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SERIES Q: SWITCHING AND SIGNALLING

Physical realization of next generation networks

ITU-T Q-series Recommendations – Supplement 64

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Supplement 64 to ITU-T Q-series Recommendations

Physical realization of next generation networks

Summary

The next generation network (NGN) architecture defined in Recommendation ITU-T Y.2012 is a generalized architecture in which abstract functional entities are specified. However, to address the issues of interoperability within an NGN network, there is a need to identify physical realizations showing which functional entities are implemented in a network component and by implication the interfaces that are important to ensure the interoperability of systems. Supplement 64 to the ITU-T Q-series of Recommendations provides guidance on the physical realization of NGNs by describing a number of possible physical entities corresponding to a functional entity or a group of functional entities specified in the generalized functional architecture of NGN.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Introduction

The NGN architecture defined in Recommendation ITU-T Y.2012 (2010) is a generalized architecture in which abstract functional entities are specified. However, to address the issues of interoperability within an NGN network, there is a need to identify physical realizations showing which functional entities are implemented in a network component and by implication the interfaces that are important to ensure the interoperability of systems. This document is intended to give guidance on the physical realization of NGNs by describing a number of possible physical entities corresponding to a functional entity or a group of functional entities specified in the generalized functional architecture of NGN.

Clause 6 describes the NGN architecture and functions defined in terms of various functional entities and clause 7 gives examples of physical components in which these functional entities may be realized. Reference is made to Recommendation ITU-T Q.3900, which describes the mapping of NGN functional entities into physical components for the purpose of defining a model for the testing of NGN equipment and Supplement 2 to Recommendation ITU-T Y.2012 that describes the realization of session border controllers (SBCs) in an NGN environment.

More detailed information on NGN, in particular on the protocol mechanisms employed, can be found in the ITU-T Handbook on NGN "Converging Networks".

Supplement 64 to ITU-T Q-series Recommendations

Physical realization of next generation networks

1 Scope

Supplement 64 to the ITU-T Q-series of Recommendations provides guidance on the physical realization of NGNs by describing a number of possible physical entities corresponding to a functional entity or a group of functional entities specified in the generalized functional architecture of NGN.

2 References

References to documents made in this Supplement are found in the bibliography.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses terms defined in [b-ITU-T Y.2091].

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3GPP	Third Generation Partnership Project
ABG-FE	Access Border Gateway Functional Entity
AF-PE	Application Function Physical Entity
AGC-FE	Access Gateway Control Functional Entity
AM-FE	Access Management Functional Entity
AMF	Account Management Function
AMG-FE	Access Media Gateway Functional Entity
AN-FE	Access Node Functional Entity
ANI	Application Network Interface
APL-GW-FE	Application Gateway Functional Entity
APL-SCM-FE	Application Service Coordination Manager Functional Entity
APP-FE	Application provisioning functional entity
AR-FE	Access Relay Functional Entity
AS	Application Server
AS-FE	Application Support Functional Entity
ASS-PE	Application and Service Support Physical Entity

ASUP-FE	Application Support User Profile Functional Entity
ATM	Asynchronous Transfer Mode
BGC-FE	Breakout Gateway Control Functional Entity
BS	Billing System
CCF	Charging Collection Function
CD-PE	Content Distribution Physical Entity
CD&LC-FE	Content Distribution & Location Control Functional Entity
CDC-FE	Content Delivery Control Functional Entity
CDF	Content Delivery Function
CDP-FE	Content Delivery Processing Functional Entity
CGCM-FE	CPN Gateway Configuration and Management Functional Entity
CGF	Charging Gateway Function
CGNA-FE	CPN Gateway Network Attachment Functional Entity
CGPD-FE	CPN Gateway Policy Decision Functional Entity
CGPE-FE	CPN Gateway Policy Enforcement Functional Entity
CGSC-FE	CPN Gateway Service Control Functional Entity
CIR	Charging Information Record
CPE	Customer Premises Equipment
CPN	Customer Premises Network
CPR-FE	Content Preparation Functional Entity
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DSL	Digital Subscriber Line
EN-FE	Edge Node Functional Entity
GSC-FE	General Services Control Functional Entity
GSM	Global System for Mobile communications
GW	Media Gateway
GW-LTE	Media Gateway for Legacy Terminal Equipment
HDC-FE	Handover Decision and Control Functional Entity
HDF	Handover Decision Function
HGWC-FE	Home Gateway Configuration Functional Entity
I-CSC-FE	Interrogating Call Session Control Functional Entity
IBC-FE	Interconnection Border gateway Control Functional Entity
IBG-FE	Interconnection Border Gateway Functional Entity
IdM	Identity Management

IdMCC-FE	IdM Coordination and Control Functional Entity
IMS	IP Multimedia Subsystem
IN	Intelligent Network
INAP	Intelligent Network Application Protocol
IP	Internet Protocol
IPCGF	Inter-Provider Charging Gateway Function
IPTV	Internet Protocol Television
ISDN	Integrated Services Digital Network
IVR	Interactive Voice Response
L1	Layer 1
L2	Layer 2
L2HCF	Layer 2 Handover Control Function
L2HE-FE	Layer 2 Handover Execution Functional Entity
L3	Layer 3
L3HCF	Layer 3 Handover Control Function
MDS	Media Server
MeS	Messaging Server
MGC	Media Gateway Controller
MGC-FE	Media Gateway Control Functional Entity
MLM-FE	Mobile Location Management Functional Entity
MMCF	Mobility Management and Control Function
MPLS	Multi-Protocol Label Switching
MRB-FE	Media Resource Broker Functional Entity
MRC-FE	Media Resource Control Functional Entity
MRP-FE	Media Resource Processing Functional Entity
MS	Management System
NAC-FE	Network Access Configuration Functional Entity
NAC-PE	Network Access Configuration Physical Entity
NACF	Network Attachment Control Function
NAPT	Network Address and Port Translation
NAT	Network Address Traversal
NGN	Next Generation Network
NGN-IAD	Next Generation Network Integrated Access Device
NID-FE	Network Information Distribution Functional Entity
NIR-FE	Network Information Repository Functional Entity

NNI	Network-Network Interface
NSIW-FE	Network Signalling Interworking Functional Entity
OCF	Online Charging Function
P-CSC-FE	Proxy Call Session Control Functional Entity
P-CSCF	Proxy – Call/Session Control Function
PD-FE	Policy Decision Functional Entity
PE-PE	Policy Enforcement Physical Entity
PPP	Point-to-Point Protocol
PS	Proxy Server
PSTN	Public Switched Telephone Network
RACF	Resource and Admission Control Function
RADIUS	Remote Authentication Dial In User Service
RF	Rating Function
RSVP	Resource Reservation Protocol
S-CSC-FE	Serving Call Session Control Functional Entity
SAA-FE	Service Authentication and Authorization Functional Entity
SBC	Session Border Controller
S/BC	Session/Border Control
SC-PE	Service Control Physical Entity
SCF	Service Control Function
SCP	Service Control Point
SCP-FE	Service and Content Protection Functional Entity
SG	Signalling Gateway
SG-FE	Signalling Gateway Functional Entity
SIP	Session Initiation Protocol
SL-FE	Subscription Locator Functional Entity
SLA	Service Level Agreement
SNI	Service Network Interface
SS-FE	Service Switching Functional Entity
SUP-FE	Service User Profile Functional Entity
TAA-FE	Transport Authentication and Authorization Functional Entity
TE	Terminal Equipment
TLM-FE	Transport Location Management Functional Entity
TMG-FE	Trunking Media Gateway Functional Entity
TNE	Transport Network Environment

TRC-FE	Transport Resource Control Functional Entity
TRE-FE	Transport Resource Enforcement Functional Entity
TUP-FE	Transport User Profile Functional Entity
UE	User Equipment
UNI	User-Network Interface
USIW-FE	User Signalling Interworking Functional Entity
VoD	Video on Demand
VPN	Virtual Private Network
WLAN	Wireless Local Area Network
xDSL	Digital Subscriber Line technology

5 Conventions

None.

