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

Next Generation Networks – Frameworks and functional architecture models

Functional architecture for distributed service networking

Recommendation ITU-T Y.2080

International Telecommunication Union

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	**Y.2000–Y.2099**
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Numbering, naming and addressing	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.2080

Functional architecture for distributed service networking

Summary

Recommendation ITU-T Y.2080 specifies the functional architecture for distributed service networking (DSN), taking into account the requirements and capabilities for DSN as described in Recommendation ITU-T Y.2206.

The main objective of this Recommendation is to provide guidance regarding the design of networks, services and applications making use of DSN.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2080	2012-06-15	13

Keywords

Distributed service networking, DSN, functional architecture, functions, reference points.

FOREWORD

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Table of Contents

Recommendation ITU-T Y.2080

Functional architecture for distributed service networking

1 Scope

This Recommendation describes the functional architecture of distributed service networking (DSN) and its relationships with next generation networks (NGNs). This Recommendation provides a description of functions required for the support of the DSN and reference points between DSN 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.2011] Recommendation ITU-T Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.

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

[ITU-T Y.2206] Recommendation ITU-T Y.2206 (2010), *Requirements for distributed service networking capabilities*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 control plane [ITU-T Y.2011]: The set of functions that controls the operation of entities in the stratum or layer under consideration, plus the functions required to support this control.

3.1.2 distributed service networking [ITU-T Y.2206]: An overlay networking which provides distributed and manageable capabilities to support various multimedia services and applications.

3.1.3 DSN node [ITU-T Y.2206]: A node used in DSN providing distributed functionalities, including distributed routing and distributed storage.

3.1.4 functional entity [ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.5 hash function [b-ITU-T X.810]: A (mathematical) function that maps values from a (possibly very) large set of values into a smaller range of values.

3.1.6 management plane [ITU-T Y.2011]: The set of functions used to manage entities in the stratum or layer under consideration, plus the functions required to support this management.

3.1.7 overlay network [b-ITU-T Y-Sup.10]: A network of nodes and logical links that is built on top of the underlying, e.g., transport, network with the purpose of providing network service that is not available in the underlying network.

3.1.8 peer-to-peer (P2P) [ITU-T Y.2206]: A system is considered to be P2P if the nodes of the system share their resources in order to provide the service the system supports. The nodes in the system both provide services to other nodes and request services from other nodes.

NOTE – Peer is the node in a P2P system.

3.1.9 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.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 bootstrap node: The first node of the overlay network to which an enrolling node can connect.

3.2.2 buffer map: A map indicating the availability of chunks in a DSN node, which can be shared between DSN nodes.

3.2.3 chunk: A basic unit of data resulting from partitioning content into defined component parts.

NOTE – A DSN node may use a chunk as a unit of storage, advertisement and exchange among peers.

3.2.4 content delivery: In the context of the DSN functional architecture, the operation of sending and receiving content between the requested peer and the requesting peer or client.

NOTE – A client is a service consumer external to DSN. A peer is a node within DSN.

3.2.5 content distribution: In the context of the DSN functional architecture, the whole process of content sending from one or more content sources, and sharing among DSN nodes.

NOTE – During the content distribution process, content is often sent to appropriate intermediate nodes to enable subsequent delivery.

3.2.6 content ID: In the context of the DSN functional architecture, a global unique content name for identifying the content.

3.2.7 content node: A DSN node which can be used for media content distribution, storage and/or caching.

3.2.8 control node: A DSN node which provides service control functionalities.

3.2.9 distributed hash table (DHT): A hash table which is stored across a set of distributed peers.

3.2.10 hash table: A data structure that uses a hash function for mapping input values to their associated attributes. A hash function is applied to map the input values (typically a large range of them) to a smaller range of index values that are spread in an equal probability distribution in its range statistically. The resulting index values point to the tables which manage the attributes associated to the original input values.

NOTE – In a common implementation, the first step (index calculation) is installed in any nodes enquiring for the associated attributes and the second step (attribute table) is installed in a dedicated node.

3.2.11 overlay algorithm: An algorithm which forms and maintains a topology of interconnections among the peers, and determines the peers for storing a particular piece of data in the overlay (i.e., independent from the underlying network) and locates the peers in order to find a piece of data.

3.2.12 relay node: A DSN node which relays data packets in order to improve node reachability and QoS by changing the original route of the packets. The data can be voice data, video data, etc.

3.2.13 resource: In the context of the DSN functional architecture, data or an instance of service logic residing in DSN nodes. A resource in DSN is accessible by authorized DSN nodes only.

NOTE 1 – Examples of resource in DSN include user profile data, content, relay, session control or other service capability.

NOTE 2 – In the DSN environment, resources can have multiple replicas residing in different DSN nodes.

3.2.14 user profile: In the context of the DSN functional architecture, a collection of information that specifies the subscribed services and access privileges related to a DSN service user. The data in the user profile is called user profile data.

NOTE – A user profile may include the following attributes: user ID and other data related to authentication and authorization, user preferences, service status, service class, usage and/or contribution information, or subscriber accounting characteristics, etc.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AF Application Function

CDF Content Delivery Function

CPU Central Processing Unit

CSAF Content Service Application Function

DHT Distributed Hash Table

DSN Distributed Service Networking

EF End-user Function

ID Identifier

MF Management Function

NAT Network Address Translation

NEF Node Enrolment Function

NGN Next Generation Network

P2P Peer-to-Peer

PSTN Public Switched Telephone Network

RF Relay Function

RLF Resource Location Function

SCF Service Control Function

TOCF Traffic Optimization Control Function

UE User Equipment

5 Conventions

The following conventions apply:

1) The meaning of functions is as follows.

functions: In the context of the DSN functional architecture, "functions" are defined as a functional group composed of functional entities. It is represented by the following symbol:

2) In this Recommendation:

The keywords "**is required to**" and "**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 adherence to this requirement need not be present to claim conformance.

The keywords "**can optionally**" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term means the vendor may not choose to provide the feature (and an operator may choose not to offer it) but still claim conformance with the Recommendation.

In the main body of this Recommendation and its annexes, the words "shall", "shall not", "should", and "may" sometimes appear, in which case they are to be interpreted, respectively, as "is required to", "is prohibited from", "is recommended" and "can optionally". The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

3) In this Recommendation:

DSN network means the network constructed based on DSN.

DSN service means the service provided by the DSN network.

DSN service provider means service provider that makes use of the DSN network in order to provide services and applications to its users.

6 Characteristics of the DSN functional architecture

In a DSN environment, resources, including data and instances of service logic, are distributed throughout the whole network. In addition, DSN nodes may or may not be active at any given time.

The DSN functional architecture supports the following characteristics.

- Multiple services: The DSN functional architecture supports the capabilities to construct an overlay network for each service. DSN nodes participating in the same service constitute an overlay network. A DSN node may participate in more than one overlay network.
- Dynamic self-organization of nodes: The DSN functional architecture provides mechanisms that ensure the stability and robustness of DSN service by supporting self-organization by the DSN nodes even when a node providing a resource or service joins or leaves the DSN network.
- Distributed resource management: The DSN functional architecture defines capabilities to locate, manage and utilize the distributed resources which are spread across the DSN network.
- Traffic optimization: The DSN functional architecture provides functions for network status monitoring and reporting, which supports traffic optimization. Traffic optimization is based on the monitored network information and the policies of the DSN service provider.

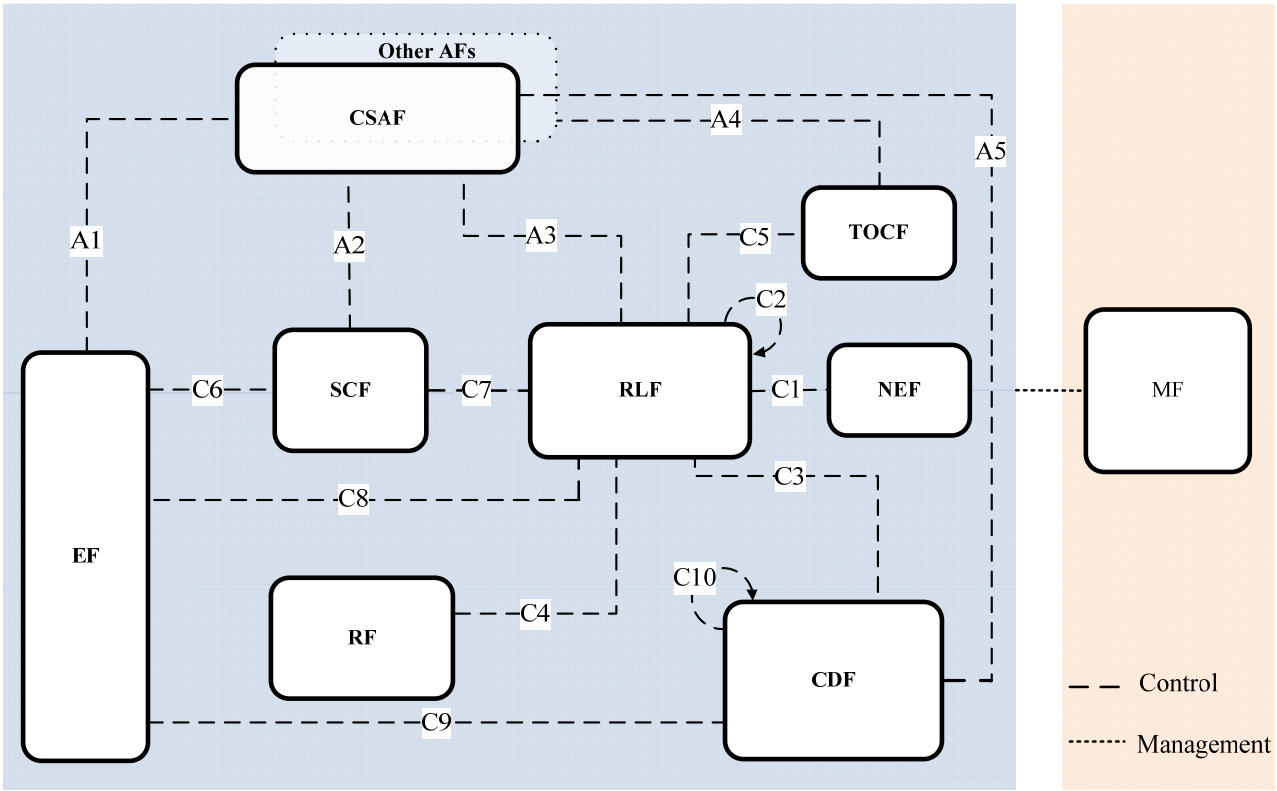
Implementing the DSN functional architecture is beneficial for avoiding single points of failure, deploying resources to optimal locations and utilizing the capabilities of various nodes, including user DSN nodes.

7 DSN functional architecture

This clause describes the DSN functional architecture by defining its functions and their logical interfaces called "reference points". The reference points are required to support both resource management, including resource location and selection, and traffic optimization, which is required to maintain the quality of service. Clause 7.1 describes the functions of the DSN functional architecture while clause 7.2 provides details about relevant reference points of the DSN functional architecture. The relationship of the DSN functional architecture with the NGN functional architecture can be found in Annex A, while detailed information flows explaining how to use the DSN functions and reference points are provided in Appendix I.

7.1 DSN architectural functions

Figure 7-1 shows the functions and reference points of the DSN functional architecture.



NOTE – This figure shows the interfaces for the control plane only. Media data transmission and transmission control are conducted through media interfaces depicted in Figure A.1.

Figure 7-1 – DSN functional architecture

As shown in Figure 7-1, the DSN functional architecture covers functions in the control plane and management plane.

The DSN functional architecture consists of several functions that interwork to provide DSN related services and capabilities. These functions include:

– node enrolment functions (NEFs);

– resource location functions (RLFs);

– relay functions (RFs);
– content delivery functions (CDFs);
– traffic optimization control functions (TOCFs);
– service control functions (SCFs);
– end-user functions (EFs);
– management functions (MFs);
– application functions (AFs).

This Recommendation only specifies the content service application functions (CSAFs), which is one kind of AF.

The descriptions of these DSN functions are provided in the following subclauses.

7.1.1 Node enrolment functions (NEFs)

When DHT is used to construct a DSN network, every DSN node is required to enrol in the DHT-based DSN network. In the DHT-based DSN network, the NEF checks the validity of the enrolling DSN node, provides initial configuration information for the DSN node and tracks the registered DSN node.

NOTE – In some service scenarios, the DSN node can join a DSN network which is not based on DHT, so it does not need to interact with the NEF. In content service, for example, only resource registration of content is needed. Enrolment for a DSN network which is not based on DHT is implementation specific and not specified in this Recommendation.

NEF allocates a globally unique node ID to each enrolling DSN node, provides bootstrap information for the DSN node to join to the DHT-based DSN network, and maintains the node profile.

NEF performs the following functions.

- Authenticate and authorize a new enrolling DSN node for the DHT-based DSN network. The NEF then establishes the identity and starts a profile of the enrolling node in the DHT-based DSN network.
- Assign a globally unique node ID to the enrolling DSN node. The ID value may be at random, based on the physical location of the node or based on the load situation of DHT-based DSN network. The node ID describes the logical position of the DSN node in the DHT-based DSN network and the resources it is responsible for.
- Configure the enrolling node with parameters and information for enrolling the DHT-based DSN network, including the algorithm for network construction and maintenance, and the position of the bootstrap node.

7.1.2 Resource location functions (RLFs)

In order to execute services, required resources residing somewhere in the DSN network must be located. The RLF maintains resource-related information and finds the required resources when enquired. RLF performs the following functions.

- Resource registration: Based on resource registration procedure activated by resource-holding DSN nodes, the RLF accepts the resource registration and maintains locations of the resources. Besides the location, the RLF stores resource information reported during registration.

  NOTE 1 – Resource location is the DSN node ID or address where the required resource resides.

  NOTE 2 – Resource information is the meta-data of the resource.
- Resource locating: Resource locating is the procedure to find the required resource in the DSN node(s). When enquired, the RLF locates the enquired resources.

- Resource location maintenance: Resource location maintenance is the procedure to update the location of a resource when a new DSN node joins or a resource-holding DSN node leaves the DSN network.
- Resource information maintenance: Resource information maintenance is the procedure to update the resource information when there is any change.
- Node status information maintenance: Node status information maintenance is the procedure to record status of the DSN nodes which have resources registered in the RLF.
- Retrieve optimization information from the TOCF for optimal resource selection in the RLF.
- Provide candidate node list to the TOCF for optimal resource selection in the TOCF.

  NOTE 3 – Optimal resource selection can be executed either in the RLF or in the TOCF.

