Case 2-1: Content not available in cluster 1 and direct streaming from cluster 2

Figure 11-8 describes the procedure where cluster 1 cannot serve the end-user, whereas cluster 2 is able to serve the end-user.

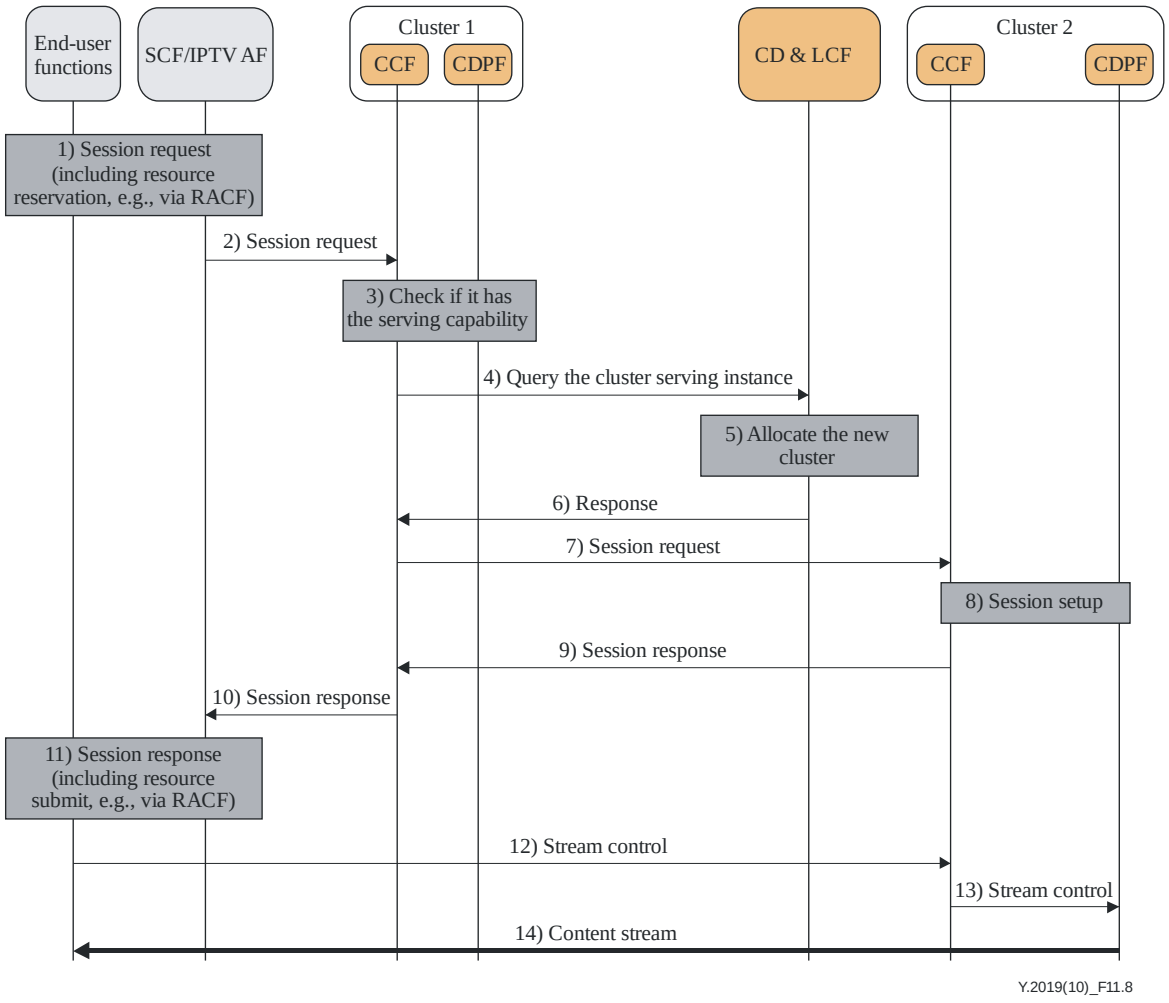


Figure 11-8 – Case 2-1, Content not available in cluster 1 and direct streaming from cluster 2

The procedure shown in Figure 11-8 contains the following steps:

1) the procedure is triggered by an action from the end-user. The end-user requests content from the IPTV application function which results in a unicast session request from the end-user functions to the SCF;
2) the SCF forward the service session request to the CCF of cluster 1;
3) the CCF of cluster 1 check if they have the serving capability (e.g., if the requested content is available in the cluster, if the load is below a given threshold, etc.);
4) if cluster 1 cannot supply the content, the CCF of cluster 1 send a query request to the CD&LCF in order to find an alternative cluster able to serve the end-user functions;
5) the CD&LCF select an alternative cluster (referred to as cluster 2), which is capable of serving the end-user for the content. The selection follows policies such as those based on priorities or on the cluster status and/or load (e.g., number of outgoing streams), etc.;
6) the CD&LCF return cluster 2 address to the CCF of cluster 1;
7) the CCF of cluster 1 send the service session request to the CCF of cluster 2;
8) the CCF of cluster 2 send the session request to the appropriate CDPF of cluster 2 and establish the content delivery session;
9) the content delivery session identification is returned through the service session setup response to the CCF of cluster 1;
10) the CCF of cluster 1 send the service session setup response to the SCF;
11) the SCF forward the service session response to the end-user functions. Reserved resources are committed in this step;
12) stream control requests generated by the end-user functions are targeted to the CCF of cluster 2;
13) the CCF cache the stream control requests to the appropriate CDPF within cluster 2;
14) the CDPF in cluster 2 stream the media directly to the end-user functions.