6 Next generation network architecture

6.1 Overview

One of the main characteristics of the NGN architecture is the decoupling of services from the transport infrastructure allowing services to be offered separately and to evolve independently. There is therefore a separation between the service control functions (SCFs) and the transport functions in the NGN architecture. This is illustrated in Figure 1. SCFs reside in the service stratum and the transport stratum provides connectivity with an appropriate quality of service (QoS) for the various services.

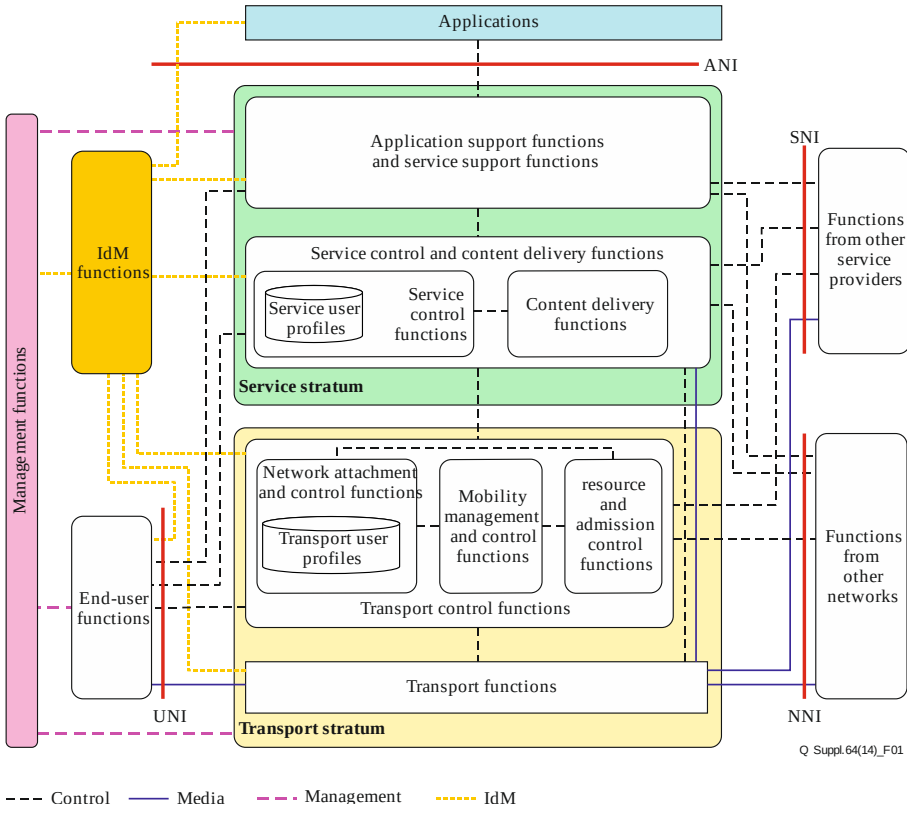


Figure 1 – NGN architecture overview

The transport stratum is composed "transport functions" and "transport control functions". The "transport functions" provide connectivity between all NGN network elements, including the access network, edge and core transport elements, and gateway functions for the transfer of media, control and management information. All services are carried over the Internet protocol (IP), although IP itself may in turn be carried over a number of underlying technologies, such as asynchronous transfer mode (ATM) or Ethernet.

The "transport control functions" are those of controlling network attachment, the use of transport resources and mobility management.

The network attachment control functions (NACFs) provide dynamic provisioning of IP addresses and other user equipment (UE) configuration parameters; authentication prior to, or during, the IP address allocation procedure; authorization based on user profiles (e.g., access transport subscription); access network configuration based on user profiles; and may, in addition, provide the addresses of NGN Service stratum components such as an IP multimedia subsystem (IMS) proxy – call/session control function (P-CSCF) to the customer premises equipment (CPE).

The resource and admission control function (RACF) acts as the arbitrator for resource negotiation and allocation between the service control and transport functions within the NGN architecture. SCFs supporting various NGN services interact with the RACF to provide capabilities for the control of NGN transport resources. Resource reservation, admission control and gate control can be used to provide an appropriate QoS for specific information flows and it is possible to control network address and port translation (NAPT) and firewall traversal.

The RACF interacts with transport functions to control one or more of the following functionalities in the transport stratum: packet filtering; traffic classification, marking and policing; bandwidth reservation and allocation; prevention of IP address spoofing; NAPT, firewall traversal; and usage metering.

Admission control can be performed on the basis of authorization checks based on user profiles, service level agreements (SLAs), operator specific policy rules, and the availability of resources within the access and core transport networks.

The RACF also interacts with the NACF to configure parameters; perform network access registration, authentication and authorization; and to check user profiles against SLAs.

At present, similar services are offered to users on both fixed access networks and on mobile networks. A major feature of NGN is generalized mobility in which services are consistently realized to a user independent of network access technology. The mobility management and control functions (MMCFs) support IP-based mobility within the transport stratum.

The service stratum comprises SCFs. These are typically registration, authentication and authorization functions at the service level, session control and resource control coordination.

An illustration of how the various services are supported is given in Figure 2.