7.1.3 Relay functions (RFs)

When a DSN node or UE is behind a NAT/firewall or is affected by traffic overloads, it may not be able to use or provide DSN services. In order to handle such cases, the DSN functional architecture is required to provide functions for NAT/firewall traversal or redirection to avoid the congested point of the network. The RF relays particular application traffic for the DSN nodes to achieve NAT/firewall traversal and QoS improvement.

RF performs the following functions.

- NAT or firewall traversal: The RF can be used for traversing the NAT and firewall. DSN nodes and UE can send and/or receive packets over NAT/firewalls using intermediate DSN nodes with the RF.
- Traffic relay: The RF relays traffic for DSN nodes and UE when a direct data path does not provide the required QoS.
- Relay node status monitoring and report: The RF maintains status information of the relay node in which it resides for further reporting to the RLF.

  NOTE 1 – Status information includes CPU usage, memory usage, disk usage, network interface usage, etc.
- Event monitoring and report: The RF reports event related information (e.g., the node status) to the RLF when an event occurs.

  NOTE 2 – Examples of events monitored by the RF include the case where the load of the relay node in which the RF resides reaches a given threshold.
- Flow monitoring and report: The RF maintains and reports the flow statistics information of the relay node in which the RF resides to the management functions (MFs) for accounting or node/resource contribution statistics.

7.1.4 Content delivery functions (CDFs)

CDF stores, processes, and delivers content to DSN nodes or UE. It performs the following functions.

- CDF caches, stores and processes (e.g., transcoding, encryption) content.
- CDF delivers content to other CDFs or end-user functions (EFs).
- CDF initiates content registration to the RLF.
- CDF maintains and reports content related information to the RLF (which includes but is not limited to: content availability, content popularity, etc.).
- CDF requests the RLF for content location information when it needs to pull content from other CDFs.
- CDF provides buffer map information to other CDFs and EFs.

- CDF supports content access check.

  NOTE 1 – Access check means verifying whether the content requestor has the authority to download the content.
- CDF provides content chunking and reassembly of chunks.
- CDF provides integrity check and error recovery in content delivery.
- CDF provides delivery of content with flow control.
- CDF maintains status information of the content node in which it resides to be reported to the RLF.

  NOTE 2 – Status information includes: CPU usage, memory usage, disk usage, network interface usage, etc.
- CDF reports event related information (e.g., the node status) to the RLF when an event occurs.

  NOTE 3 – Examples of events include that the load of the content node in which the CDF resides reaches a given threshold.
- CDF optionally maintains and reports the flow statistics information to the MF for accounting or contribution statistics.

7.1.5 Traffic optimization control functions (TOCFs)

TOCF monitors and analyses network information and provides guidance to DSN nodes in order to make the delivery and distribution of application traffic in the DSN network more efficient and cost-effective.

TOCF performs the following functions:

- network information (including topology and traffic information) collection;
- traffic policy enforcement;
- provides location service to the DSN nodes (DSN nodes can query the TOCF about its geographic location in the network. DSN nodes can also query the TOCF for its network topology information, when necessary);
- provides network topology and traffic related information to the RLF and CSAF;
- provides preferred DSN node(s) from a set of candidate nodes that provide desired services (the TOCF provides a ranking service of DSN nodes based on the traffic information or topology information for traffic optimization; candidate nodes are provided by the RLF);
- provides specific traffic event notification function (the applications can subscribe to specific events such as the change of access bandwidth).

7.1.6 Management functions (MFs)

In order to use resources more efficiently and to manage services based on DSN, management functions for the DSN network and for the DSN service are needed. The MF inherits the functions of the MF in [ITU-T Y.2012], including:

- fault management;
- configuration management;
- accounting management;
- performance management;
- security management.

Specifically, the MF performs the following functions:

- records the statistics and accounting information generated by the RF and CDF which relates to usage and contribution of DSN services;

- supports scalable network management;

  NOTE 1 – The DSN network may contain tens of thousands of network entities in a single administrative domain and the number of network entities may continuously increase after initial deployment. This requires a scalable and distributive design of the MF in the DSN. The capacity of the MF should increase as the network size increases.

- minimizes the impact of DSN node churn;

  NOTE 2 – DSN nodes may frequently join and leave the DSN network. Maintaining long-term links from the MF to every DSN node becomes impossible. Therefore, a mechanism for dynamically setting up relationships between DSN nodes and the MF is needed. The mechanism enables the MF to discover the right DSN node and the DSN node to discover the right MF when a given management task needs to be performed. Furthermore, ungraceful leave (i.e., leave without normal leaving procedure) of DSN nodes may incur management information inconsistency. Thus, the management information should be stored in multiple MF/DSN nodes and synchronized when DSN nodes leave or join the DSN network.

- supports the redistribution of resources and functions.

  NOTE 3 – DSN resources and network functions are no longer tied to specific nodes. Resources may move between DSN nodes and the role of a DSN node may change dynamically. Therefore, management tasks may need to be attached to the target resource or functions instead of specific DSN nodes so that management tasks can move with the resources or functions between different DSN nodes.

7.1.7 Service control functions (SCFs)

In the DSN, the SCF defined in NGN architecture [ITU-T Y.2012] is reused for service control.

NOTE – the DSN SCF interacts with DSN functions which are not defined in [ITU-T Y.2012] for resource location, application support, etc. The specification of reference points between the DSN SCF and other DSN functions may not be identical to that of the NGN.

7.1.8 End-user functions (EFs)

EF is a function of the DSN UE, which supports access to a DSN network and service.

NOTE – Besides the EF, UE may include other functions, such as the CDF and RF. When UE provides the capabilities of those functions, the contribution of the UE to the DSN network may be recorded and taken into account in the accounting. Which functions UE can support depends on the capability of the UE and the decision of the end user and DSN service provider. Refer to Appendix II for further information.

7.1.9 Content service application functions (CSAFs)

CSAF is an application function responsible in the DSN functional architecture for the provision of content-related services to the EF.

NOTE 1 – As shown in Figure 7-1, AFs different from the CSAF can be defined in the future for the provision of services other than content-related services.

CSAF performs the following functions:

- executes service logic based on the user profile and other information such as terminal capability, etc.;
- interacts with the SCF for user authentication and service authorization;
- interacts with the RLF to locate content resources for UE/applications;
- enables the EF to discover, select and purchase content;
- content preparation, which includes content naming, advertisement insertion, content slicing, trans-coding, encryption, etc.;
- pushes content to CDFs for distribution.

NOTE 2 – The CSAF pushes content to the root CDF. After content pushing, content can be distributed from the root CDF to other CDFs or end users.

7.2 Reference points

NOTE – Procedures described in this clause are intended to help the reader better understand the DSN functional architecture and the use of the reference points. The information flows are intended to be protocol agnostic, i.e., independent of any particular protocols.

7.2.1 Reference point C1

The C1 reference point is between the NEF and RLF.

This reference point is used by the RLF to request enrolment of a DSN node in which the RLF resides in the DHT-based DSN network.

This reference point is used by the NEF to provide configuration and bootstrap information to the RLF regarding a DSN node that newly joins the DHT-based overlay in the DSN network.

NOTE – The configuration information may contain the algorithm for the DHT-based overlay construction and maintenance. The bootstrap information may contain the location (for instance, IP address) of the bootstrap node.

Figure 7-2 shows the general procedures of a DSN node (with the RLF) enrolling to the DHT-based overlay.

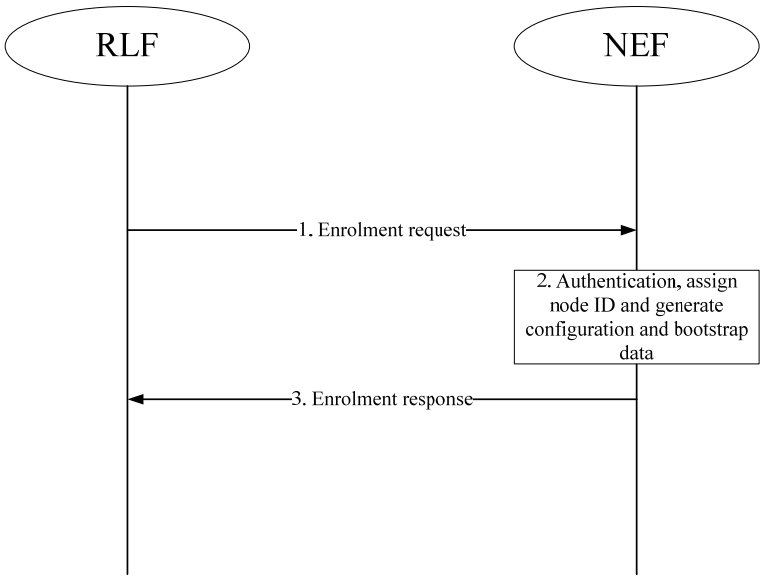


Figure 7-2 – DSN node (with the RLF) enrolling to the DHT-based overlay

Steps shown in Figure 7-2 are as follows.

1. RLF sends an enrolment request to the NEF. The enrolment request contains the identification of the requestor and information by which the NEF can authenticate the requestor.
2. NEF authenticates the RLF and assigns the node ID for the node in which the RLF resides. It also generates the configuration and bootstrap information for the RLF.
3. NEF returns the configuration and bootstrap information in the enrolment response to the RLF.

7.2.2 Reference point C2

The C2 reference point is between RLFs.

This reference point is used to exchange the information that constructs and maintains the DHT-based overlay in the DSN network.

This reference point is also used to forward resource location requests or resource location update requests to RLFs.

Figure 7-3 shows the general procedure for constructing and maintaining the overlay network. This procedure is mainly used in the DHT-based overlay formed by the RLF.

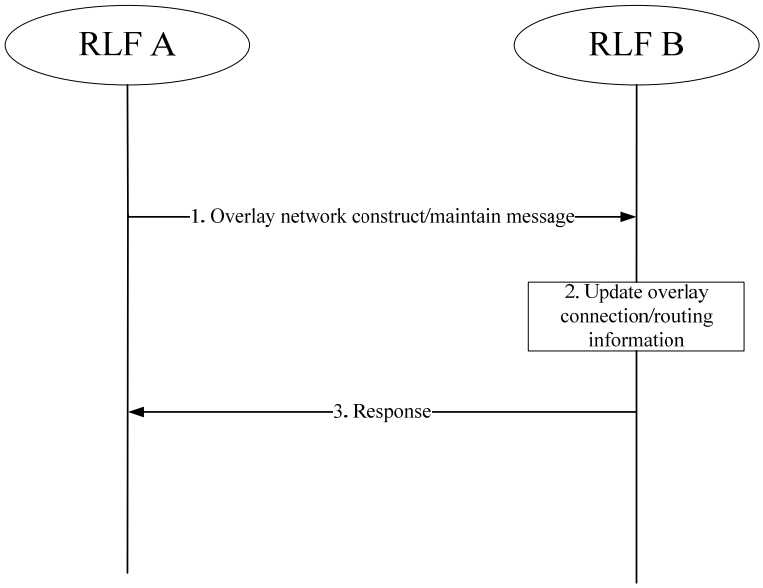


Figure 7-3 – Exchanging information to construct and maintain the overlay

Steps shown in Figure 7-3 are as follows.

1. RLF A sends an overlay construct message (for instance, join, leave, connection messages) or an overlay maintain message (for instance, update messages) to RLF B. The selection of RLF B depends on the type of the message and on the overlay algorithm in use.
2. RLF B updates the overlay routing or connection information accordingly.
3. RLF B sends a response message to RLF A for acknowledgement.

Figure 7-4 shows the procedure for exchanging information between different RLFs to update resource location information.

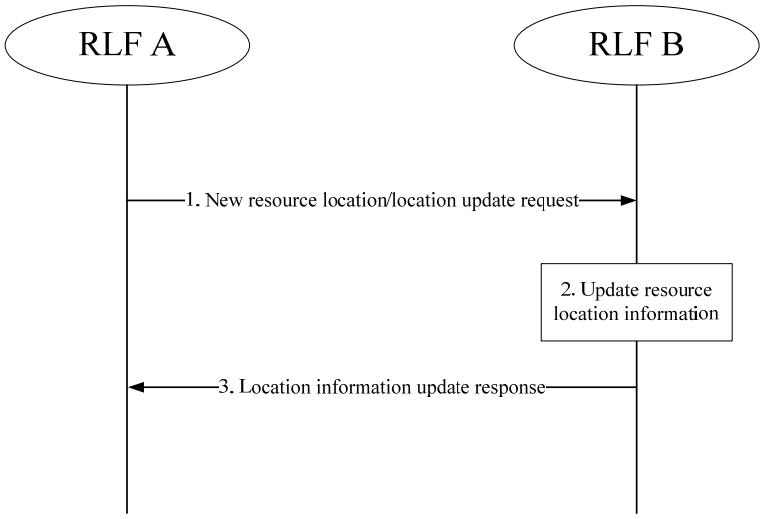


Figure 7-4 – Exchanging information to update resource location

Steps shown in Figure 7-4 are as follows.

1. RLF A sends a new resource location information message or a resource location update message to RLF B.
2. RLF B updates the resource location information.
3. RLF B sends a response message to RLF A to indicate the location information update result.

Figure 7-5 shows the procedure of an RLF sending a resource location request message to another RLF.

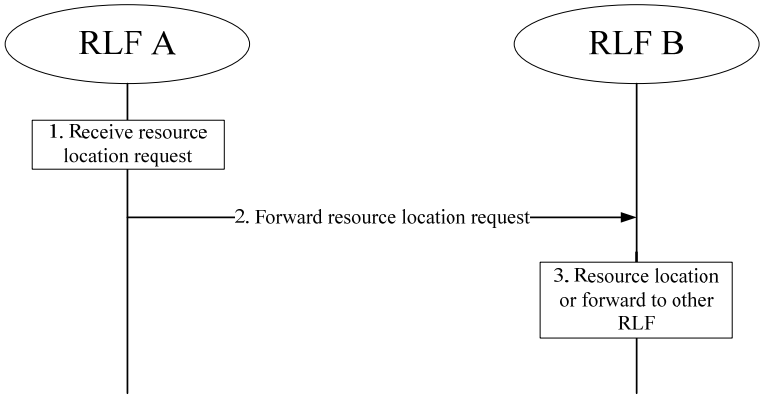


Figure 7-5 – RLF sending a location request message to another RLF

Steps shown in Figure 7-5 are as follows.

1. RLF A receives resource-locating request, and the location information of the requested resource is not stored in RLF A.
2. RLF A forwards the resource-locating request to RLF B. In the DHT-based environment, RLF B resides in the next hop node.

   NOTE – In the DHT-based environment, to arrive at a destination, one message needs to pass one or more nodes decided by the DHT routing algorithm; the next hop node is the node to which the message will be sent from the node it is now residing in.
3. RLF B looks up the resource location information; if RLF B stores the information, it will respond to the requestor with the location information; if RLF B does not store the information it will forward the locating request to another RLF.