NOTE – Steps 1 and 11 correspond to service control procedures (refer to [ITU-T Y.1910] for further guidance).

11.2.4.1.3 Case 2-2: Content not available in cluster 1 and streaming from cluster 2 through cluster 1

Figure 11-9 describes the procedure where cluster 1 does not contain the requested content although the load of cluster 1 is enough to serve the end-user. In this procedure, an alternative cluster supplies cluster 1 with the requested content.

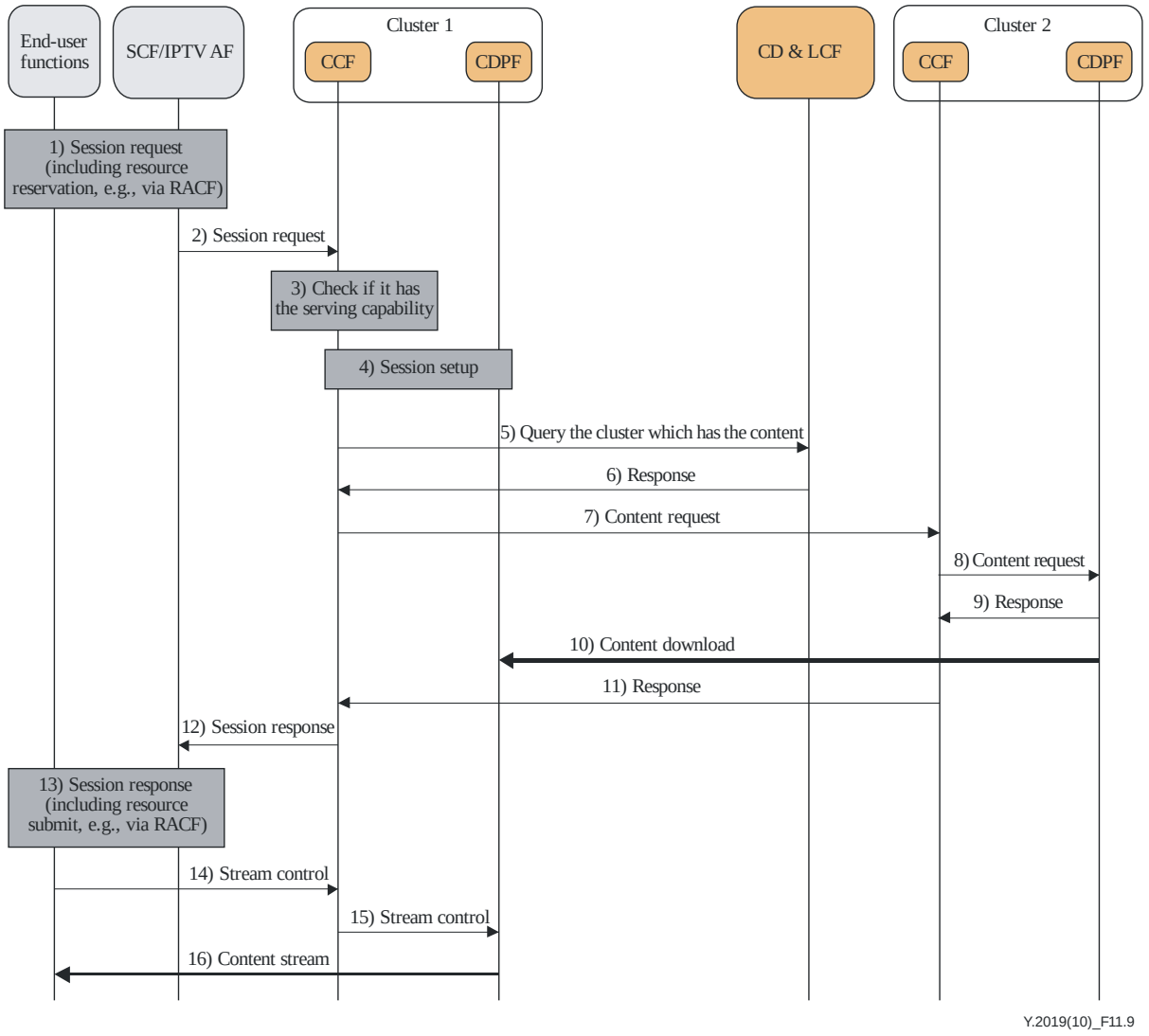


Figure 11-9 – Case 2-2, Content not available in cluster 1 and streaming from cluster 2 through cluster 1

The procedure shown in Figure 11-9 contains the following steps:

1) the sequence is triggered by an action from the end-user. The end-user requests a content from the IPTV AF which results in a unicast session request from the end-user functions to the SCF;
2) the SCF forward the service session request to the CCF of cluster 1;
3) the CCF of cluster 1 check if they have the serving capability (e.g., if the request content is available in cluster 1 and if the load does not reach a given threshold, etc.);
4) the CCF of cluster 1 send the session request to the appropriate CDPF within cluster 1 and set up the content delivery session;
5) the CCF of cluster 1 send the query request to the CD&LCF to select a cluster(s) which has the requested content. Hereinafter, the selected cluster is referred to as cluster 2;
6) the CD&LCF send the query result to the CCF of cluster 1;
7) the CCF of cluster 1 send the content request to the CCF of cluster 2 to ask for the requested content;
8) the CCF of cluster 2 send the request to an appropriate CDPF within cluster 2 for the requested content;

9) the selected CDPF of cluster 2 send an acknowledgement back to the CCF of cluster 2;

10) the CDPF of cluster 2 download the requested content to cluster 1 (to the previously selected CDPF within cluster 1);

11) the CCF of cluster 2 respond to the CCF of cluster 1 to notify that the requested content has been supplied to cluster 1;

12) the CCF of cluster1 send a service session setup response to the SCF;

13) the SCF forward the service session response to the end-user functions. Reserved resources are committed in this step (e.g., via RACF as specified in [ITU-T Y.2111]);

14) stream control requests generated by the end-user functions are targeted to the CCF of cluster 1;

15) the CCF of cluster 1 cache the stream control requests to the appropriate CDPF;

16) the CDPF stream the media directly to the end-user functions.

NOTE 1 – Steps 1 and 13 correspond to service control procedures (refer to [ITU-T Y.1910] for further guidance).

NOTE 2 – Step 10 allows to cache enough content in cluster 1 before content is streamed in step 16.

11.2.4.2 Multicast-based content delivery procedure

The procedures in this clause cover optional requirement R11 (see clause 8.2).

11.2.4.2.1 Network multicast-based content delivery procedure

Figure 11-10 shows the procedure for multicast-based content delivery procedure when CDPF serves as linear TV relay or linear TV multicast for multicast service (e.g., user generated content service, linear TV service).

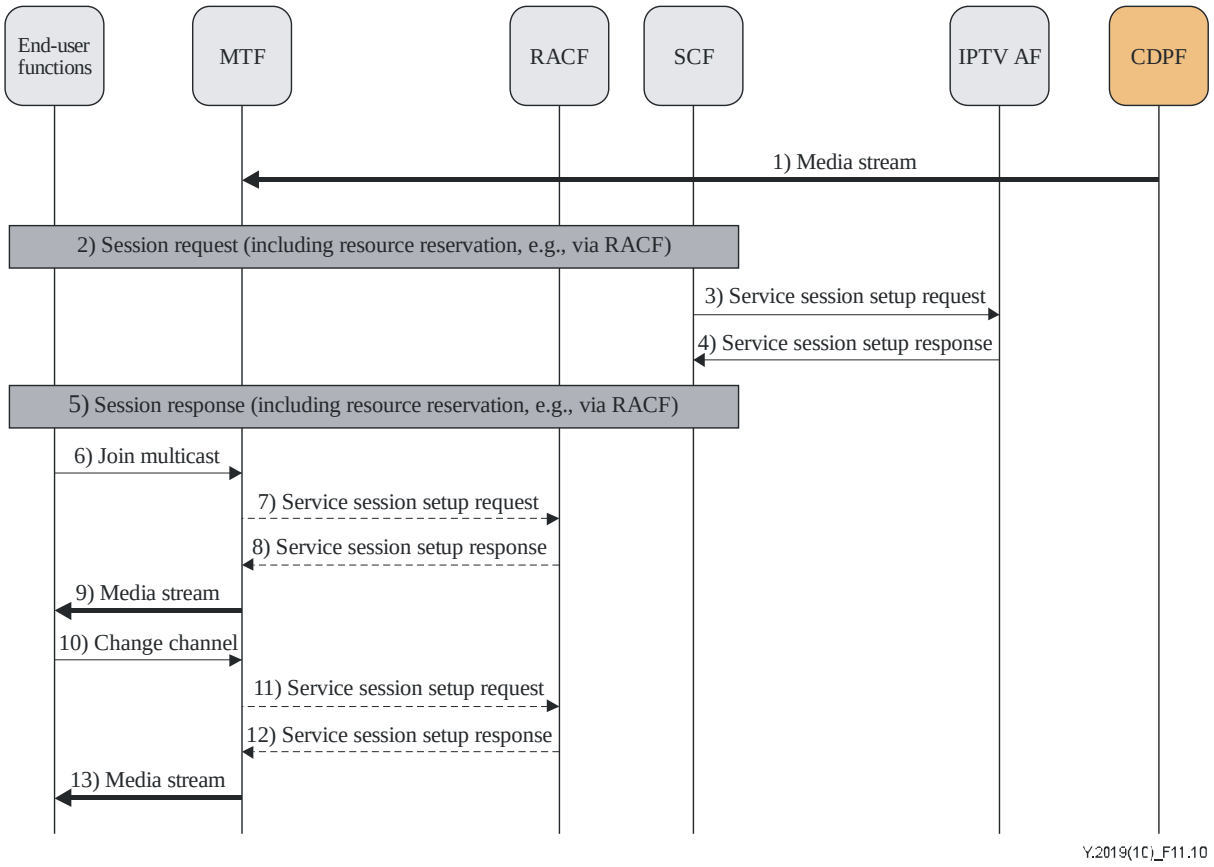


Figure 11-10 – Network-based multicast procedure

1) the CDPF relay the multicast stream to the MTF. MTF include a multicast control point functional block (McCP-FB) and a multicast replication functional block (McR-FB), as defined in [ITU-T Y.1910];