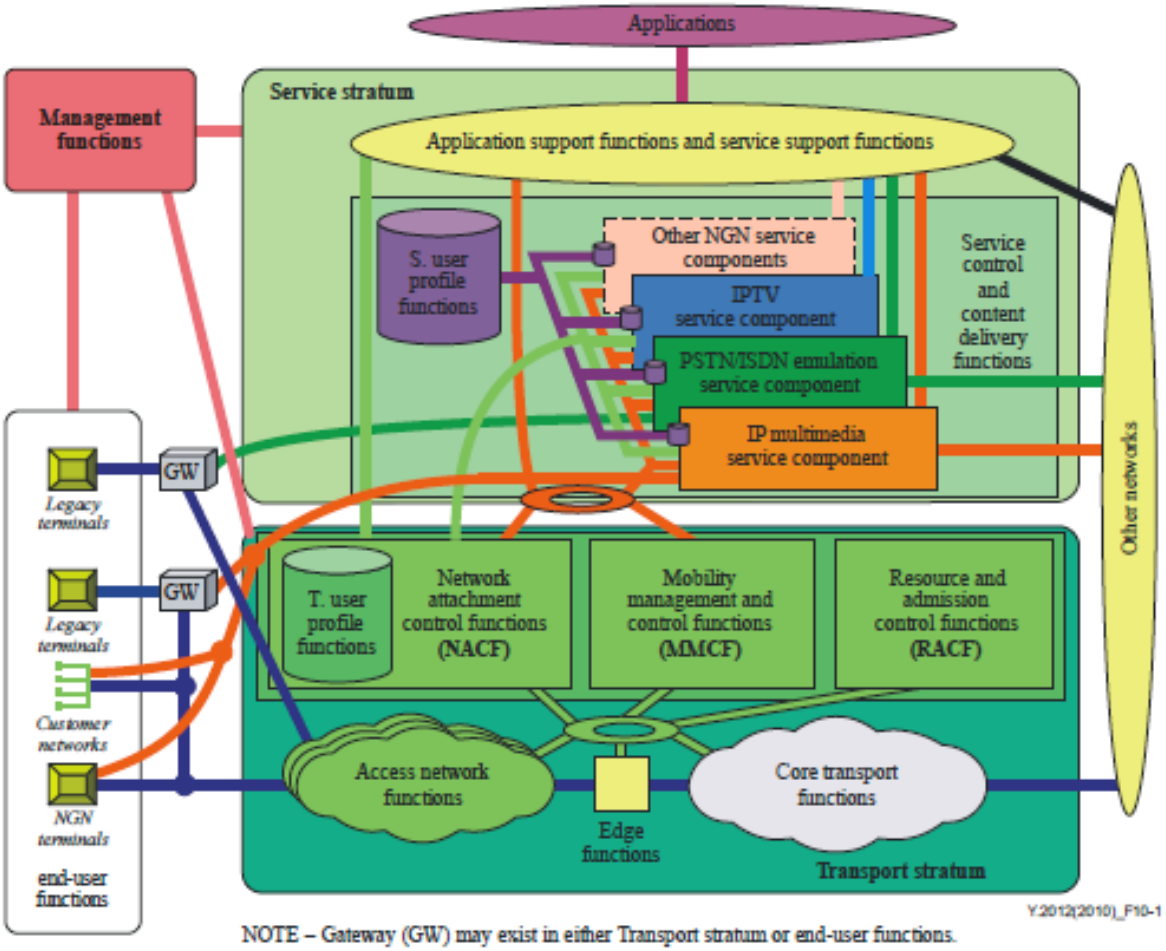


Figure 2 – NGN components

The service control layer includes IMS support. IMS was initially developed by the 3rd Generation Partnership Project (3GPP) for non-voice applications, such as Presence and Push-to-talk, and was then adopted by ETSI TISPAN and the ITU-T as a session control mechanism for voice and other services, such as Internet protocol television (IPTV), in NGN. IMS is extended in NGN to support

additional access network types such as digital subscriber line (xDSL) and wireless local area network (WLAN). IMS is a system specification based on the use of the session initiation protocol (SIP) defined by the IETF.

In addition, SIP user-network interface (UNI) and network-network interface (NNI) signalling profiles have been defined to ensure interoperability of equipment at these interfaces.

The content delivery functions (CDFs) receive content from the application and service support functions (for IPTV for example) and then store, process, and deliver this content under control of the SCFs to the end-user using the capabilities of the transport functions.

Identity management (IdM) is the set of functions and capabilities used for the assurance of identity information (e.g., identifiers, credentials or attributes) and of the identity of an entity (e.g., users/subscribers, groups, user devices, organizations, network and service providers, network elements and objects, and virtual objects).

The NGN functional entities controlling policy, sessions, media, resources, service delivery, security, etc., may be distributed over the infrastructure. When they are physically distributed, they communicate over open interfaces. Interworking between the NGNs of different operators and between NGNs and existing networks, such as the public switched telephone network (PSTN), integrated services digital network (ISDN) and the global system for mobile communications (GSM), is provided by means of gateways.

6.2 NGN functional architecture

The NGN functional architecture is defined in [b-ITU-T Y.2012 (2010)]. Functional entities are described to realize access and core packet transport; network access control, resource and admission control, mobility management; service control and content delivery; application and service support; identity management; charging and end-user CPE capabilities.

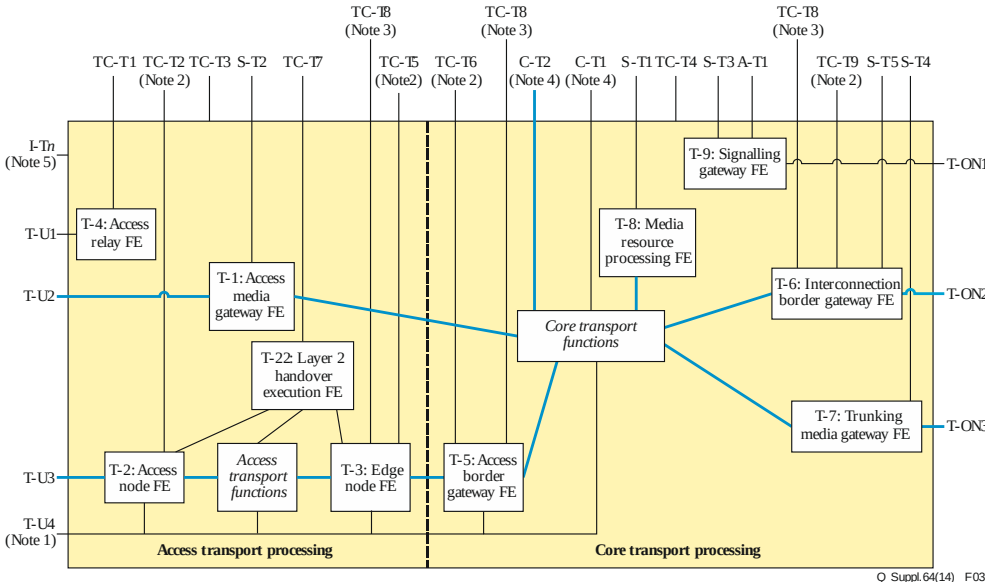
The functional architecture is dissected and its components described in more detail in the following clauses.

6.2.1 Transport stratum

6.2.1.1 Access and core transport functions

The access network includes functions for the connection of user equipment to the network using a variety of technologies (such as cable, xDSL, wireless and optical) and also the aggregation of traffic from a number of users. For example, [b-ITU-T Y.Sup6] describes how the DSL technology defined by the DSL Forum (now the Broadband Forum) can be used for NGN access. QoS control mechanisms, such as buffer management, queuing, scheduling, packet filtering, traffic classification, marking, policing and shaping, are supported in the access and core transport sections.

The processing functional entities of the transport stratum are shown in Figure 3.



NOTE 1 – T-U4 is a reference point between end-user functions and the transport processing functions that is used for multicast control. Depending on the network configuration, the T-U4 reference point can terminate in either the access node functional entity (AN-FE), or the edge node functional element (EN-FE), or the access border gateway functional entity (ABG-FE) or within the access or core transport functions. The entity terminating the T-U4 reference point includes EC-FE and EF-FE that are multicast capable, i.e., the EC-FE includes a multicast control point function (see [b-ITU-T Y.2017]), while the EF-FE includes a multicast replication function (see [b-ITU-T Y.2017]).

NOTE 2 – When used, the entity terminating the corresponding reference point includes a PE-FE.

NOTE 3 – When used, the entity terminating the corresponding reference point includes a Layer 3 handover execution function (L3HEF) as per [b-ITU-T Y.2018].

NOTE 4 – Although not shown in in this figure and depending on the network configuration, both C-T1 and C-T2 reference points can be connected to the access transport functions instead of the core transport functions.

NOTE 5 – This is to be understood as referring to the different I-Tn reference points that may exist between IdM functions and relevant transport functional entities (see clause 9.3.7 of [b-ITU-T Y.2012 (2010)] for further information).

NOTE 6 – Other reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 3 – Transport processing functional entities

The access media gateway functional entity (AMG-FE) (T-1) provides an interworking function between PSTN/ISDN lines and packet-based transport for the connection of legacy terminal equipment (TE). It has an interface to the access gateway control function in the service stratum that handles PSTN/ISDN call control signalling.