7.2.3 Reference point C3

The C3 reference point is between the RLF and CDF.

This reference point is used by the CDF:

– to register content to the RLF;
– to request the RLF for content location information;
– to report to the RLF the status of a node in which the CDF resides; the status information includes: CPU usage, memory usage, disk usage and network interface usage, etc.;
– to report event related information to the RLF, for instance, the event may be that the load of the node in which the CDF resides reached threshold;
– to report content related information to the RLF, for instance, the content availability or content popularity, etc.

Figure 7-6 shows the general procedure of content registration.

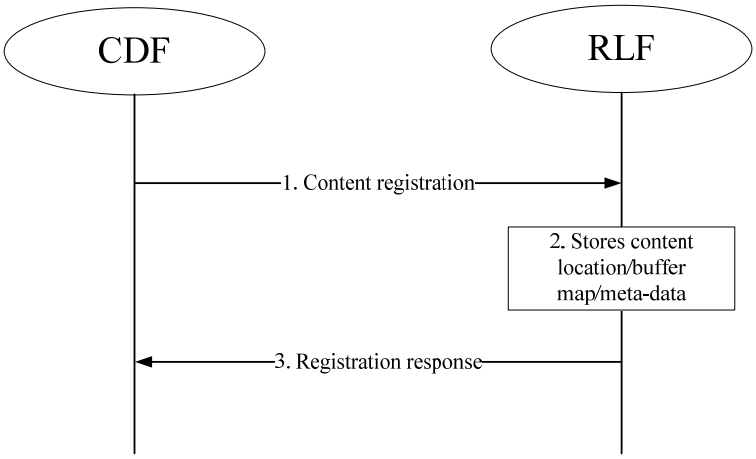


Figure 7-6 – Content registration to the RLF

Steps shown in Figure 7-6 are as follows.

1. CDF initiates a content registration request to the RLF. The request message contains at least the content ID and the location of the content. It may also contain the buffer map and the meta-data of the content, including the format of the content and the size of the content.
2. When the RLF receives the content registration request, it stores the content location, buffer map and meta-data.
3. RLF sends a response to inform the CDF of the result of content registration.

Figure 7-7 shows the general procedure of the CDF requesting the RLF for content location information.

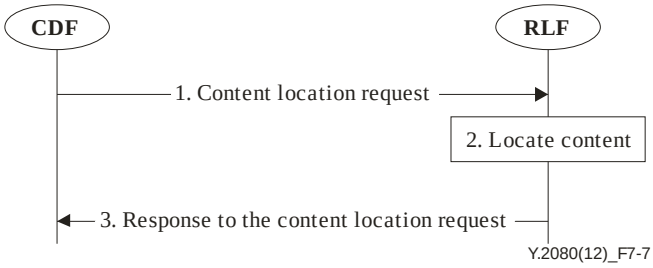


Figure 7-7 – CDF requesting the RLF for content location information

Steps shown in Figure 7-7 are as follows.

1. When the CDF needs to download content from other CDFs, it sends a content location request to the RLF; the request message contains content ID.
2. RLF locates the requested content.
3. RLF sends a response to the CDF with the location of the requested content.

Figure 7-8 shows the general procedure of the CDF reporting to the RLF the status of the node in which it resides.

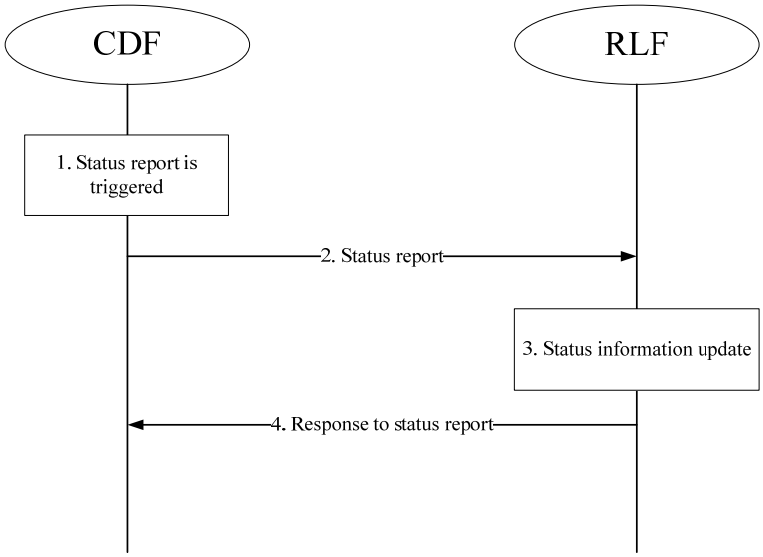


Figure 7-8 – CDF reporting the status of the node in which it resides

Steps shown in Figure 7-8 are as follows.

1. The status report is triggered either by the request of the RLF, or as a periodic status report performed by the CDF.
2. CDF reports to the RLF the status information of the node in which it resides.
3. RLF updates the node status information based on the status report received from the CDF.
4. RLF sends a response to inform the CDF of the status report result.

Figure 7-9 shows the general procedure of the CDF reporting an event to the RLF.

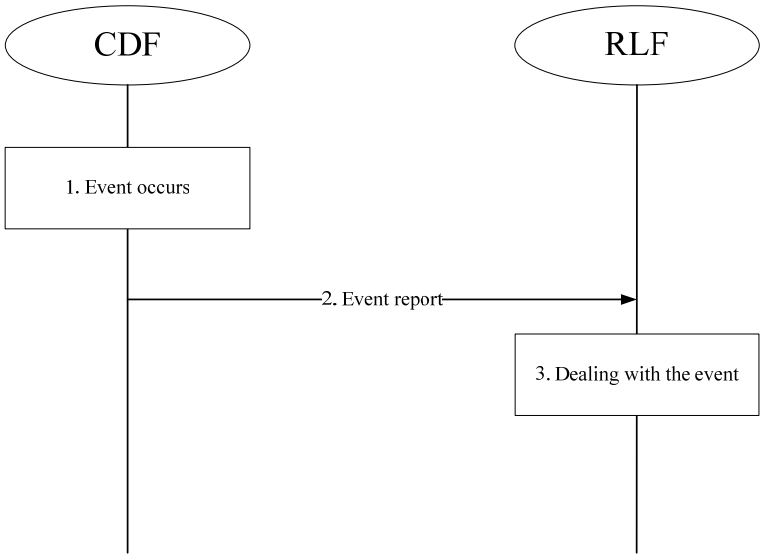


Figure 7-9 – CDF reporting an event to the RLF

Steps shown in Figure 7-9 are as follows.

1. An event occurs in the node in which the CDF resides, for instance, the load of the node has reached a given threshold.
2. CDF reports the event to the RLF. The event report message may contain the node ID and the event description.

3. RLF receives the event report and deals with the event. For instance, if the node is overloaded, the RLF may stop sending the location of this node to content requestors.

Figure 7-10 shows the general procedure of the CDF reporting content related information to the RLF.

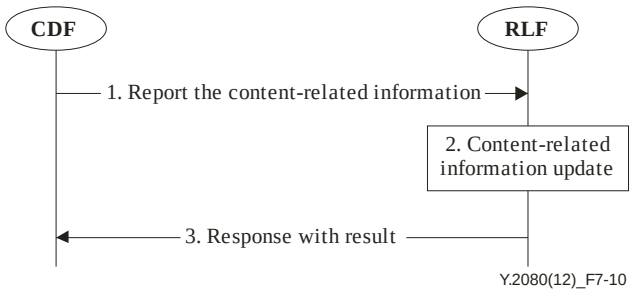


Figure 7-10 – CDF reporting content related information to the RLF

Steps shown in Figure 7-10 are as follows.

1. CDF sends a content related information report message to the RLF. This message should contain the content ID as well as content related information such as the availability of the content or the popularity of the content, etc.
2. RLF updates the content related information.
3. RLF sends a response to inform the CDF of the result regarding the content-related information update.

7.2.4 Reference point C4

The C4 reference point is between the RF and RLF.

This reference point is used by the RF to register with the RLF the relay node in which it resides.

This reference point is used by the RF to report to the RLF the status of the node in which it resides; the status information includes: CPU usage, memory usage, disk usage, network interface usage, etc.

This reference point is used by the RF to report event related information to the RLF, for instance, the event may be that the load of the node in which RF resides reached threshold.

This reference point is used by the RF to report the QoS measurement message to the RLF.

This reference point is used by the RLF to reserve resources on the RF.

Figure 7-11 shows the general procedure of relay node registration.

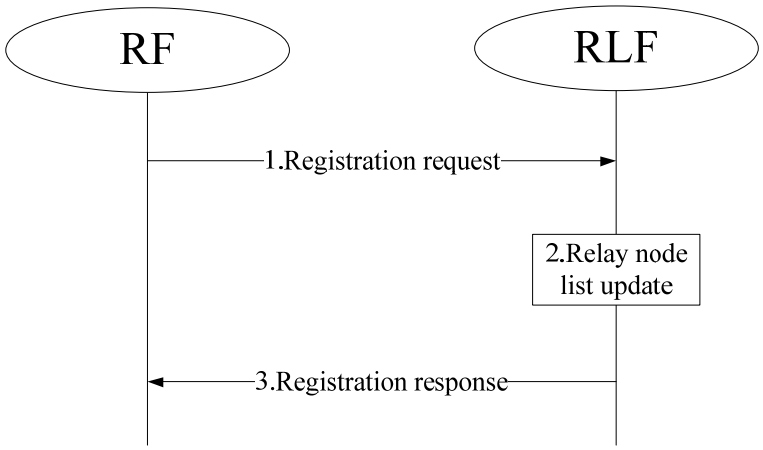


Figure 7-11 – Relay node registration

Steps shown in Figure 7-11 are as follows.

1. RF sends a registration request to the RLF. The registration request includes whether the RF is active or not, the address of the relay node in which the RF resides and the type of access network that the relay node is connecting to.
2. RLF updates the relay node list information based on the registration request it received.
3. RLF returns the registration response to the RF to indicate the result of the relay node registration.

Figure 7-12 shows the general procedure of relay node status information report.

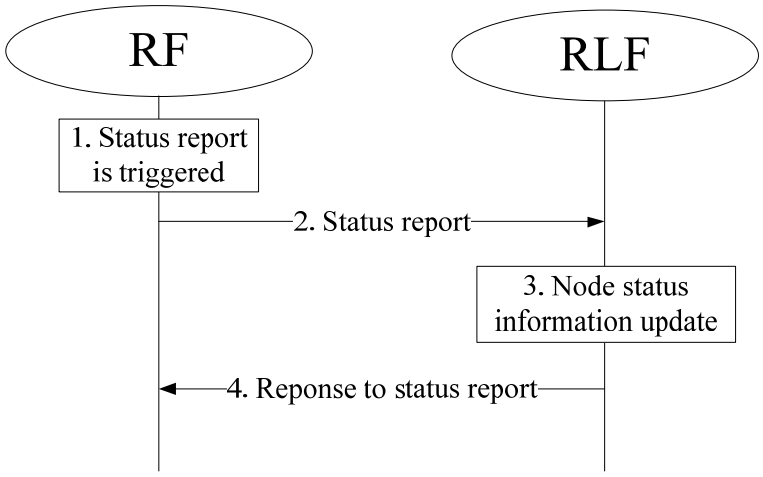


Figure 7-12 – Relay node status information report

Steps shown in Figure 7-12 are as follows.

1. The status report is triggered either at the request of the RLF, or as a periodic status report performed by the RF.
2. RF reports to the RLF the status information of the relay node in which it resides.
3. RLF updates the relay node status information based on the status report it received.
4. RLF sends a response to inform the RF of the status report result.

Figure 7-13 shows the general procedure of the RF reporting an event to the RLF.

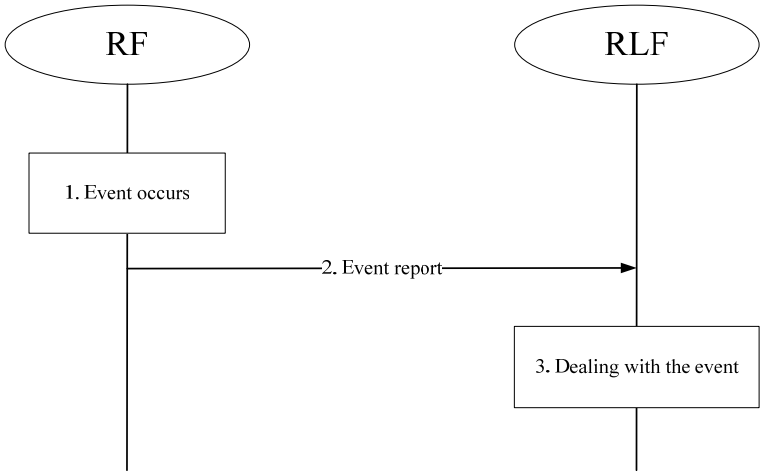


Figure 7-13 – RF reporting an event to the RLF

Steps shown in Figure 7-13 are as follows.

1. An event occurs in the relay node in which the RF resides, for instance, the load of the relay node reached a given threshold.
2. RF reports the event to the RLF; the report message may contain the node ID of the relay node and the event description.
3. RLF receives the event report and deals with the event. For instance, if the relay node is overloaded, the RLF may stop sending the location of this relay node to the relay service requestors.

Figure 7-14 shows the relay node resource reservation procedure.

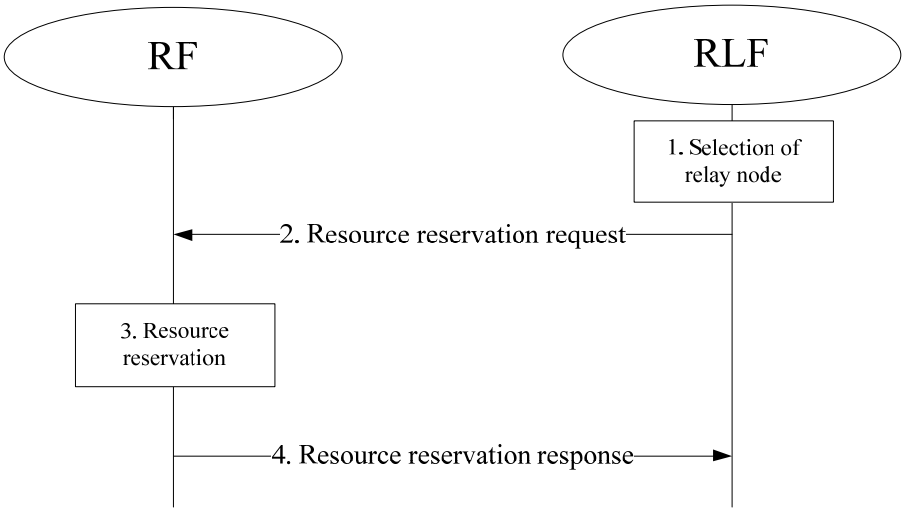


Figure 7-14 – Relay node resource reservation

Steps shown in Figure 7-14 are as follows.