2) the end-user functions send a service session setup request to the SCF, including a media offer for the scheduled content service. The SCF reserve transport resources according to the media offer;

3) the SCF forward the request to the IPTV AF, which check that the user is authorized for the service and has the rights to consume the content;

4) the IPTV AF reply to the SCF with the bandwidth required for the specific scheduled content and can optionally retrieve other parameters;

5) if the media offer has changed or new parameters are received, the SCF request admission control. Then the service session setup response is forwarded to the end-user functions;

6) the end-user functions send a request to the MTF to join the multicast channel in order to view the content;

7-8) an interaction between the MTF and RACF occurs in order to guarantee the needed bandwidth and QoS for the channel. This may happen in different cases, for example, when the multicast channel is not present at network access node to which the user is connected, or when end-user functions wish to join a multicast channel with different QoS requirements (e.g., zapping from a standard definition to a high definition channel);

9) the media stream is forwarded to the end-user functions;

10) the end-user functions send a request to the MTF to change the channel, i.e., join another multicast channel;

11-13) the procedures are identical to those of steps 7-9.

11.2.4.2.2 Multicast within cluster-based content delivery procedure

When the network is not multicast capable, the CDPF can optionally also support similar functions such as multicast transport functions (MTF). In this case, the end-user functions interact with the CDPF to join the multicast channel.

Figure 11-11 describes multicast within cluster-based content delivery procedure.