IP terminal equipment is connected to the access node functional entity (AN-FE) (T-2). This is a layer 2 device that may also support layer 3 (i.e., IP) functions. It supports QoS functions under the control of the RACF such as packet filtering, traffic classification, marking, policing and shaping at the flow or user level. If it is IP-enabled it may also support policy enforcement.

The edge node functional entity (EN-FE), T-3, is an IP-capable device that performs similar functions to the AN-FE at the interface to the core network.

The access relay functional entity (AR-FE), T-4, inserts local pre-configuration information when necessary. For example, when using dynamic host configuration protocol (DHCP), the AR-FE acts as a DHCP relay agent and may add information before forwarding a message, such as inserting the identifier of an ATM virtual channel carrying IP traffic in a DHCP request.

The access border gateway functional entity (ABG-FE), T-5, in the core transport section performs functions such as:

- opening and closing of gates (allowing certain packet flows but blocking others);
- packet filtering based on the use of a firewall;

- traffic classification and marking;
- traffic policing and shaping;
- network address and port translation;
- media relay (i.e., media latching) for NAPT traversal, in which the destination IP address of packets forwarded in the outbound direction is derived from the source IP address of packets received in the inbound direction;
- collection of traffic data (e.g., start-time, end-time, octets of sent data); and
- policy enforcement under the control of the RACF.

The ABG-FE may in addition support IPv4 – IPv6 conversion.

The interconnection border gateway functional entity (IBG-FE), T-6, supports the interconnection of one operator's core transport network with the core transport network of another operator. It has similar capabilities to the ABG-FE.

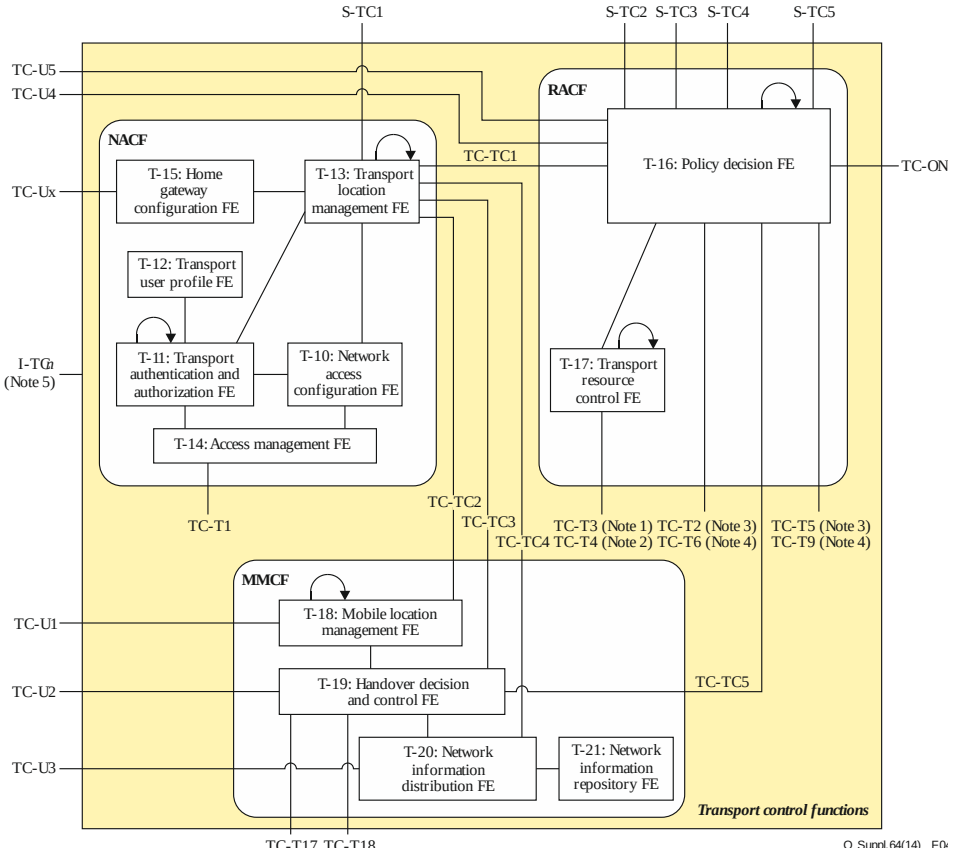
The media resource processing functional entity (MRP-FE), T-8, provides functions based on the processing of packet payloads. For example, it allocates specialized resources such as announcement servers, notification tones, voice recognition resources, voice menu and conference resources.

The trunking media gateway functional entity (TMG-FE) and signalling gateway functional entity (SG-FE), T-7 and T-9, respectively, are used for interconnection with PSTN/ISDN networks.

The transport stratum also includes policy enforcement and transport resource enforcement functional entities under the control of the policy decision and transport resource control functional entities, respectively, of the resource and admission control subsystem; and the layer 2 handover execution functional entity (L2HE-FE) under the control of the handover control functional entity.

6.2.1.2 Transport control functions

The transport control functions are shown in Figure 4.



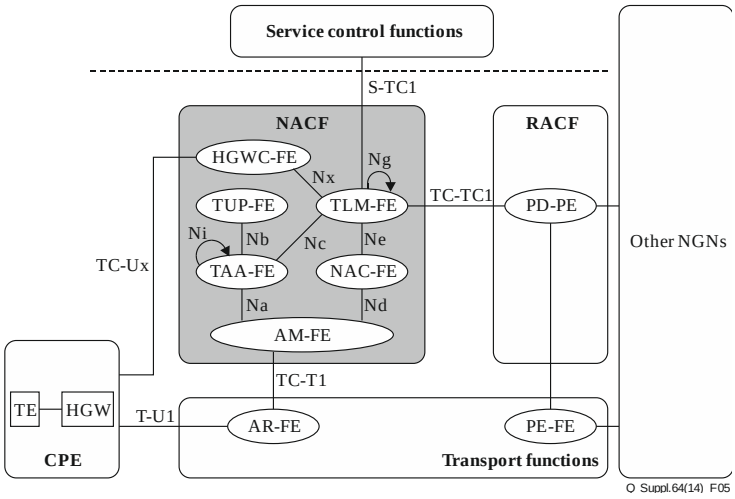
NOTE 1 – This reference point is applicable when TRC-FE operates in the access network domain.
NOTE 2 – This reference point is applicable when TRC-FE operates in the core network domain.
NOTE 3 – This reference point is applicable when PD-FE operates in the access network domain.
NOTE 4 – This reference point is applicable when PD-FE operates in the core network domain.
NOTE 5 – This is to be understood as referring to the different I-TC*n* reference points that may exist between IdM functions and relevant transport control functional entities (see clause 9.3.7 of [b-ITU-T Y.2012 (2010)] for further information).
NOTE 6 – Additional reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 4 – Transport control functional entities

6.2.1.2.1 Network attachment control function (NACF)

When a user's device is turned on it requires an IP address to be assigned (if it has not been allocated a permanent address) and a number of other parameters have to be configured. These are performed by the NACF. Apart from the dynamic provisioning of IP addresses and other CPE configuration parameters, procedures for mutual authentication (between the end user and the network) and authorization of network access (based on user profiles) are supported. The NACF also supports location management at the IP layer.

[b-ITU-T Y.2014] describes the network attachment control functions and a number of access scenarios. The functional entities comprising the NACF are shown in Figure 5.



NOTE – Reference points shown within the NACF are described in [b-ITU-T Y.2014], other reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 5 – NACF functional architecture

The NACF comprises the following functional entities:

- T-10 Network access configuration functional entity (NAC-FE);
- T-11 Transport authentication and authorization functional entity (TAA-FE);
- T-12 Transport user profile functional entity (TUP-FE);
- T-13 Transport location management functional entity (TLM-FE);
- T-14 Access management functional entity (AM-FE);
- T-15 Home gateway configuration functional entity (HGWC-FE).