1. RLF has selected one proper relay node for performing network traffic relay.
2. RLF sends a reservation request to the RF residing in the relay node to reserve relay resources, e.g., bandwidth, port of relay node.
3. RF reserves necessary resources.

4. RF returns information about reserved resources.

Figure 7-15 shows the procedure for measurement implementation.

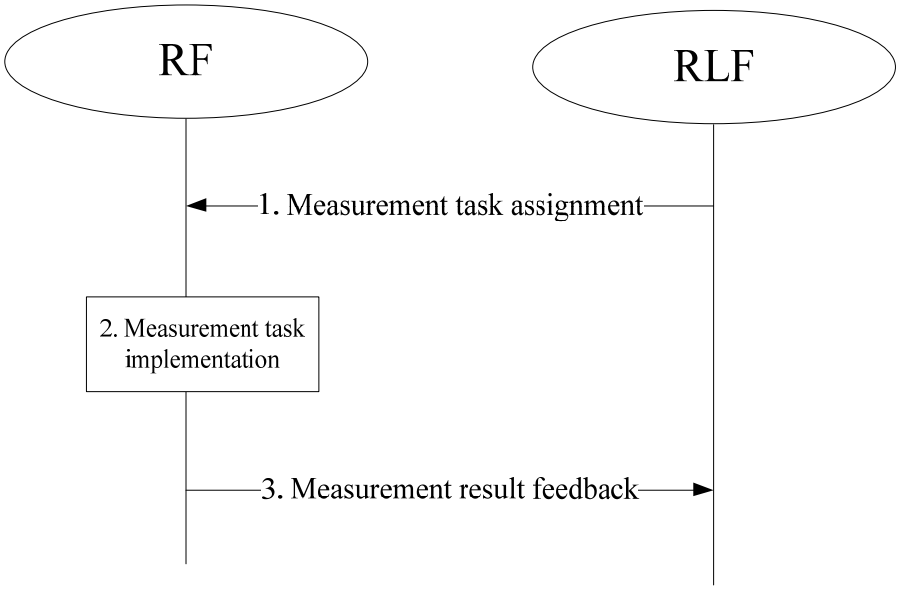


Figure 7-15 – Measurement implementation

Steps shown in Figure 7-15 are as follows.

1. RLF sends a measurement task assignment to the RF. The task assignment may include the address of measurement destination (which is the destination of the link to be measured, while the source is the RF), connection parameters, the type of requested QoS measurement information, desired measurement methods and requested measurement times, duration and frequency, etc.
2. RF performs the requested measurement task. The RF may connect to measurement destination and send measurement packets to gather measurements.
3. RF sends back the measurement results to the RLF.

7.2.5 Reference point C5

The C5 reference point is between the TOCF and RLF.

This reference point is used by the RLF to enquire from the TOCF about network information.

This reference point is used by the RLF to request a traffic optimization result from the TOCF.

Figure 7-16 shows the general procedure for enquiring network information.

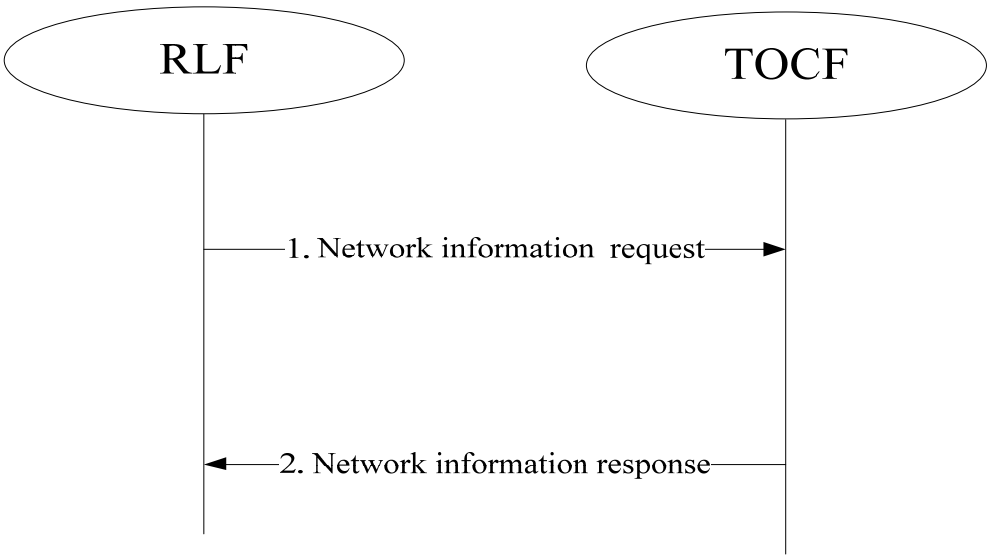


Figure 7-16 – Network information enquiring

Steps shown in Figure 7-16 are as follows.

1. RLF sends a network information request to the TOCF to obtain network topology information and traffic information regarding the overlay network and the underlying network.
2. TOCF feeds back network information to the RLF, including network map, cost map and QoS map between different DSN nodes.

Figure 7-17 shows the general procedure related to the traffic optimization information request.

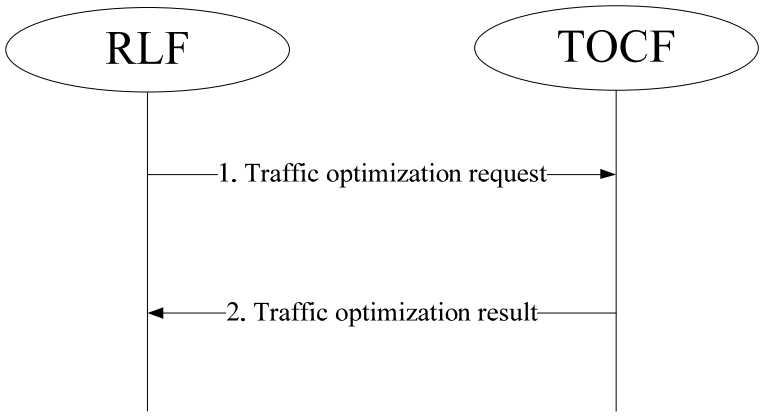


Figure 7-17 – Traffic optimization information request

Steps shown in Figure 7-17 are as follows.

1. RLF sends a traffic optimization request to the TOCF for optimization concerning the routing of signalling messages, content node selection, control node selection or relay node selection.
2. TOCF replies the optimization result to the RLF according to its optimization policy, including the control node priority list, control node priority list or relay node priority list.

7.2.6 Reference point C6

The C6 reference point is between the EF and SCF. This reference point is used to exchange service control related information between the EF and SCF (for instance, registration information or service request information). Since the flows at the C6 reference point may differ depending on the services, detailed procedures are not specified in this Recommendation.

7.2.7 Reference point C7

The C7 reference point is between the RLF and SCF.

This reference point is used by the SCF to request resource location from the RLF.

Figure 7-18 shows the general procedure for the SCF requesting resource location.

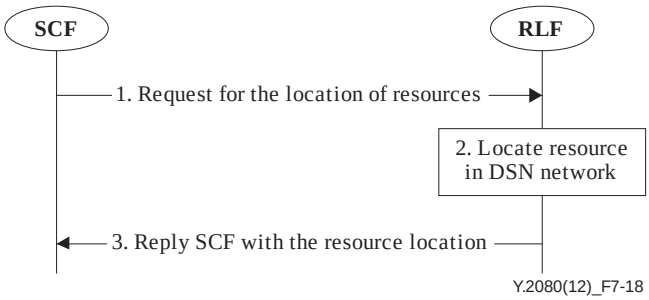


Figure 7-18 – SCF requesting resource location

Steps shown in Figure 7-18 are as follows.

1. SCF sends a request to the RLF for locating resource for service control. The request message should include the identification of the resource.
2. RLF locates the resource in the DSN network.
3. RLF replies to the SCF with the location of the requested resource.

7.2.8 Reference point C8

The C8 reference point is between the RLF and EF.

This reference point is used by the EF to request resource location from the RLF.

Figure 7-19 shows the general procedure of the EF requesting the location of a resource.

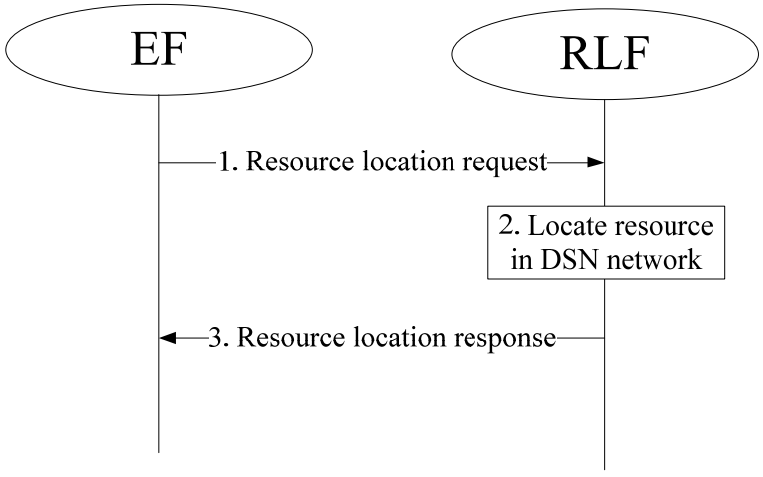


Figure 7-19 – EF requesting resource location

Steps shown in Figure 7-19 are as follows.

1. EF sends a resource location request to the RLF; the request message contains the information that identifies the resource.
2. RLF locates the resource in the DSN network.
3. RLF replies to the EF with the resource location.

7.2.9 Reference point C9

The C9 reference point is between the EF and CDF.

This reference point is used by the EF to query a buffer map from the CDF.

This reference point is used by the EF to request content from the CDF.

Figures 7-20 shows the general procedure of the EF requesting a buffer map and downloading content from the CDF.

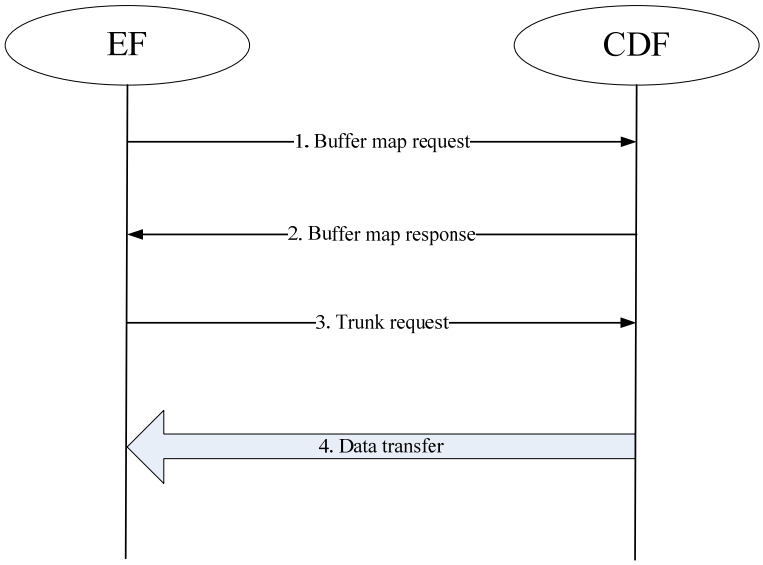


Figure 7-20 – EF requesting and downloading content

Steps shown in Figure 7-20 are as follows.

1. EF sends a buffer map request to the CDF; the message contains the content ID.
2. CDF sends the buffer map to the EF, indicating the content chunks it contains.
3. EF sends a request to the CDF to download the selected content chunks.
4. The content is transferred from the CDF to the EF.

7.2.10 Reference point C10

The C10 reference point is between CDFs.

This reference point is used by the CDF to query a buffer map from another CDF.

This reference point is used by the CDF to request content from another CDF.

Figure 7-21 shows the general procedure of the CDF requesting a buffer map and downloading content from another CDF.

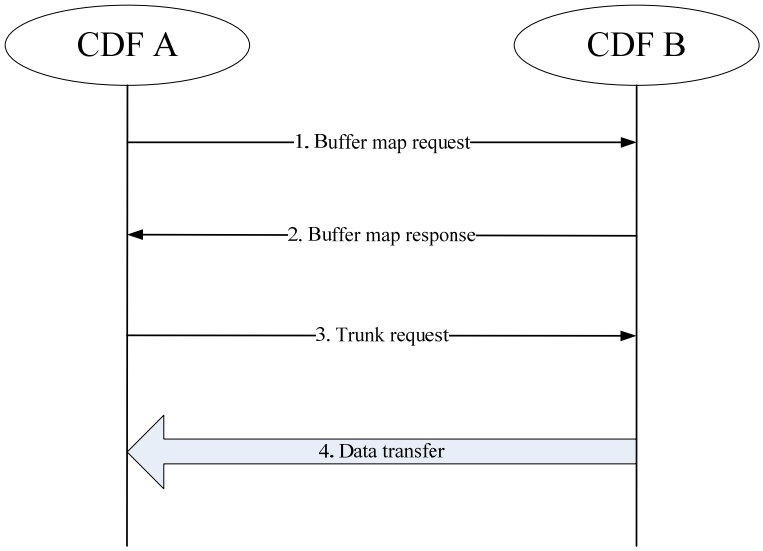


Figure 7-21 – CDF querying buffer map and requesting content from another CDF

Steps shown in Figure 7-21 are as follows.

1. CDF A sends a buffer map request to CDF B; the buffer map request contains the content ID.
2. CDF B returns the buffer map to CDF A, indicating the content chunks it contains.
3. CDF A sends a request to CDF B to download the selected content chunks.
4. The content is transferred from CDF B to CDF A.

7.2.11 Reference point A1

The A1 reference point is between the EF and CSAF.

This reference point is used by the EF for accessing content service.

This reference point is used by the EF for requesting content location.

Figure 7-22 shows the procedure of the EF accessing content service.

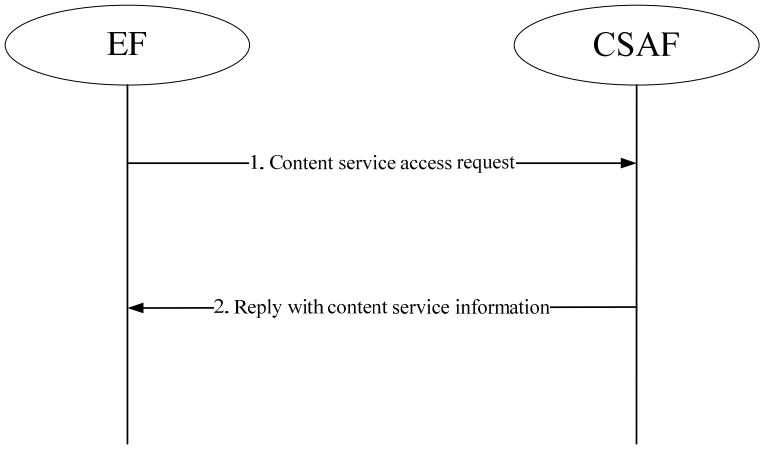


Figure 7-22 – EF accessing content service

Steps shown in Figure 7-22 are as follows.