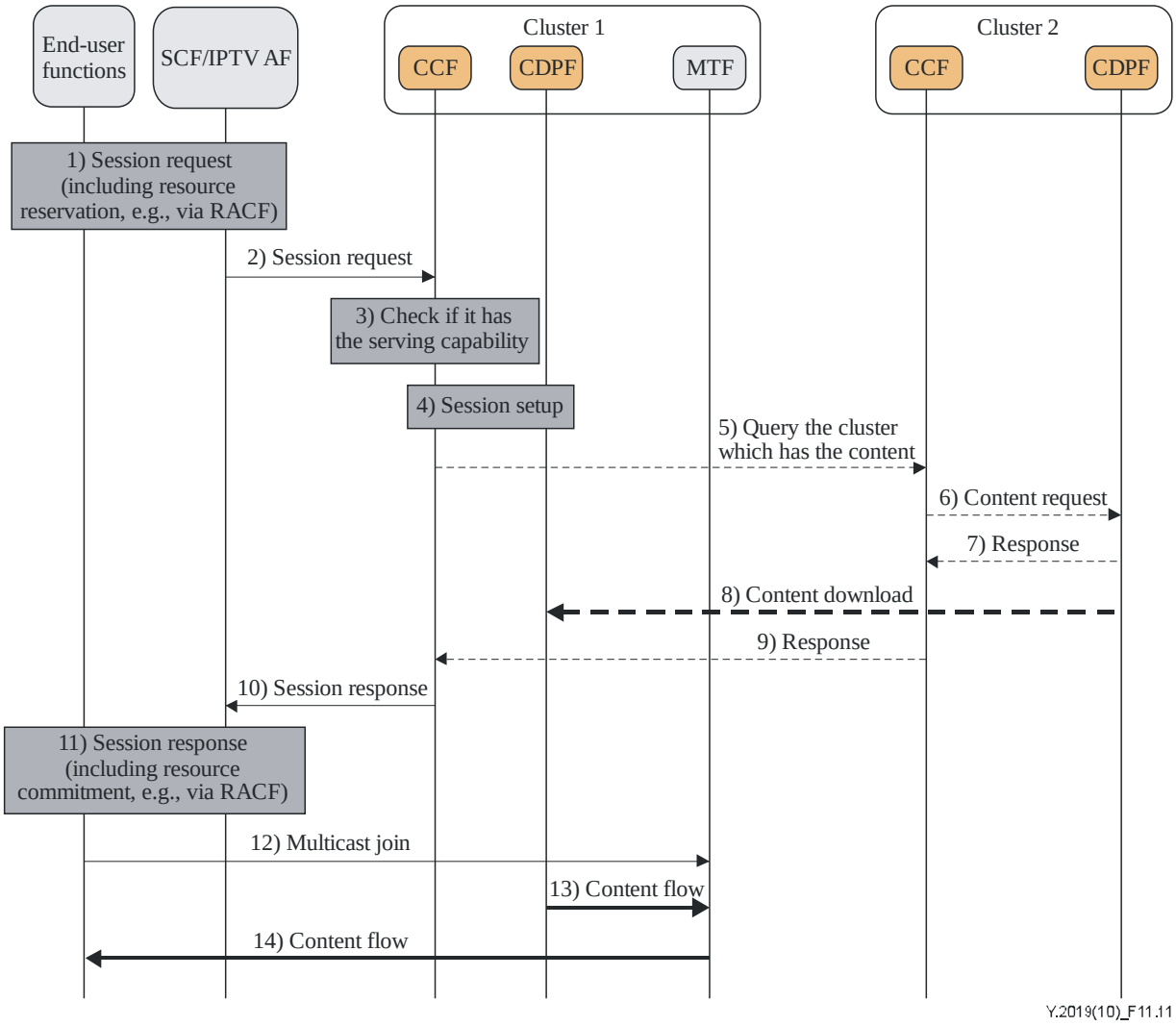


Figure 11-11 – Content delivery based multicast procedure

NOTE 1 – It is assumed that multicast transport functions (MTF) are located in cluster 1. The MTF is an entity in the transport stratum which can optionally be located inside or outside of cluster 1, depending on the implementation choice. MTF include a multicast control point functional block (McCP-FB) and a multicast replication functional block (McR-FB), as defined in [ITU-T Y.1910].

NOTE 2 – In Figure 11-11, cluster 1 may or may not have the requested content and it is delivered to end-users by means of multicast mechanism.

1) the sequence is triggered by an action from the end-user. The end-user requests the content from the IPTV AF which results as a multicast session request from the end-user functions to the SCF;
2) the SCF forward the service session request to the CCF of cluster 1;
3) the CCF check if they have the serving capability e.g., if the requested content exists in cluster 1;
4) the CCF of cluster 1 send the session request to the appropriate CDPF of cluster 1 and set up the content delivery session;
5) the CCF of cluster 1 send the query request to the CCF of cluster 2 to supply the requested content;
6) the CCF of cluster 2 send the request to the appropriate CDPF of cluster 2 for the requested content;
7) the CDPF of cluster 2 send an acknowledgement to the CCF of cluster 2;

8) the CDPF of cluster 2 download the requested content to the CDPF of cluster 1;

9) the CCF of cluster 2 notify the CCF of cluster 1 that the requested content has been supplied;

10) the CCF of cluster 1 send the service session setup response to the SCF;

11) the SCF forward the service session response to the end-user functions. Reserved resources are committed in this step;

12) the end-user joins the multicast channel;

13-14) the content stored in cluster 1 is delivered to the end-user functions through the multicast channel.

11.2.5 Procedures of user created content (UCC) upload and delivery

The procedures cover optional requirement R10 (see clause 8.2).

11.2.5.1 Procedure for UCC upload

Figure 11-12 describes the procedure of user created content upload.

NOTE 1 – As an alternative to the procedure described in this clause, user created content (UCC) can be handled and delivered the same way as content provided by content provider functions, the user playing the role of a content provider [ITU-T Y.1910]. In such a scenario, UCC will be first handled by application functions, e.g., for content preparation functions (for further checking or processing by the IPTV service provider). Procedures defined for content ingestion (see clause 11.2.1), content dispatching (see clause 11.2.2), content aging (see clause 11.2.3) and content delivery (see clauses 11.2.4.1 and 11.2.4.2) will then be reused for UCC distribution and delivery.