Access management functional entity (AM-FE)

The AM-FE terminates the layer-2 transport connection between the CPE and the NACF for registration and initialization of the CPE. It translates network access requests issued by the CPE into a format that can be understood by the NACF; forwards requests for allocation of an IP address and possibly additional network configuration parameters to the NAC-FE; and forwards requests to the TAA-FE to authenticate the user, authorize or deny network access and retrieves user-specific access configuration parameters.

If the point-to-point protocol (PPP) [b-IETF RFC 1661] is used as the data link protocol, the AM-FE terminates the PPP connection and provides the interworking with the NACF using the remote authentication dial in user service (RADIUS) [b-IETF RFC 2865] or Diameter [b-IETF RFC 3588] protocols. The AM-FE acts as a RADIUS client if the TAA-FE is implemented in a RADIUS server.

Network access configuration functional entity (NAC-FE)

The NAC-FE is responsible for the allocation of IP addresses to the CPE. It may also distribute other network configuration parameters, such as the addresses of domain name system (DNS) server(s) and signalling proxies for specific service stratum components (for example, the address of the IMS P-CSCF). The NAC-FE is typically implemented using DHCP and RADIUS servers.

The NAC-FE may provide the CPE with an access network identifier to uniquely identify the access network to which the CPE is attached. The CPE may send this information to applications as a hint to locate the TLM-FE. The mechanism for transporting the access network identifier to the CPE uses

extensions to existing protocols (e.g., a new DHCP option or the use of DHCP option 120 [b-IETF RFC 2131]).

Transport authentication and authorization functional entity (TAA-FE)

The TAA-FE performs user authentication and network access authorization checking based on user profiles. The TAA-FE retrieves authentication data and access authorization information for each user from the user profile information contained in the TUP-FE.

Transport user profile functional entity (TUP-FE)

The TUP-FE is responsible for storing user profiles, such as the QoS profile, and addresses of the proxy call session control functional entity (P-CSC-FE) and HGWC-FE associated with the user. The TUP-FE performs basic data management and maintenance functions for user profile management.

Transport location management functional entity (TLM-FE)

The TLM-FE registers the association between the IP address allocated to the user equipment and the related network location information provided by the NAC-FE (e.g., the access line identifier). The TLM-FE registers the association between network location information received from the NAC-FE and geographical location information.

The TLM-FE may also store the identifier that is received from the TAA-FE of the user/user equipment to which the IP address has been allocated, as well as the user network QoS profile and user preferences regarding the privacy of location information. If the TLM-FE does not store this information, the TLM-FE is able to retrieve it from the TAA-FE.

The TLM-FE responds to location queries from service control components, such as the P-CSCF, and applications.

Home gateway configuration functional entity (HGWC-FE)

The HGWC-FE is used for the initialization and updating of home gateways. For example, firewalls can be configured internally in home gateways and indications of the required QoS marking of IP packets can be provided.

6.2.1.2.2 Resource and admission control subsystem (RACF)

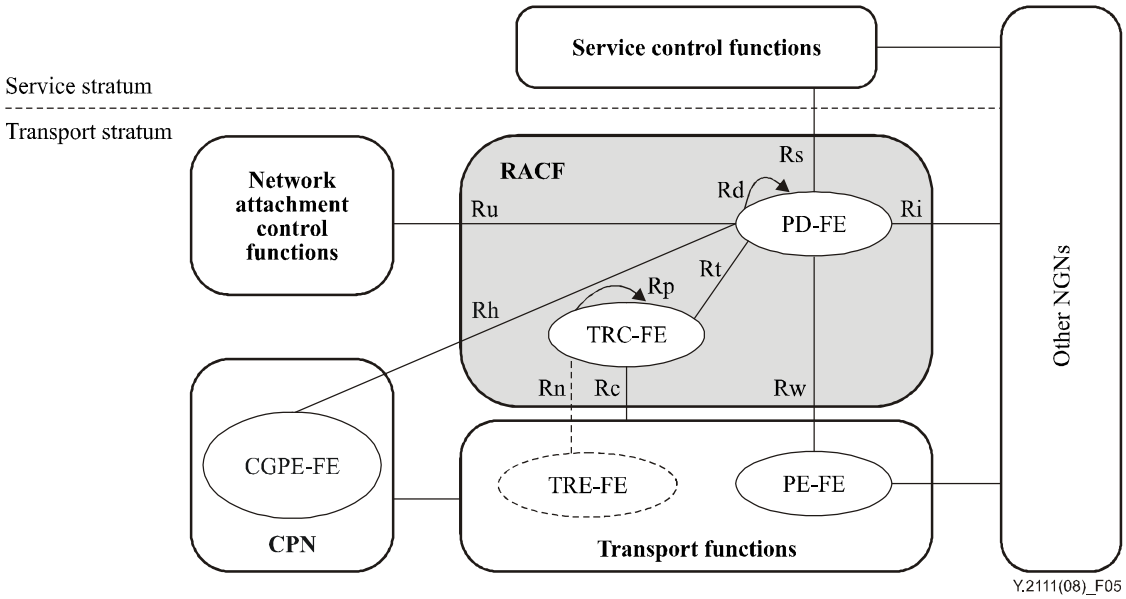
The functional architecture and requirements for resource and admission control are defined in [b-ITU-T Y.2111]. The RACF provides real-time application-driven and policy-based transport resource management in support of end-to-end QoS. Capabilities are provided for network border control (at access-core and inter-domain boundaries), gate and firewall control, network address translation and traversal of remote network address translators. The RACF is not service-specific and is applicable to a variety of access and core transport technologies. [b-ITU-T Y.2111] includes extensions to address issues related to multicast in support of IPTV services, nomadicity and interactions between CPE and the RACF.

The RACF acts as the arbitrator in the NGN architecture between SCFs and transport functions for QoS-related transport resource control within access and core networks. The provision of services is decoupled from the details of the transport facilities such as the network topology, connectivity, resource utilization and QoS mechanisms employed. Policy decisions are made by the RACF based on transport subscription information, SLAs, network policy rules, service priority (as defined by [b-ITU-T Y.2171], for example) and transport resource status and utilization information.

SCFs request policy-based transport resource control to be executed by the RACF. The RACF takes the capabilities of transport networks and associated transport subscription information for subscribers into account by interacting with the NACF TLM as described above. The RACF then

determines transport resource availability, makes admission decisions, and applies controls to transport functions for enforcing the policy decisions. The RACF interacts with transport functions for the purpose of controlling one or more of the following functions in the transport stratum: bandwidth reservation and allocation; packet filtering; traffic classification, marking, policing, and priority handling; network address and port translation; and firewall. QoS is ensured by making use of mechanisms such as those defined for differentiated services; the resource reservation protocol (RSVP) and multi-protocol label switching (MPLS).

The resource and admission control architecture is illustrated in Figure 6.



NOTE – Reference points are described in [b-ITU-T Y.2111].

Figure 6 – Generic resource and admission control functional architecture

The RACF consists of two functional entities: the policy decision functional entity (PD-FE) and the transport resource control functional entity (TRC-FE). This decomposition of PD-FE and TRC-FE enables the RACF to support a variety of access and core networks (e.g., fixed and mobile access networks) within a general resource control framework.