1. EF sends a content service access request to the CSAF to get the content service information (including the available contents, the price of the contents or the introduction of the contents, etc.). The ID and device type of the EF are included in the content service access request. The content service access request may also include information about the types of contents requested and the authentication information of the user.
2. CSAF replies to the EF with the content service information. EF may present the information to the user.

Figure 7-23 shows the procedure of the EF requesting the location of content from the CSAF.

There are two options for this procedure.

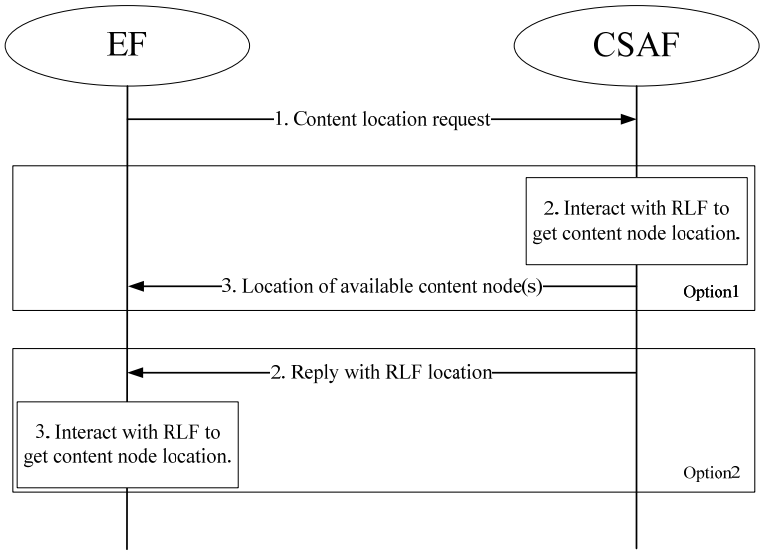


Figure 7-23 – EF requesting the location of content

Steps shown in Figure 7-23 are as follows.

1. EF sends a content location request to the CSAF to get the location information of available content node(s). The content ID is included in the request. The request may also include the ID of the EF and authentication information.

   Option 1:

2. CSAF interacts with the RLF to get the location information of available content node(s).
3. CSAF replies to the EF with the location of available content node(s).

   Option 2:

2. CSAF replies to the EF with the location of the RLF.
3. EF interacts with the RLF to get the location of available content node(s).

7.2.12 Reference point A2

The A2 reference point is between the SCF and CSAF.

This reference point is used for user authentication and authorization.

Figure 7-24 shows the general procedure.

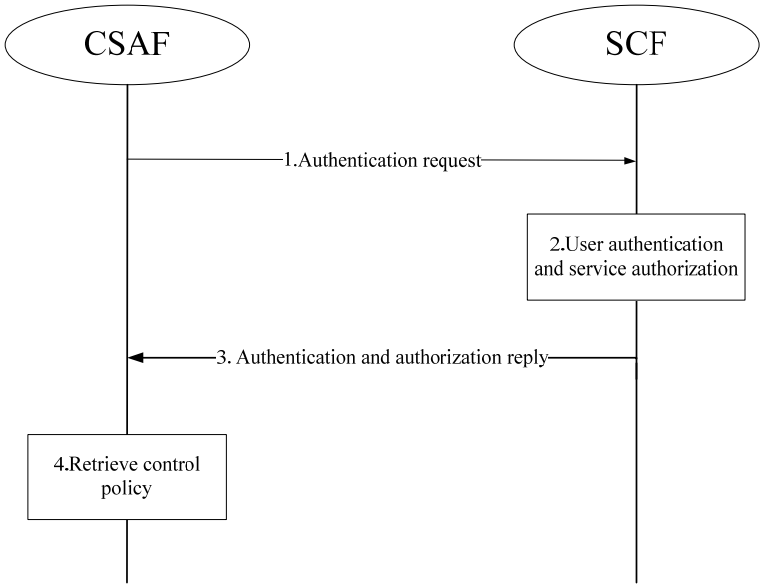


Figure 7-24 – User authentication and authorization

Steps shown in Figure 7-24 are as follows.

1. When a user logs into the CSAF through the EF, the CSAF sends an authentication request to the SCF. In the authentication request, the CSAF includes the ID of the EF and the authentication information sent by the EF.
2. SCF performs procedures for user authentication and then service authorization.
3. SCF sends back the authentication and authorization results to the CSAF.
4. CSAF retrieves the control policy, e.g., content access rights, from the authorization results for a user's service access control.

7.2.13 Reference point A3

The A3 reference point is between the CSAF and RLF.

This reference point is used by the CSAF to request the RLF for the available content node.

Figure 7-25 shows the general procedure.

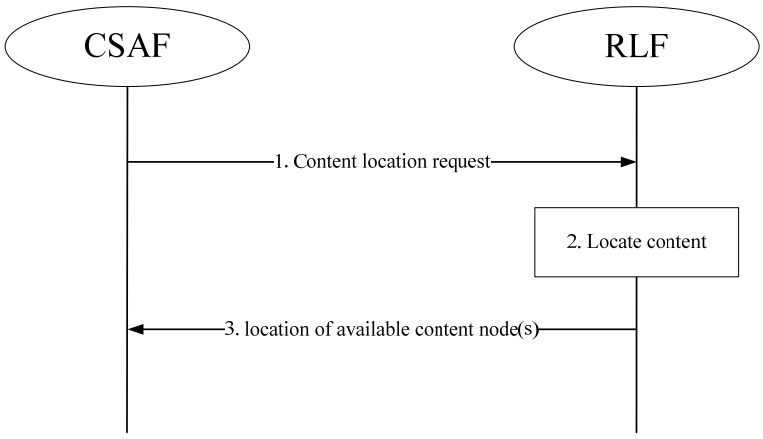


Figure 7-25 – CSAF requesting the RLF for content location

Steps shown in Figure 7-25 are as follows.

1. CSAF sends a content location request to the RLF; the request message should contain the content ID.
2. RLF locates the requested content.
3. RLF replies to the CSAF with the location of available content node(s).

7.2.14 Reference point A4

The A4 reference point is between AFs and the TOCF.

This reference point is used by AFs to query and subscribe to specific traffic related information.

NOTE – The A4 reference point is used by the TOCF to open its network information to third-party applications for traffic optimization.

The detailed information flows on the A4 reference point are for further study.

7.2.15 Reference point A5

The A5 reference point is between the CDF and CSAF.

This reference point is used by the CSAF to direct the CDF to process (e.g., transcoding, encryption) content.

Figure 7-26 shows the general procedure.

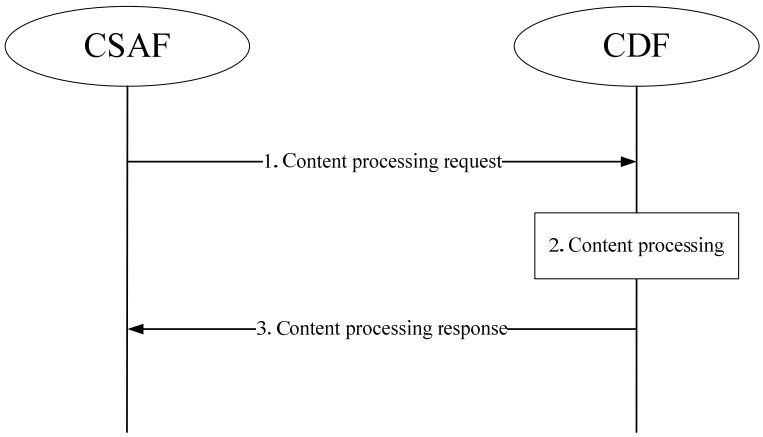


Figure 7-26 – CSAF directs the CDF to process content

1. CSAF sends a content processing request to the CDF; the request message should contain the content ID, the operations to the content, etc.
2. CDF processes the content according to the content processing request.
3. CDF returns the processing result and the processed content information (e.g., the new content ID or meta-data) in a content processing response message to the CSAF.

8 Security considerations

Security considerations are not addressed in this Recommendation.

Annex A

Relationship between the DSN functional architecture and the NGN functional architecture

(This annex forms an integral part of this Recommendation.)

As described in [ITU-T Y.2012], the NGN architecture is a general service- and technology-independent architecture that can be later instantiated in customized architectures that can respond to specific contexts in terms of the services offered and the technologies used.

DSN is based upon the use of a collection of DSN nodes (organized in a peer-to-peer, P2P, or other distributed fashion) and links between DSN nodes for the purpose of enabling multimedia services and applications.

This annex describes the mapping of DSN functions and NGN functions as well as the relationship between the DSN functional architecture described in this Recommendation and the NGN functional architecture.

A.1 Functional mapping between DSN functions and NGN functions

Although DSN is an extension of NGN, it does not inherit all the functions of the NGN. There are three main points when addressing the differences between DSN and NGN functions. First, the DSN network supports multimedia services and it does not impact the functions in the transport stratum of the NGN. Second, some functions of the NGN are extended to cover additional functionalities in order to support the distributed characteristic of the DSN. Finally, there are some newly defined functions introduced for the DSN which do not exist in the NGN [ITU-T Y.2012].

Table A.1 provides the mapping of DSN functions described in this Recommendation to NGN functions [ITU-T Y.2012].

Table A.1 – Functional mapping between DSN and NGN functions

No.	DSN functions	NGN functions [ITU-T Y.2012]	Remarks
1	End-user functions	End-user functions	The DSN EF is an extension of the NGN EF with additional functions defined in the DSN.
2	Service control functions	Service control functions	The DSN SCF inherits some functionalities of the NGN with additional functions defined in the DSN.
3	Content delivery functions	Content delivery functions	The DSN CDF inherits some functionalities of the NGN CDF with additional functions defined in the DSN.
4	Management functions	Management functions	The DSN MF is an extension of the NGN MF with additional functions defined in the DSN.

Table A.1 – Functional mapping between DSN and NGN functions

No.	DSN functions	NGN functions [ITU-T Y.2012]	Remarks
5	Content service application functions	Application support functions and service support functions	The DSN CSAF inherits some functionality of the NGN ASF & SSF to run the content-based services (e.g., live streaming, VoD).
6	Traffic optimization control functions	No equivalent	New functions in the DSN to provide traffic optimization capabilities.
7	Resource location functions	No equivalent	New functions in the DSN to provide distributed resource location functions.
8	Relay functions	No equivalent	New functions in the DSN to provide network traffic relay capabilities.
9	Node enrolment functions	No equivalent	New functions in the DSN to enrol a node to the DSN network as a DSN node.

A.2 Relationship between the DSN functional architecture and NGN functional architecture

As described in clause A.1, DSN functions can be mapped to five NGN-based functions and four newly defined functions. This clause shows the relationship between the DSN and NGN in the functional architecture aspect. Figure A.1 illustrates the relationship between the DSN functional architecture and NGN functional architecture.

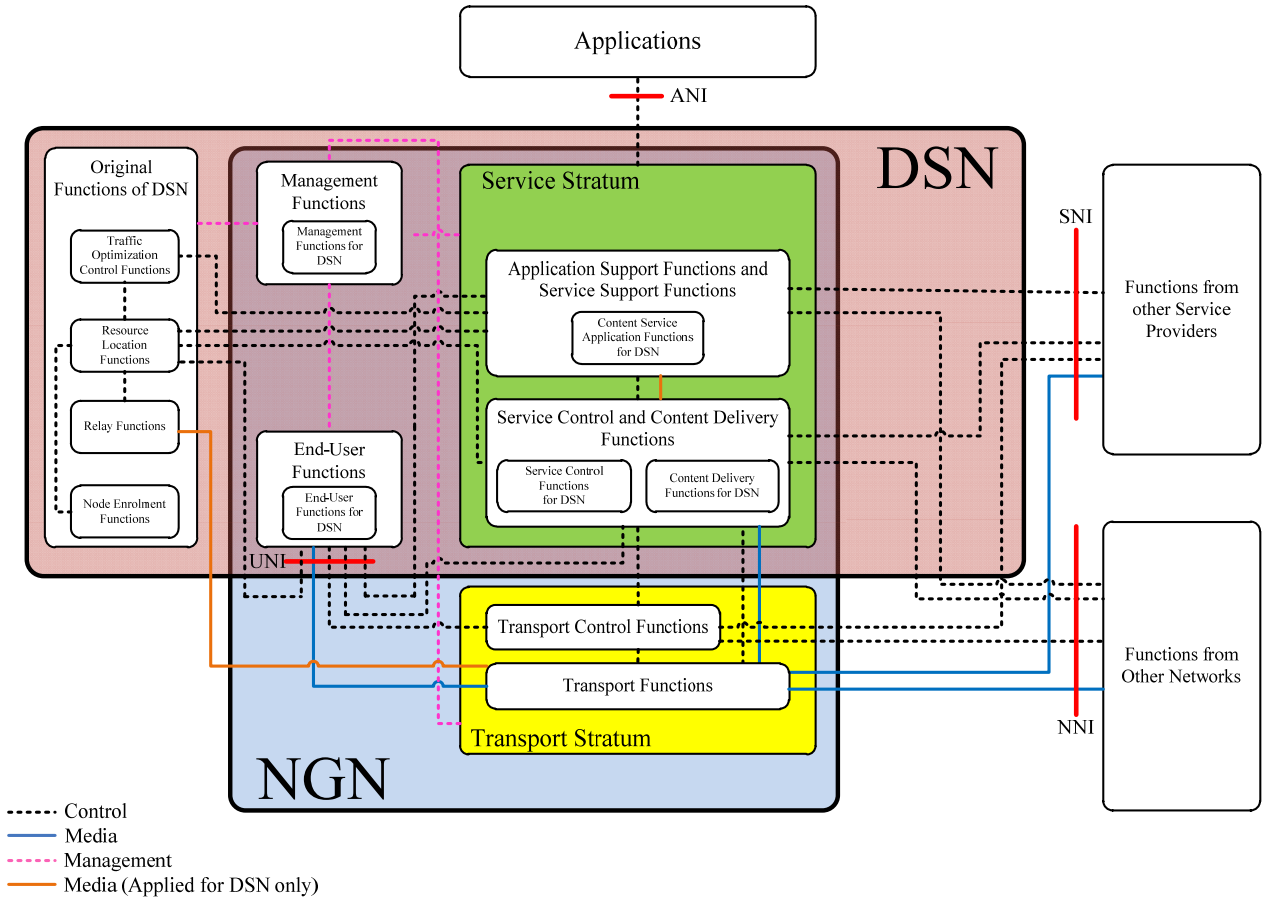


Figure A.1 – Relationship between the DSN and NGN from a functional architecture view

The DSN functional architecture consists of the functions in the service stratum of the NGN, management functions, end-user functions, and four newly defined functions for the DSN. The DSN has reference points for interaction between functions. The detailed descriptions of the functions and reference points of the DSN are described in clause 7.