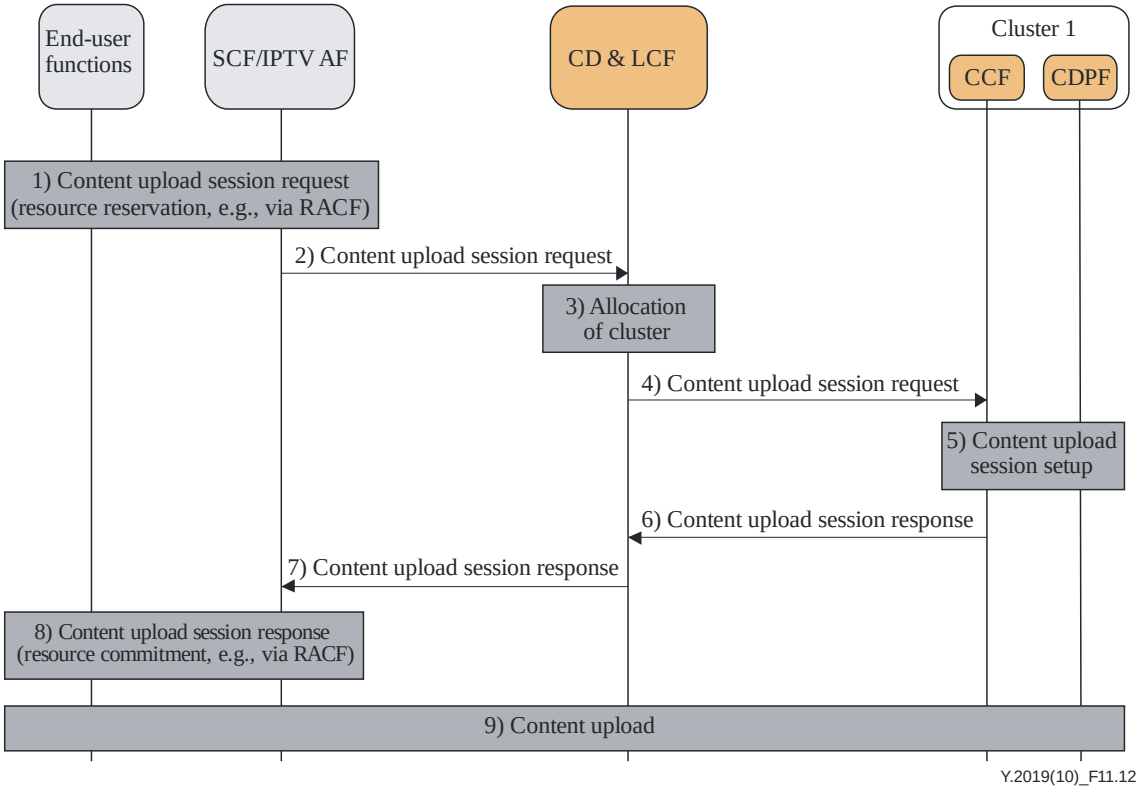


Figure 11-12 – UCC upload procedure

1) the sequence is triggered by an action from the end-user. The end-user requests the upload of content by means of a content upload session request from end-user functions to the SCF/IPTV AF; resources are reserved, e.g., via RACF;

2) the SCF/IPTV AF forward the content upload session request to the CD&LCF;

3) the CD&LCF allocate the appropriate cluster to receive the content according to the content upload session request, depending on information such as specific geographical location, the load of the clusters;

NOTE 2 – Multiple clusters can optionally be allocated according to the content upload session request.

4) the CD&LCF send the content upload session request to the CCF of the selected cluster 1;

5) the CCF sends the content upload session request to the appropriate CDPF and set up the content upload session. The following actions are performed:

   i) the CCF send the content upload session request (e.g., RTSP DESCRIBE) to the selected CDPF;

   ii) the CDPF send the content upload session response to the CCF including information such as the storage path for the content;

   iii) the CCF set up the content upload channel (e.g., via RTSP SETUP) with the CDPF;

   iv) the CDPF confirm the establishment of the content upload session to the CCF including information such as the session identification;

   v) the CCF allocate resources according to the established content upload session;

6) the content upload session identification is returned, through the content upload session response, from CCF back to the CD&LCF;

7) the CD&LCF send the content upload session response to the SCF/IPTV AF;

8) the SCF/IPTV AF forward the content upload session response to the end-user functions. Reserved resources are committed during this step, e.g., via RACF;

9) content is uploaded by the end-user functions to the CCF according to the returned information received by the end-user functions. If content is uploaded using a streaming mode mechanism, then:

   i) the end-user functions send a content record request to the selected CCF;

   ii) the CCF send the content record request to the selected CDPF;

   iii) the CDPF send a content record response to the CCF;

   iv) the CCF send the content record response to the end-user functions. Then the CDPF record the content streamed from the end-user functions.

NOTE 3 – Steps 1 and 8 correspond to service control procedures (refer to [ITU-T Y.1910]).

11.2.5.2 Procedure for UCC delivery

The procedure for UCC delivery follows the procedures for content delivery described in clause 11.2.4.

11.2.6 Procedure of content delivery for content serving transfer

This procedure covers optional requirement R13 (see clause 8.2). The aim of content serving transfer is to maintain the quality of content delivery when the quality decreases because the end-user moves from one geographical area to another.

Figure 11-13 describes the procedure of content delivery for content serving transfer.