The PD-FE provides a single contact point to the SCF and hides the details of transport network from the SCF. The PD-FE makes the final decision regarding network resource and admission control based on network policy rules, SLAs, service information provided by the SCF, transport subscription information provided by the NACF, and resource-based admission decision results provided by TRC-FE. The PD-FE controls the gates in the policy enforcement functional entities (PE-FEs) at a per flow level. The PD-FE consists of transport technology-independent resource control functions. The policy rules used by the PD-FE are service-based. One PD-FE instance may serve multiple service providers and may control all, or a sub-set of, PE-FE instances belonging to the same domain. Multiple PD-FE instances within the same network operator's domain can be interconnected through the Rd reference point.

The TRC-FE deals with the diversity of underlying transport technologies and provides the resource-based admission control decision results to the PD-FE. The TRC-FE is service-independent and consists of transport technology-dependent resource control functions. The PD-FE requests the TRC-FE instances in the transport network via the Rt reference point to detect and determine the requested QoS resource along the media flow path. The TRC-FE may collect and maintain the transport network topology and the transport resource status information and authorize resource admission control of a

transport network based on network information such as topology and/or connectivity, network and element resource availability, as well as the transport subscription information in access networks.

Multiple TRC-FE instances may co-exist in a transport network, for the control of different non-overlapping sub-domains or areas, if part of the same core transport network can be interconnected at the Rp reference point. TRC-FE instances in different operators' domains interact indirectly through PD-FE instances.

The PD-FE may contact one or more TRC-FE instances. When only one designated TRC-FE instance is contacted, the TRC-FE instances communicate with each other through the Rp reference point to detect and determine the requested QoS resources from edge to edge in the network. When the PD-FE contacts multiple TRC-FE instances, the requested QoS resources are determined directly from each TRC-FE instance from edge to edge in the network.

Within a single domain, a given TRC-FE instance may interact with multiple PD-FE instances and a given PD-FE instance may interact with multiple TRC-FE instances.

SCFs in the service stratum of NGN request resources and admission control decisions for the media flows of a given service via the Rs reference point.

A transport infrastructure is shared among multiple SCF instances and even possibly shared among multiple service providers. Transport resource separation mechanisms (i.e., L1/L2/L3 virtual private network (VPN)) may be used among SCF instances for security and network performance.

The PE-FE in the transport stratum is a packet-to-packet gateway at the boundary of different packet networks and/or between the customer premises network (CPN) and access network. It is the key node to enforce dynamic QoS and resource control, NAPT control and network address traversal (NAT).

The CPN gateway policy enforcement functional entity (CGPE-FE) in the CPN enforces the transport policy rules for upstream traffic instructed by the PD-FE.

The transport resource enforcement functional entity (TRE-FE) in the transport stratum enforces the transport resource policy rules instructed by the TRC-FE at the technology-dependent aggregate level. Note that the detailed requirements for TRE-FE are different for different transport technologies.

6.2.1.2.3 Mobility management and control function (MMCF)

[b-ITU-T Q.1707] defines a generic framework for the support of mobility in the NGN transport and service strata. In addition, the transport control architecture has been enhanced by [b-ITU-T Y.2018] to include the control of IP-based mobility in NGN. The scope of [b-ITU-T Y.2018] differs from that of [b-ITU-T Q.1707] in that it only supports the mobility of a single device in the transport stratum as opposed to the movement of sessions from one device to another (session mobility). Mechanisms are provided to achieve seamless mobility if network conditions permit, but there are no mechanisms specified to deal with service adaptation if the post-handover QoS is degraded from the QoS before handover. Handover is supported across different technologies.

The functional entities of the MMCF are as follows:

T-18: Mobile location management functional entity (MLM-FE)

The MLM-FE manages location registration on behalf of the user equipment and manages the binding of IP addresses.

T-19: Handover decision and control functional entity (HDC-FE)

The HDC-FE has three sub-functions: handover decision function (HDF), layer 2 handover control function (L2HCF) and layer 3 handover control function (L3HCF).

T-20: Network information distribution functional entity (NID-FE)

The NID-FE distributes operator-defined handover policy.

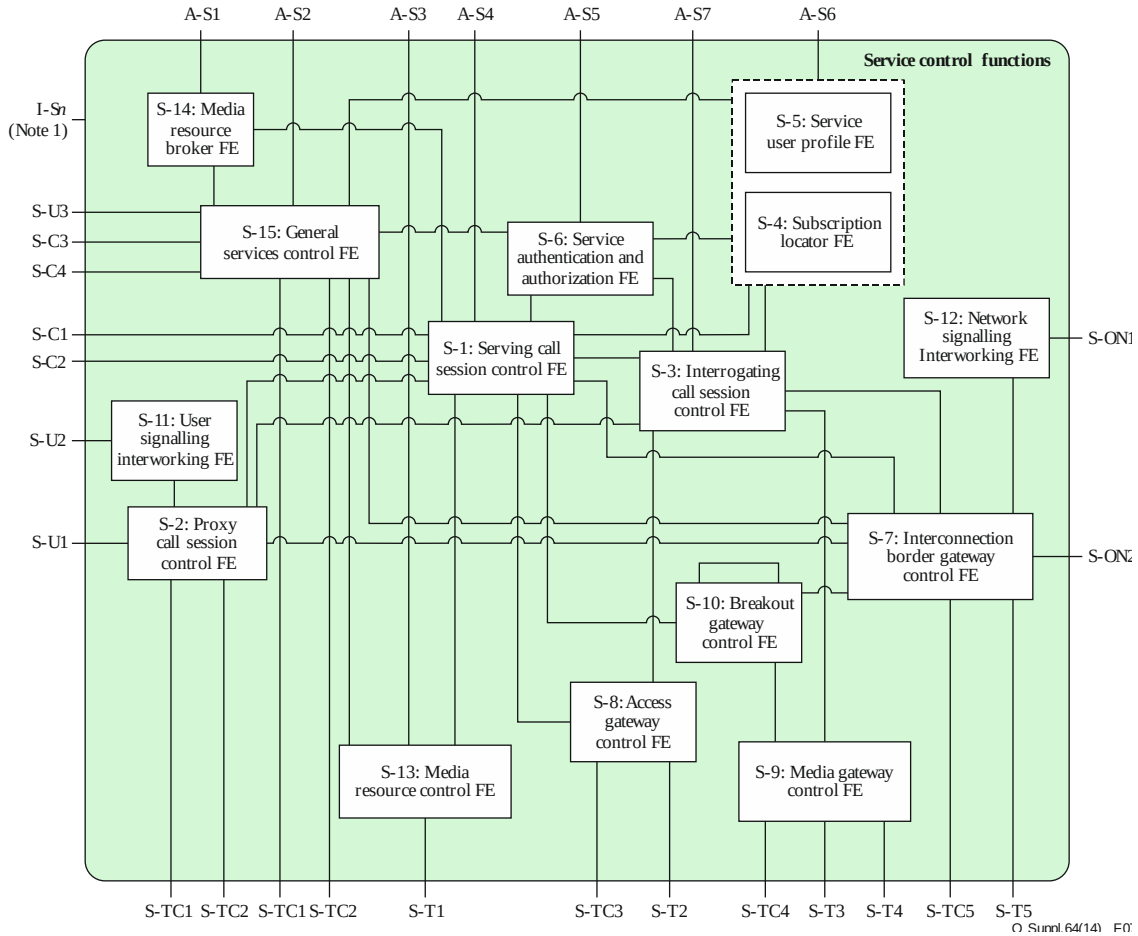
T-21: Network information repository functional entity (NIR-FE)

The NIR-FE provides static information on neighbouring networks to the NID-FE to assist the access network discovery and selection decision.