The DSN can interact with functions of other service providers as well as functions of other networks such as PSTN/ISDN, the public Internet, and so forth. This interaction can be provided through the gateway functions of NGN in transport stratum, which can be controlled by the SCF. However, the description on the way to interact with other networks is not covered in this Recommendation because the operation of functions in the transport stratum of the NGN is outside the scope of this Recommendation.

Appendix I

Information flows for DSN service

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

This appendix is intended to help readers better understand the DSN functional architecture. The messages and flows used in this appendix are representative and are not meant to indicate any particular protocol.

I.1 General information flows

I.1.1 Control node enrolling to the DHT-based overlay in the DSN network

Figure I.1 shows the flows for a control node (taking node with the RLF as an example) enrolling to the DHT-based overlay in the DSN network. It assumes that the first entry point address (i.e., address of the node with the NEF) is already configured in the control node.

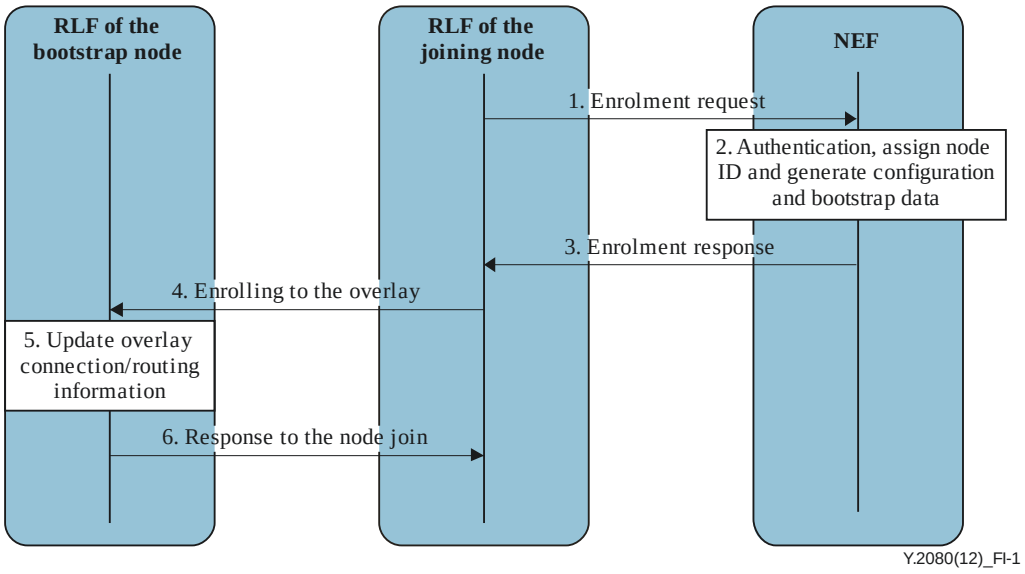


Figure I.1 – Control node enrolment to DHT-based overlay in the DSN network

Steps shown in Figure I.1 are as follows.

1. RLF of the enrolling node sends an enrolment request to the NEF. The enrolment request contains the identification of the requestor and information by which the NEF can authenticate the requestor.
2. NEF authenticates the RLF of the enrolling node and assigns the node ID to the RLF. It also generates the configuration and bootstrap information for the RLF.

   NOTE – The configuration information may contain the algorithm for the DHT-based overlay construction and maintenance. The bootstrap information may contain the location (for instance, IP address) of the bootstrap node.
3. NEF returns the configuration and bootstrap information in the enrolment response to the RLF.
4. RLF of the enrolling node sends an enrolling message to the RLF of the bootstrap node.
5. RLF of the bootstrap node updates the overlay routing or connection information accordingly.

6. RLF of the bootstrap node sends a response message to the RLF of the enrolling node for acknowledgement.

I.1.2 Reporting of DSN node status/event

Figure I.2 shows the flows related to the reporting of node status (for instance, relay node status or content node status) to the RLF. There are three types of reports. The first type is a periodic report where the RF/CDF is responsible for reporting the node (in which RF/CDF resides) status periodically to the RLF to which it is registered. The second type is an on-demand report for which the RLF can request the RF/CDF to report the node (in which RF/CDF resides) status. Upon receiving the request, the RF/CDF should report the requested information. The third type is an event-driven report: when a critical event occurs, the RF/CDF should report the event to the RLF.

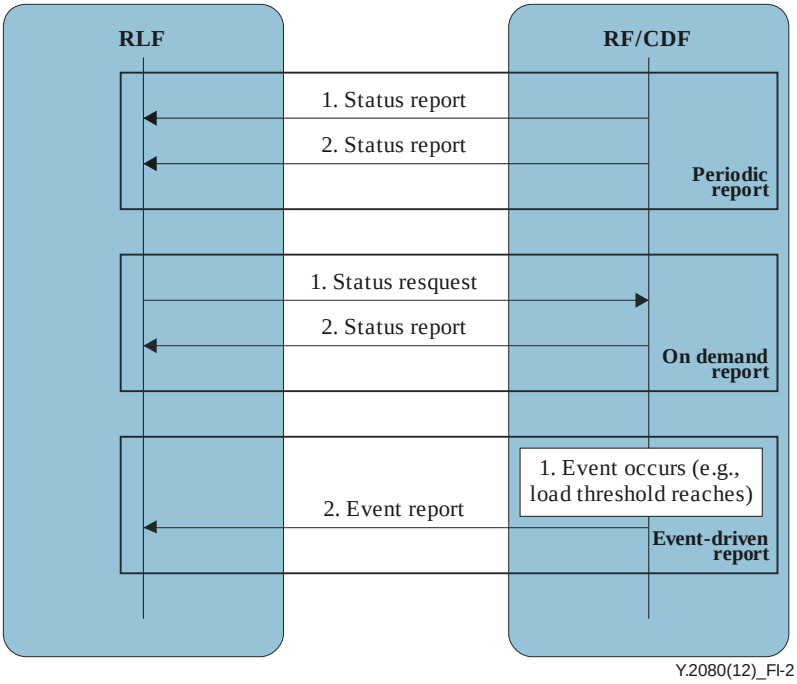


Figure I.2 – Reporting of DSN node status/event

Steps shown in Figure I.2 are as follows.

The periodic report

1. RF/CDF sends the status report to the RLF.
2. After a predefined interval, the RF/CDF sends the status information again to the RLF.

The on-demand report

1. RLF requests status information of relay node or content node.
2. Upon receipt of the report request from the RLF, the RF/CDF responds with the requested information.

The event driven report

1. A critical event occurs.
2. Upon recognizing the event, the RF/CDF reports the event to the RLF.

I.2 Content delivery

Content delivery service is one of the DSN services that provide content in a distributed manner for efficient content sharing between multiple DSN nodes.

To better understand the content delivery flows, two assumptions are made.

– One receiver can receive chunks for the same contents from multiple content nodes. This does not mean that content nodes send the same data.

– Content nodes can send partial or full content regardless of their location. Content nodes can reside within a service provider's domain or user's domain.

I.2.1 General flows

Figure I.3 illustrates the message flows for providing content delivery services in the DSN. There are two options for this information flow.

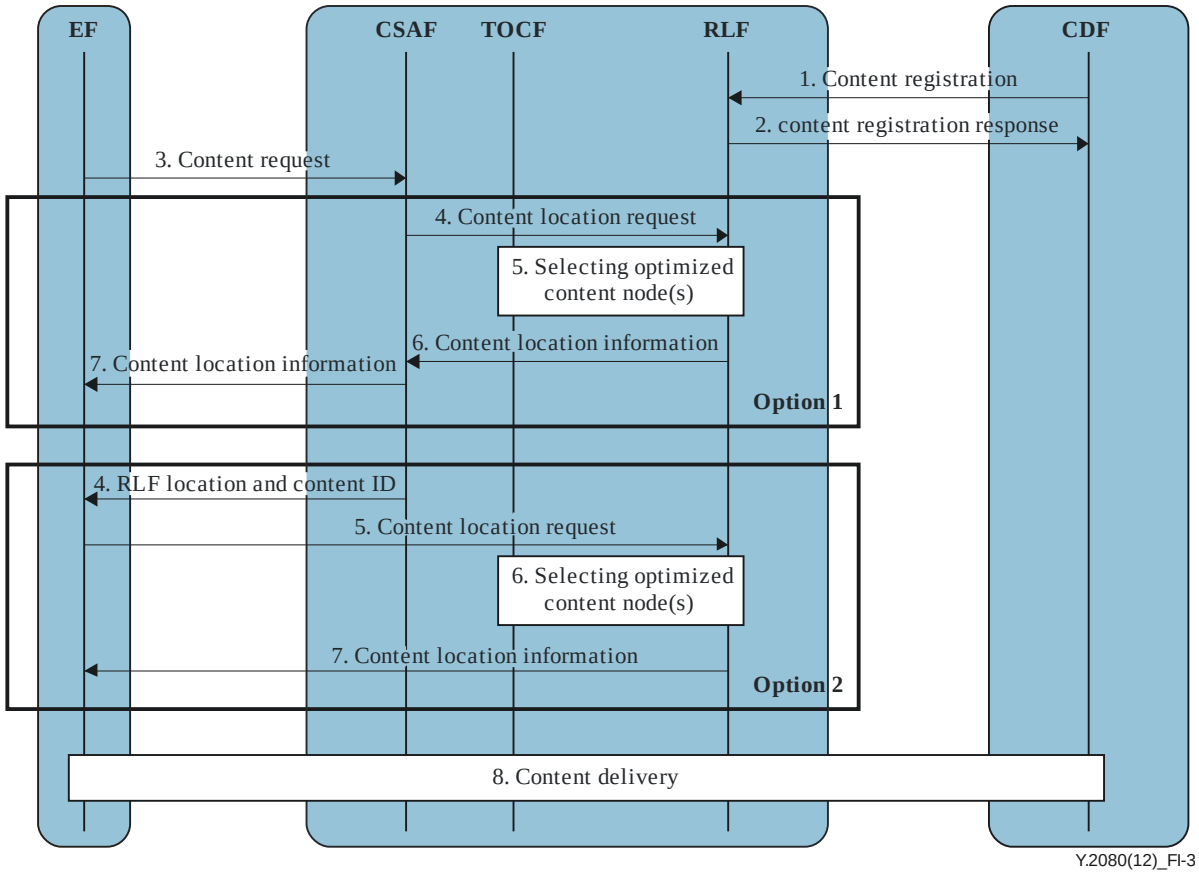


Figure I.3 – Providing content delivery services

Steps shown in Figure I.3 are as follows.

1. CDF registers the content to the RLF.
2. RLF answers the CDF to notify the result of the registration.
3. EF sends a message to the CSAF to request content.

Option 1:

4. CSAF sends a message to the RLF to retrieve the location of the contents.
5. RLF interacts with the TOCF to select the optimized content node(s).
6. RLF sends the location information of the selected content node(s) to the CSAF.
7. CSAF forwards the location information to the EF.
8. Content delivery is conducted from the CDF to the EF.

Option 2:

4. CSAF responds to the EF with the location of the RLF and ID of the content that the EF requests.
5. EF sends a request message to the RLF to retrieve the location of the content.
6. RLF interacts with the TOCF to select the optimized content node(s).
7. RLF sends the location information of the selected content node(s) to the EF.
8. Content delivery is conducted from the CDF to the EF.

I.2.2 Selecting optimized content node(s)

Figure I.4 shows the flows related to selecting optimized content node(s). There are two options for this information flow.

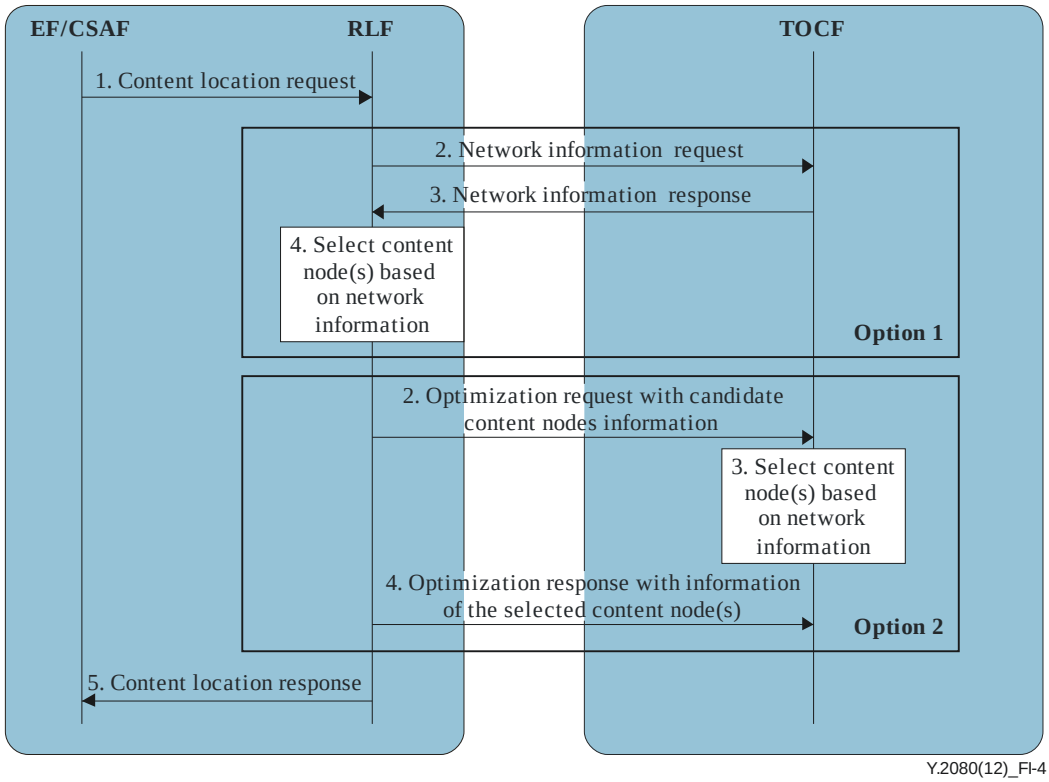


Figure I.4 – Selecting optimized content node(s)

Steps shown in Figure I.4 are as follows.

1. EF/CSAF requests for the location of content nodes that can provide the requested content.

Option 1:

2. RLF requests for network information from the TOCF.
3. TOCF responds to the RLF with the network information.
4. RLF selects optimal content node(s) based on the network information.
5. RLF sends the location of the selected optimal content node(s) to the EF/CSAF.