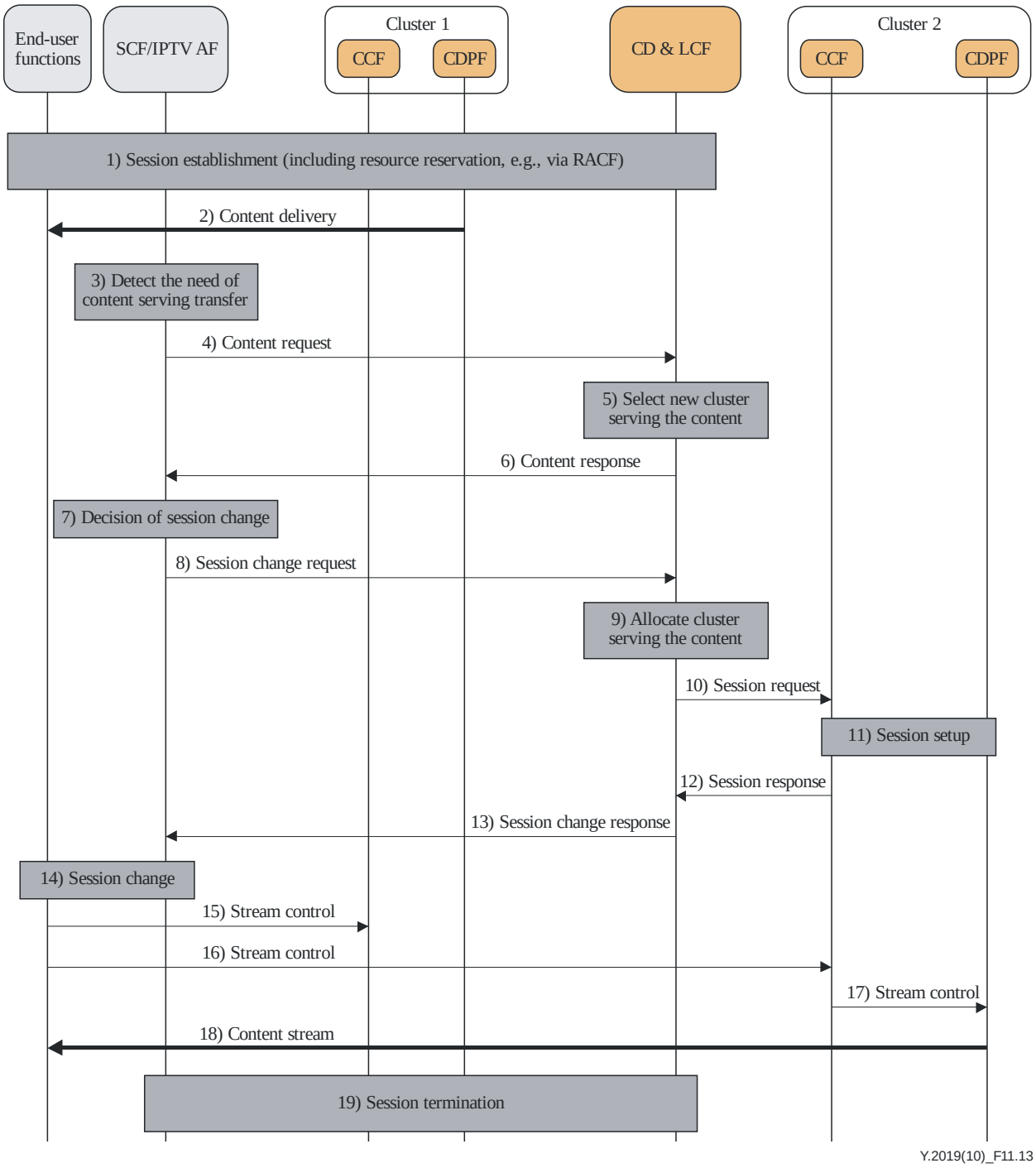


Figure 11-13 – Content delivery procedure for content serving transfer

1) initial session is established between the end-user functions and the content delivery functions; a CDPF in cluster 1 is allocated for the content delivery session;
2) the CDPF in cluster 1 stream the media to the end-user functions;
3) SCF/IPTV AF detect a potential need of content serving transfer (e.g., due to a change of the end-user location);
4) SCF/IPTV AF issue a content request to CD&LCF to request CD&LCF whether a new cluster can be allocated for the session;

5) CD&LCF select cluster 2 as a candidate cluster for content serving transfer based on some parameters (e.g., the end-user location and delivery policy);

NOTE 1 – Steps 4 and 5 allow the CD&LCF to check whether a candidate cluster is available for achieving the content serving transfer since this responsibility belongs to CD&LCF. Decision regarding the allocation of a new serving cluster is dependent upon SCF/IPTV AF subsequent decisions (see the following steps 7 and 8).

6) CD&LCF return the cluster 2 address to SCF in the content response;

7) the SCF/ IPTV AF decide whether to change the session established between the end-user functions and cluster 1;

8) if the SCF decide to change the session, they forward a session change request to CD&LCF;

9) the CD&LCF allocate the new serving cluster 2, which can optionally be one single serving cluster or multiple serving clusters with different serving priorities according to the delivery policy such as taking into account the delivery status, load (e.g., number of outgoing streams), etc.;

10) the CD&LCF send the session request to the CCF in cluster 2;

11) the CCF send the session request to the selected CDPF in cluster 2 and set up the content delivery session;

12) the content delivery session identification is returned, through the service session setup response, to the CD&LCF. Session related information between the end-user functions and cluster 1 may be delivered to cluster 2 for the new session;

13) CD&LCF send a session change response to the SCF;

14) SCF notify the status of the new session to the end-user functions. The end-user functions perform the session change involving SCF. A new service session is established between cluster 2 and the end-user functions;

15) stream control requests are generated by the end-user functions in order to terminate content delivery from cluster 1;

16) stream control requests generated by the end-user functions are targeted to the selected CCF in cluster 2;

NOTE 2 – End-user functions directly synchronize content delivered by cluster 1 and cluster 2 using stream control messages in steps 15 and 16.

17) the CCF in cluster 2 forward the stream control requests to the selected CDPF;

18) the CDPF in cluster 2 stream the content directly to the end-user functions;

19) SCF terminate the service session with the original cluster 1.

12 Security considerations

This Recommendation conforms to [ITU-T Y.2701] for security aspects. No specific security considerations have been identified.

Appendix I

Deployment model

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

I.1 Delivery deployment model

IPTV services such as linear TV, video on demand (VoD), time-shift TV and network personal video recorder (nPVR) need content delivery mechanisms in the network. There are several models for content delivery and storage: client/server model, proxy instance model and hybrid model.