6.2.2 Service control and content delivery

6.2.2.1 Service control

The service control functional entities are shown in Figure 7.



NOTE – Reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 7 – Service control functional entities (see Figure 9-4 of [b-ITU-T Y.2012 (2010)] for an explanation of the Note)

S-1 Serving call session control functional entity (S-CSC-FE)

The S-CSC-FE handles user registration; session establishment, modification and teardown; and routing of session control messages.

S-2 Proxy call session control functional entity (P-CSC-FE)

The P-CSC-FE acts as the user contact point for session-based services and forwards session control requests to a S-CSC-FE or interrogating call session control functional entity (I-CSC-FE). Its address is provisioned statically or discovered via a NACF.

The P-CSC-FE controls ABG-FEs, AN-FE and EN-FEs via the RACF.

S-3 Interrogating call session control functional entity (I-CSC-FE)

The I-CSC-FE is the contact point within an NGN operator's network for all service connections destined to a user of that NGN operator.

S-4 Subscription locator functional entity (SL-FE)

The SL-FE is used by the S-CSC-FE, the I-CSC-FE or an application support functional entity (AS-FE) to obtain the address of the physical entity, the service user profile functional entity (SUP-FE) that holds the subscriber data for a given user identifier.

S-5 Service user profile functional entity (SUP-FE)

The SUP-FE is used to store user profiles, subscriber-related location and presence status data.

S-6 Service authentication and authorization functional entity (SAA-FE)

The SAA-FE ensures that the end-user has valid utilization rights for the requested service and performs policy control at the service level by using policy rules contained in a user profile database.

S-7 Interconnection border gateway control functional entity (IBC-FE)

The IBC-FE controls IBG-FEs via the RACF to interwork with other packet-based networks.

S-8 Access gateway control functional entity (AGC-FE)

The AGC-FE controls one or more AMG-FEs that provide access PSTN or ISDN users. The AGC-FE performs registration, authentication, and security for the AMG-FE and handles session control signalling.

S-9 Media gateway control functional entity (MGC-FE)

The MGC-FE controls the TMG-FE to interwork with the PSTN/ISDN.

S-10 Breakout gateway control functional entity (BGC-FE)

The BGC-FE selects the network in which PSTN breakout is to occur and selects the MGC-FE.

S-11 User signalling interworking functional entity (USIW-FE)

The USIW-FE performs interworking and information screening functions for different types of application signalling at the subscriber side (access-to-core).

S-12 Network signalling interworking functional entity (NSIW-FE)

The NSIW-FE performs interworking for different types and profiles of application signalling at trunking side (inter-network operator) interfaces.

S-13 Media resource control functional entity (MRC-FE)

The MRC-FE controls the MRP-FE resources that are needed for services such as streaming, announcements, and interactive voice response (IVR) support.

S-14 Media resource broker functional entity (MRB-FE)

The MRB-FE assigns specific media server resources (i.e., MRC-FE and MRP-FE) to incoming calls at the request of service applications (i.e., an AS-FE).

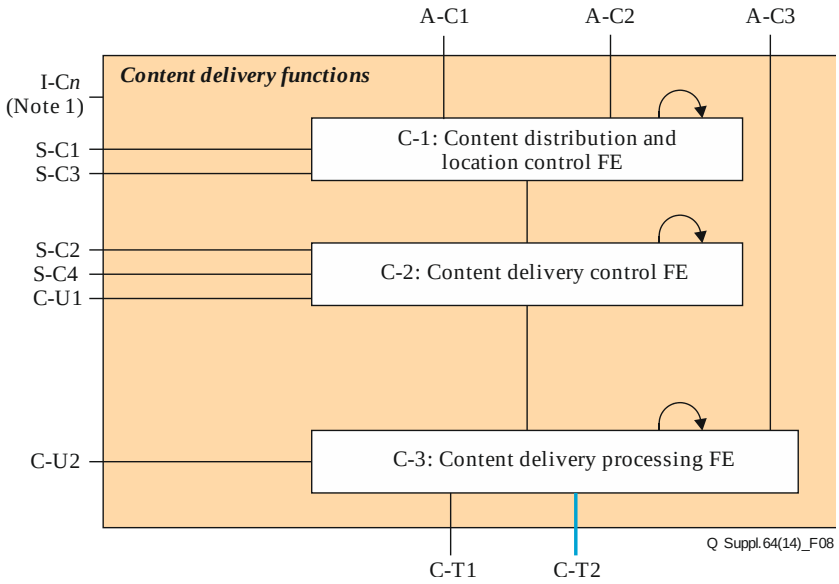
S-15 General services control functional entity (GSC-FE)

The GSC-FE provides support for services that do not require initial network-mediated session establishment procedures using a proxy call session control functional entity.

[b-ITU-T Q.3030] indicates the protocols that are employed on the interfaces between service control entities.

6.2.2.2 Content delivery

The CDFs perform cache and storage functions, optionally process the content and deliver it in accordance with instructions from end-user functions. Unicast and multicast delivery mechanisms are supported. The content delivery functional entities are shown in Figure 8.



NOTE – Reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 8 – Content delivery functional entities (see Figure 9-5 of [b-ITU-T Y.2012 (2010)] for an explanation of the Note)

C-1 Content distribution & location control functional entity (CD&LC-FE)

The CD&LC-FE handles interactions with the service control functional entities and controls the distribution of content from the content preparation functional entity (CPR-FE) to the content delivery processing functional entities (CDP-FEs).

C-2 Content delivery control functional entity (CDC-FE)

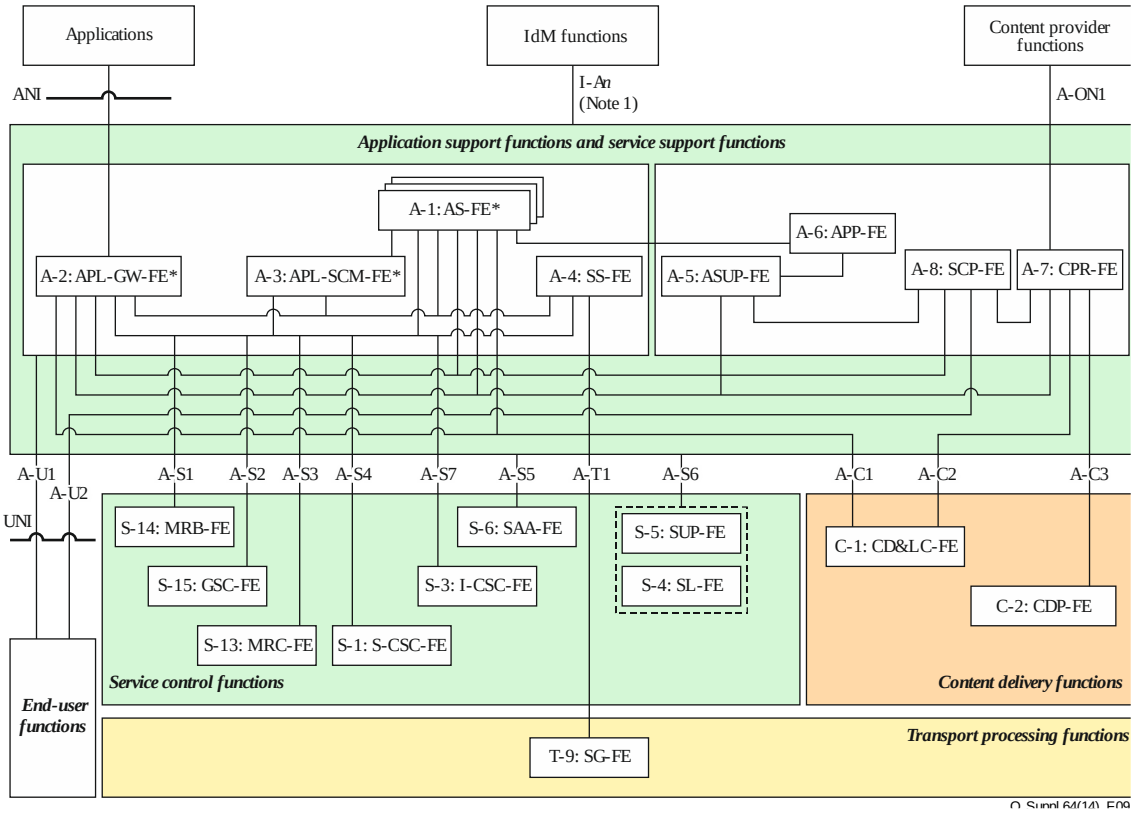
The CDC-FE controls media resources for the delivery of content.