Option 2:

2. RLF sends candidate nodes and requests for selecting the optimal content nodes to the TOCF.
3. TOCF selects the optimal content node(s) based on the network information.
4. TOCF responds to the RLF with the selected content node(s).

5. RLF sends the location of the selected optimal content node(s) to the EF/CSAF.

I.2.3 Providing DSN services through relay node

Figure I.5 shows the flows for providing DSN services, especially NAT traversal, through the relay node. It is assumed that when the UE sends the request, the relay node has already registered and the UE has received content node information from the control node.

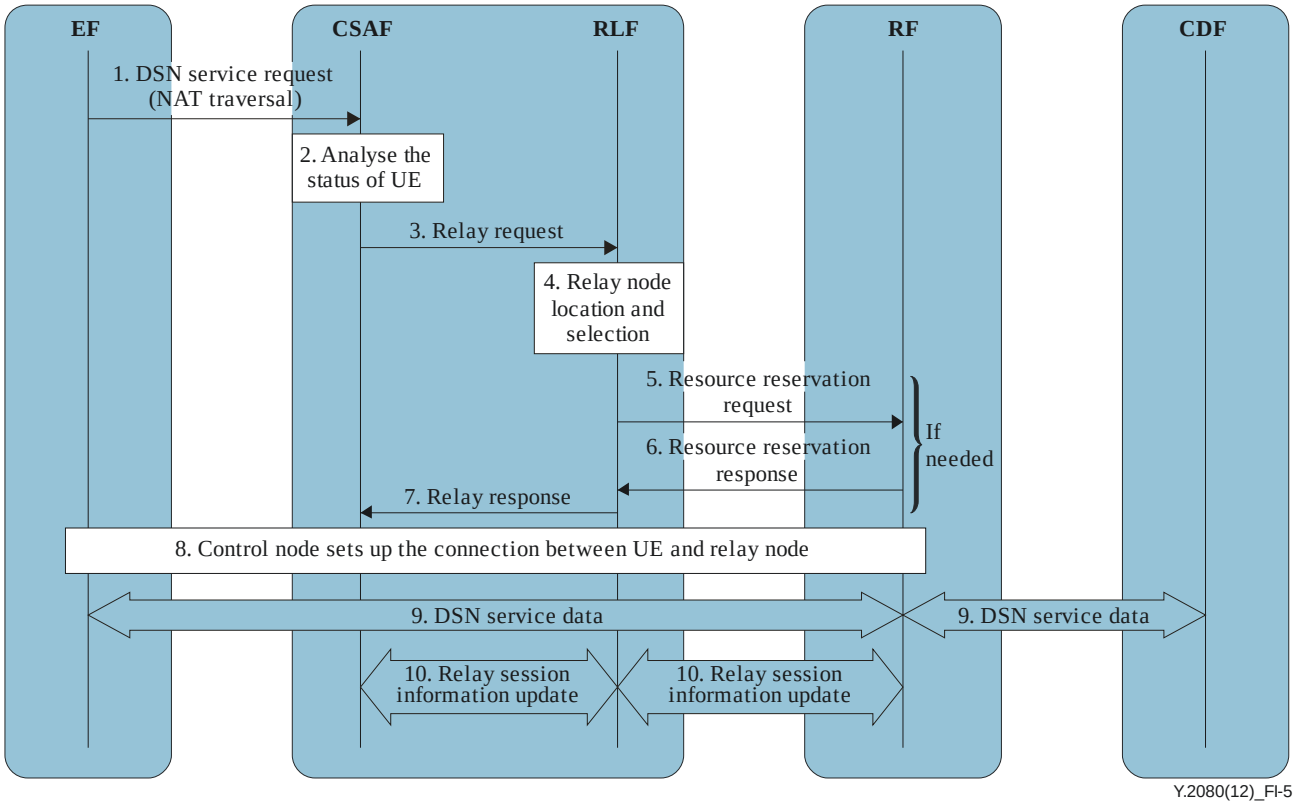


Figure I.5 – Providing DSN services through the relay node (NAT traversal based on the RF)

Steps shown in Figure I.5 are as follows.

1. EF sends a DSN service request to the CSAF.
2. CSAF processes the service request. Based on the service profile and the status of the UE and content node, the CSAF determines that relay nodes are needed in the data path.
3. CSAF sends a relay request to the RLF, which includes the address of the UE.
4. Depending on the addresses of the UE and the requested service, the RLF locates and selects suitable relay node(s) for the received request.
5. Optionally, the RLF may send a resource reservation request to the RF in the selected relay node(s) to reserve resources for relay, e.g., bandwidth, port of relay node(s). The address and port number of the CDF and the address of the UE are included in the resource reservation request.
6. RF reserves necessary resources and responds to the RLF with the information about reserved resources.
7. RLF returns the relay node(s) information to the CSAF.
8. CSAF helps the connection set-up by informing the UE and content node of the addresses that they should be connected to. One or more relay nodes could be inserted along the data path.

9. EF can exchange data packets with the CDF using the relay node(s) selected by the RLF.

10. During the relay service or after the relay service has finished, the RF sends relay session information and measurement results to the RLF for accounting. The RLF may forward the relay session information to the CSAF.

I.2.4 Retrieving content

Figure I.6 shows the flow for retrieving content from content nodes. It assumes that the EF has received the location of content nodes which contain the requested content.

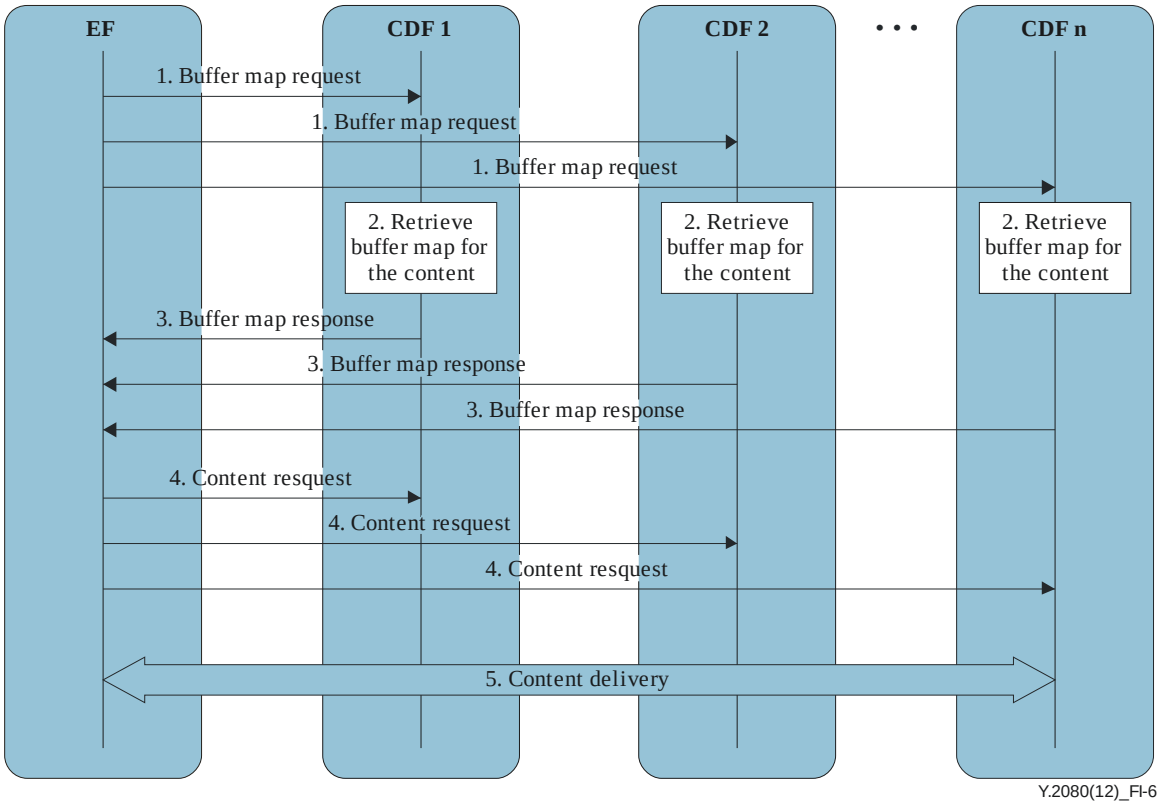


Figure I.6 – Flows for content retrieving

Steps shown in Figure I.6 are as follows.

1. EF sends a buffer map request to different CDFs in different content nodes.

2. Each CDF retrieves a buffer map of the requested content separately.

3. Each CDF responds to the EF with a buffer map.

4. EF sends a content request to the CDF to download chunks of the content. The EF requests different chunks from different content nodes.

5. Each CDF sends different chunks of the content to the EF.

I.2.5 CDF reporting flow statistic information to the MF

Figure I.7 shows the procedure of the CDF reporting flow statistic information to the MF.

NOTE – CDF may reside in the equipment of the service provider or user equipment itself; when residing in the equipment of the service provider, the flow statistic can be used for flow based accounting; when residing in user equipment, the flow can be recognized as the user's contribution to the network, and the flow statistic information can be used in encouraging or rewarding the user.

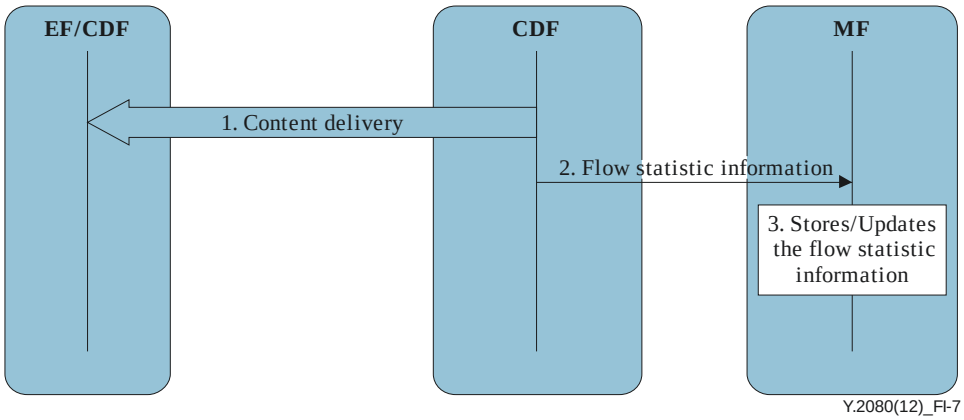


Figure I.7 – CDF reporting flow statistic information to the MF

Steps shown in Figure I.7 are as follows.

1. The content is delivered from the CDF to the EF or to another CDF.
2. After content delivery is finished, the CDF sends the flow statistic information to the MF.
3. MF stores or updates the flow statistic information.

I.3 Information flows for MMTel

I.3.1 User registration

Figure I.8 illustrates the message of user registration.

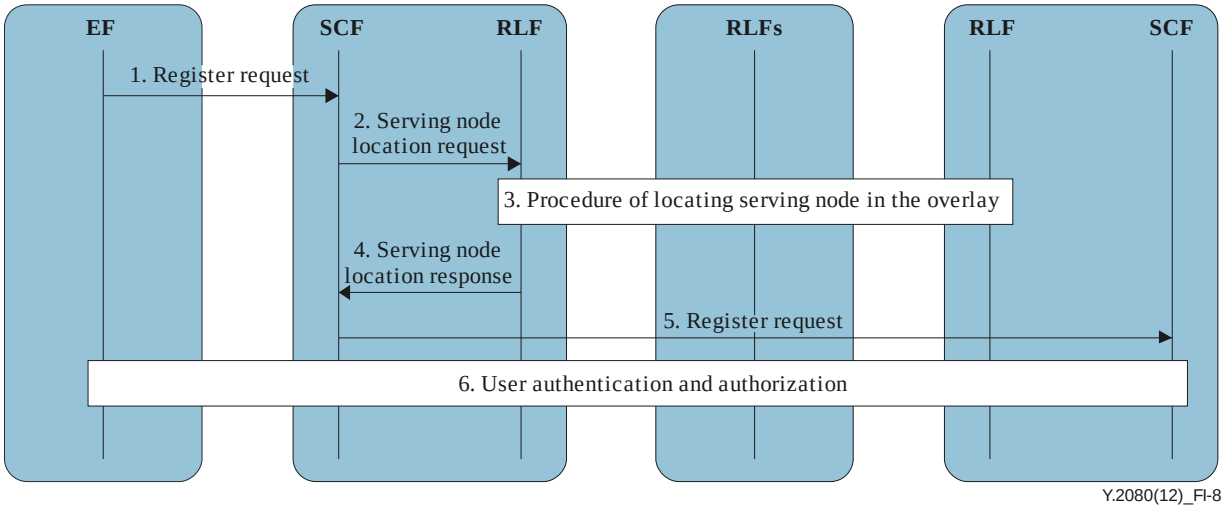


Figure I.8 – User registration in MMTel

Steps shown in Figure I.8 are as follows.

1. EF sends a registration request to a proxy SCF to register in the DSN MMTel service.
2. The proxy SCF sends the serving node location request to its associated RLF for the location of the user's serving node.
3. RLF looks up the location of the serving node through the overlay.

4. RLF returns the serving node location to the proxy SCF.
5. The proxy SCF forwards the registration request to the serving SCF.
6. The serving SCF authenticates and authorizes the user and returns the registration result.

I.3.2 Session establishment

Figure I.9 illustrates the message flow for providing MMTel service in DSN. It assumes that EF A and EF B have already registered to their respective serving nodes.