- Client/server model: Media content delivers from multicast/unicast source to the end-user functions directly.
- Proxy instance model: It consists of multiple proxy instances in which the content is stored and managed for consistency. Proxy instances are required to support linear TV relay when the network cannot support multicast.
- Hybrid model: Proxy instances participate in the content delivery system as content source for caching and transfer. Proxy instances are required to support linear TV relay when the network cannot support multicast.

I.2 Client/server model

Figure I.1 shows a client/server model. This model consists of a centralized node (CDPF or multicast source) sending contents to each end-user by unicast and multicast mode. For unicast, this model is not scalable due to limited network link capacity and server load capacities. For multicast, the content is delivered to each end-user function at the same time. This model achieves scalability by using multicast transmission, as illustrated in Figure I.2. This mode is usually used when the whole network can support multicast.

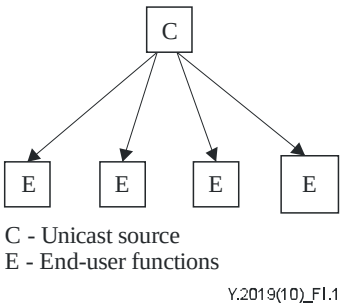


Figure I.1 – Client/server model

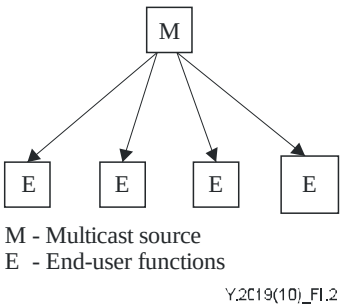


Figure I.2 – Client/server model with multicast

I.3 Proxy instance model

A proxy instance model consists of several content delivery processing functions, including origin content storage instance and proxy node. Original content storage instances (i.e., unicast or multicast content source) deliver the content to adequate proxy instances in the network, and the proxy instances cache the content. If a proxy instance receives a content delivery request from end-user functions, the proxy instance delivers the content to the end-user functions. Caching mechanisms and period depend on parameters of availability, proximity, etc.

Figure I.3 shows the proxy instance model, and when the content is delivered from content storage instance or proxy node, multicast source/relay transmission mechanisms can optionally be used, as illustrated in Figure I.4.

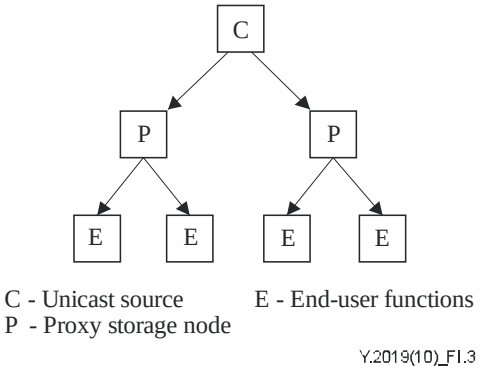


Figure I.3 – Proxy instance model

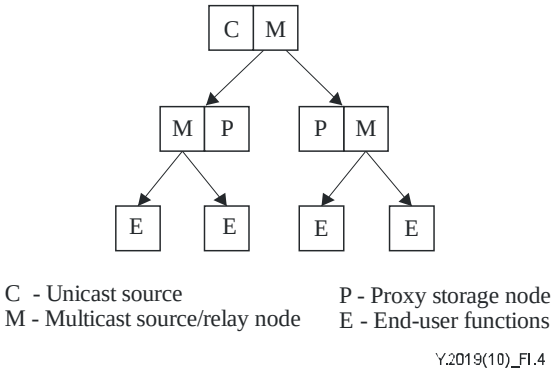
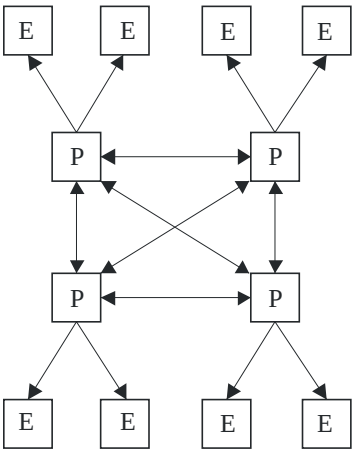


Figure I.4 – Proxy instance model with multicast

I.4 Hybrid model

Figure I.5 shows a hybrid model. The hybrid model is organized as a distributed network, using the resources of proxy instances. Proxy instances deliver totally or partially the requested content to requesting proxy instances or end-users. The end-user functions receive the content or send self-generated content. When the content is delivered from the proxy node, multicast source/relay transmission mechanisms can optionally be used, as illustrated in Figure I.6.



E - End-user functions
P - Proxy storage node

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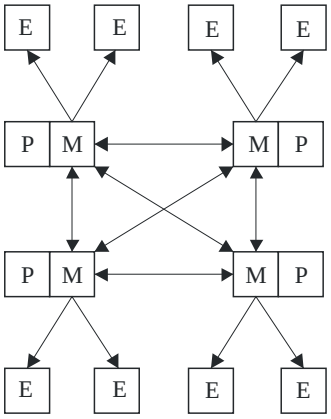
Figure I.5 – Hybrid model



E - End-user functions
P - Proxy storage node
M - Multicast source/relay node

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Figure I.6 – Hybrid model with multicast

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Printed in Switzerland
Geneva, 2011