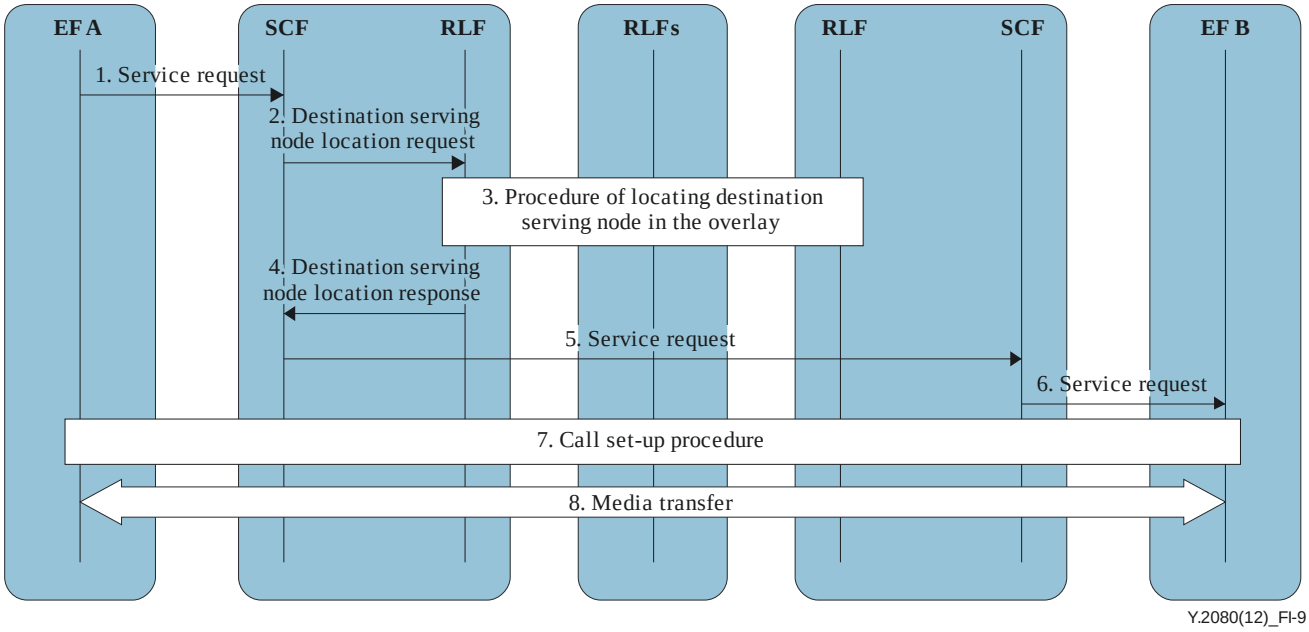


Figure I.9 – General message flows for providing MMTel service

Figure I.9 shows the session initiation procedure. Steps shown in Figure I.9 are as follows.

1. EF A sends a request to its serving SCF (via its proxy SCF) to initiate an MMTel call to EF B.
2. The serving SCF of EF A receives the request and sends a location request message to its associated RLF for the location of EF B's serving node.
3. RLF looks up the location of the serving node of EF B in the overlay.
4. RLF returns the serving node location of EF B to the serving SCF of EF A.
5. The serving SCF of EF A connects to the serving SCF of EF B and sends the request to the serving SCF of EF B.
6. The serving SCF of EF B receives the request and then forwards the request to EF B (via the proxy SCF of EF B).
7. EF A and EF B set up the media connection through the SCF.
8. Media data are transferred between EF A and EF B.

I.3.3 Session establishment with relay

Figure I.10 shows the session initiation procedure when a relay node is needed.

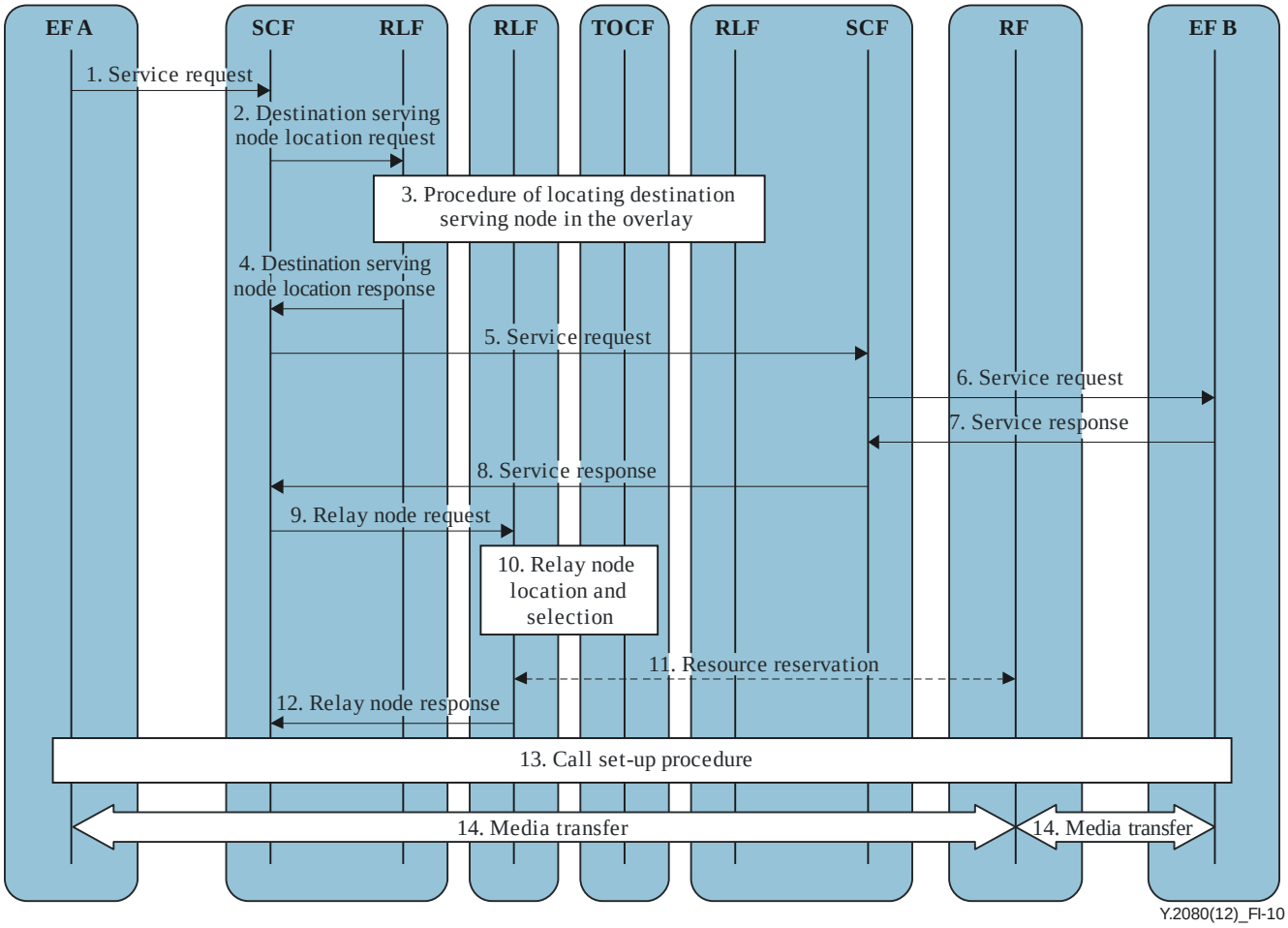


Figure I.10 – Providing MMTel service with a relay node

Steps shown in Figure I.10 are as follows.

1. EF A sends a request to its serving SCF (via its proxy SCF), to initiate an MMTel call to EF B.
2. The serving SCF of EF A receives the request and sends a location request message to its associated RLF for the location of EF B's serving node.
3. RLF looks up the location of the serving node of EF B in the overlay.
4. RLF returns the serving node location of EF B to the serving SCF of EF A.
5. The serving SCF of EF A connects to the serving SCF of EF B and sends the request to the serving SCF of EF B.
6. The serving SCF of EF B receives the request and then forwards the request to EF B (via the proxy SCF of EF B).
7. EF B sends back the service response to indicate its contact information.
8. The serving SCF of EF B forwards the service response to the serving SCF of EF A.
9. The serving SCF of EF A determines that a relay node is needed for this session. It sends a relay node request to the RLF to locate a relay node. The addresses of EF A and EF B are included in the request.

10. RLF interacts with the TOCF or other RLFs to locate and select a suitable relay node for this session.
11. Optionally, the RLF may send a resource reservation request to the RF in the selected relay node to reserve resources for relay, e.g., bandwidth, port of relay node(s).

    NOTE – The addresses of EF A and EF B are sent to the RF in a resource reservation message and the RF returns the addresses and port numbers allocated for this session.
12. RLF returns the relay node information to the serving SCF of EF A.
13. Under the control of serving SCFs, EF A and EF B set up the media connection through the relay node.
14. Media data are transferred through the relay node between EF A and EF B.

Appendix II

DSN model

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

In order to locate and fetch DSN services and contents among distributed DSN nodes in a scalable and reliable manner, DSN performs:

– distributed service control with load balancing and resource registration/locating;

– distributed content/media delivery with traffic optimization.

Within the DSN network, UE can easily obtain the locations of one or more DSN nodes which provide services logic (control node), hold the required content (content node) or relay the traffic data (relay node).

As shown in Figure II.1, DSN nodes are classified into three different types according to their roles.

– The content node holds the content by managing content storages or cache, and delivers the content when it is queried.

– The relay node can relay traffic data for DSN nodes or UE.

– The control node provides service control functions. Consequently, UE can request and access DSN service in the DSN network.

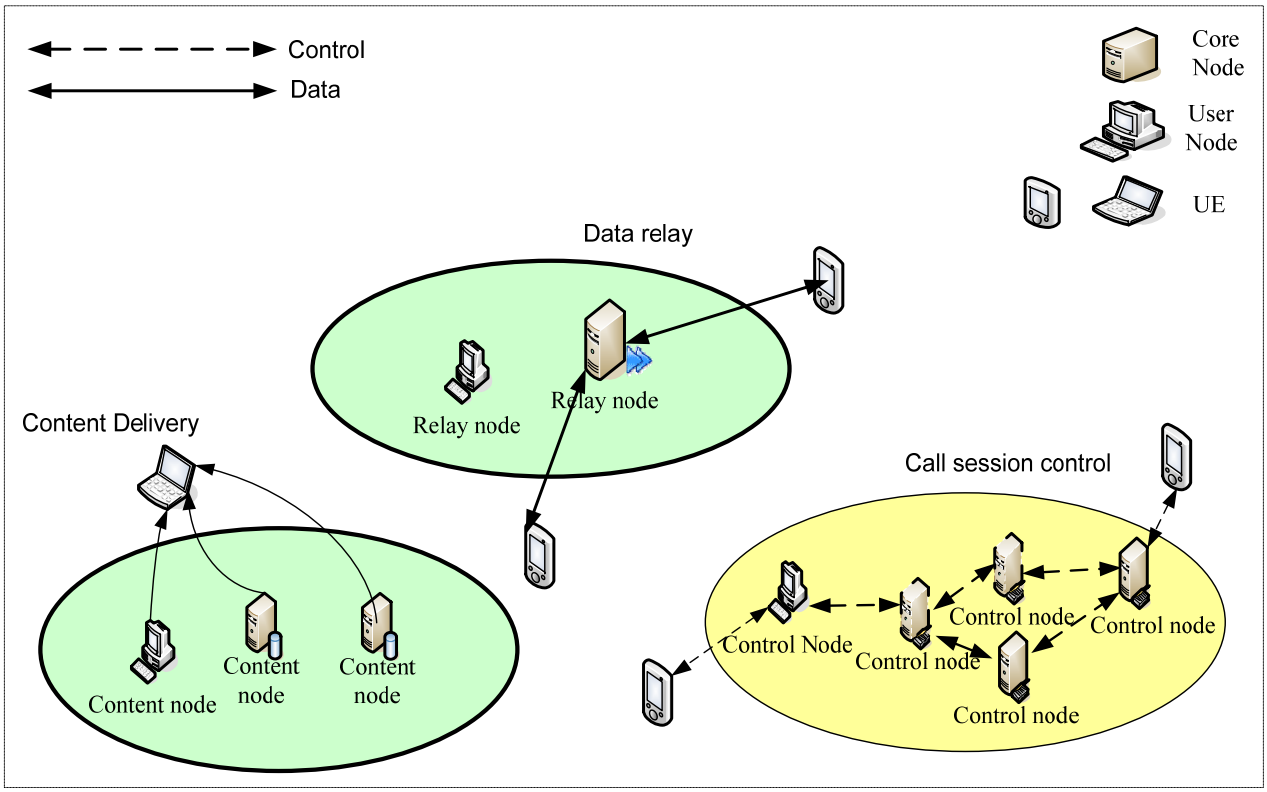


Figure II.1 – DSN model

The DSN node can also be classified into core node and user node by deployment.

Core nodes are deployed by service providers. DSN functions except EFs can be implemented in the core node. The deployment issue is outside of the scope of this appendix. The user node is a DSN node as well as UE. UE can work as follows:

– as a pure DSN client that accesses DSN services but never contributes;

– as part of the DSN service providing equipment where the user node (e.g., being a content node, relay node or control node) provides its resource to others.

The role of UE in the DSN network depends on the capability of the UE; it also depends on the decision of the end user and the DSN service provider. UE can implement one or more DSN functions, e.g., CDF, RF, SCF and RLF.

Figure II.2 shows three examples of UE with different compositions of DSN functions.

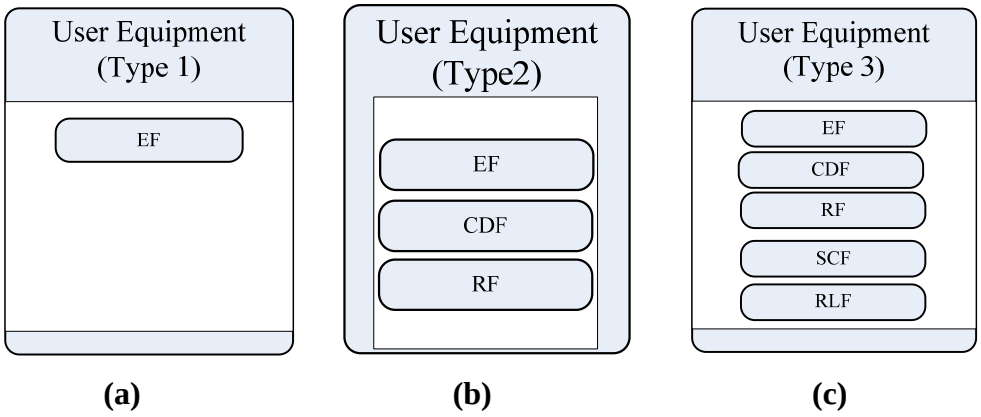


Figure II.2 – Example of UE with different compositions of DSN functions

The UE (Type 1) in Figure II.2 acts as a simple DSN client with only the EF. It could be a mobile phone with limited hardware capability and access bandwidth that cannot offer any services to others.

Figure II.2 shows UE (Type 2) that can work as a content node or/and relay node in the DSN network while accessing DSN services. This kind of UE could be a laptop or normal PC which has the capability to store, distribute or relay content for others.

If the UE is powerful enough (e.g., a high-performance and trustworthy PC with broad bandwidth and high availability) it may implement multiple DSN functions, e.g., CDF, RF, SCF and RLF as shown in Figure II.2 as UE (Type 3), to work in the DSN as both control node and content/relay node.

Bibliography

[b-ITU-T X.810] Recommendation ITU-T X.810 (1995) | ISO/IEC 10181-1:1996, *Information technology – Open Systems Interconnection – Security frameworks for open systems: Overview.*

[b-ITU-T Y-Sup.10] ITU-T Y-series Recommendations – Supplement 10 (2010), *ITU-T Y.2000 series - Supplement on distributed service network (DSN) use cases.*

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