C-3 Content delivery processing functional entity (CDP-FE)

The CDP-FE stores the content and processes it under the control of the CPR-FE and the CDC-FE. The CDP-FE is responsible for delivering content to the end-user functions using unicast and/or multicast transport mechanisms.

6.2.3 Application and service support functions

The application and service support functions are shown in Figure 9.



NOTE – Reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 9 – Application and service support functions (see Figure 9-6 of [b-ITU-T Y.2012 (2010)] for an explanation of the Note)

A-1 Application support functional entity (AS-FE)

The AS-FE supports generic application server functions, including hosting and executing services such as presence servers, various messaging servers (MeS), conferences servers, home application support servers, IPTV application support servers, service selection servers, service discovery servers, charging servers and accounting servers.

A-2 Application gateway functional entity (APL-GW-FE)

The APL-GW-FE serves as an interface between applications and the S-CSC-FE of the service stratum. It provides a secure open interface for the applications to use the capabilities and the resources of the NGN.

A-3 Application service coordination manager functional entity (APL-SCM-FE)

The APL-SCM-FE manages interactions between multiple applications and services.

A-4 Service switching functional entity (SS-FE)

The SS-FE provides access and interworking to a legacy intelligent network (IN) service control point (SCP). For IN services, the S-CSC-FE is connected through the SS-FE to the SG-FE to interact with a legacy IN SCP. The SS-FE provides IN service switching functions, including service trigger detection, service filtering, call state management and the protocol adaptation function between intelligent network application protocol (INAP) and SIP, for example.

A-5 Application support user profile functional entity (ASUP-FE)

The ASUP-FE includes information such as the capabilities of the end-user's terminal devices; language preference; application specific settings (e.g., parental control level for video on demand (VoD) application); subscribed service packages; and service action data, such as for IPTV, a list of linear TV programmes that the user has paused and is hence likely to resume later, a list of VoDs that the user has ordered and a list of PVR contents that the user has asked to be recorded.

A-6 Application provisioning functional entity (APP-FE)

The APP-FE adds or withdraws AS-FEs and manages the life-cycle of the applications supported by the AS-FEs.

A-7 Content preparation functional entity (CPR-FE)

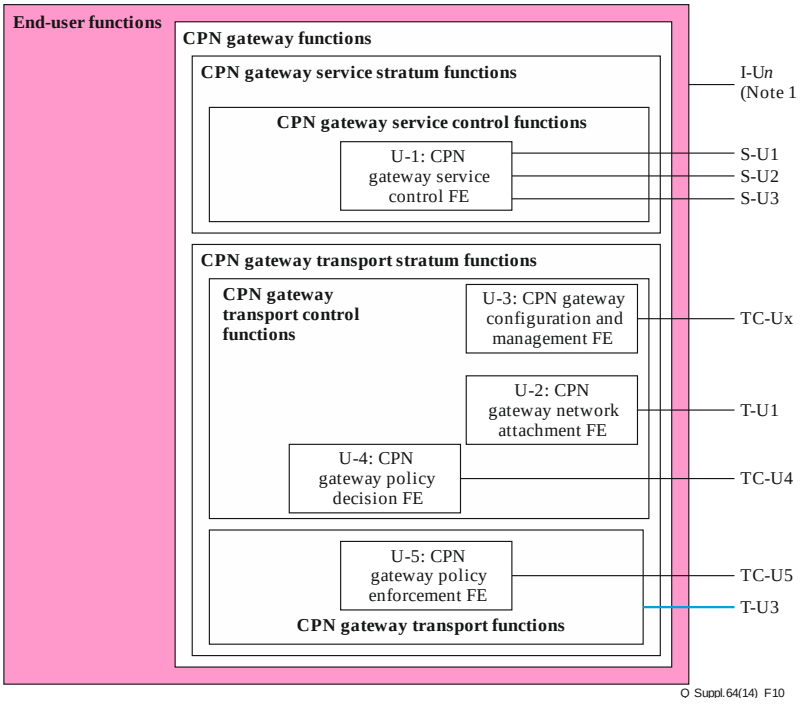
The CPR-FE controls the preparation and aggregation of contents received from the content provider functions such as VoD programmes, TV channel streams, metadata, and EPG data. The CPR-FE can optionally pre-process (e.g., transcode or edit) the content in advance of passing it to the content delivery functions, associated AS-FEs and service and content protection functional entities (SCP-FEs).

A-8 Service and content protection functional entity (SCP-FE)

The SCP-FE controls the protection of the services and content. Content protection includes control of accessing the content, using authentication and authorization schemes, and the protection of content using methods such as encryption.

6.2.4 End user functions

[b-ITU-T Y.2012 (2010)] describes CPN gateway functions and not all possible terminal functions. The CPN functions are illustrated in Figure 10.



NOTE – Reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 10 – End-user functional entities (see Figure 9-7 of [b-ITU-T Y.2012 (2010)] for an explanation of the Note)

U-1 CPN gateway service control functional entity (CGSC-FE)

A CPN gateway may include one or more CGSC-FE, such as a SIP access point to the NGN P-CSC-FE.

U-2 CPN gateway network attachment functional entity (CGNA-FE)

The CGNA-FE handles the allocation of IP addresses to the CPN gateway from the NAC-FE via the AR-FE.

U-3 CPN gateway configuration and management functional entity (CGCM-FE)

The CGCM-FE enables the configuration and management of the CPN gateway.

U-4 CPN gateway policy decision functional entity (CGPD-FE)

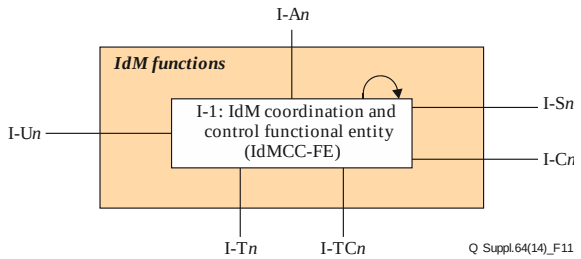
The CGPD-FE provides resource and admission control such as gate control, dynamic NAPT and firewall functions at the boundary between the CPN gateway and the NGN.

U-5 CPN gateway policy enforcement functional entity (CGPE-FE)

The CGPE-FE enforces the transport policy rules for upstream traffic instructed by the RACF PD-FE.

6.2.5 Identity management

IdM coordination and control is modelled with a single functional entity (see Figure 11). The IdM coordination and control functional entity (IdMCC-FE) interacts with many other functional entities within the NGN architecture.

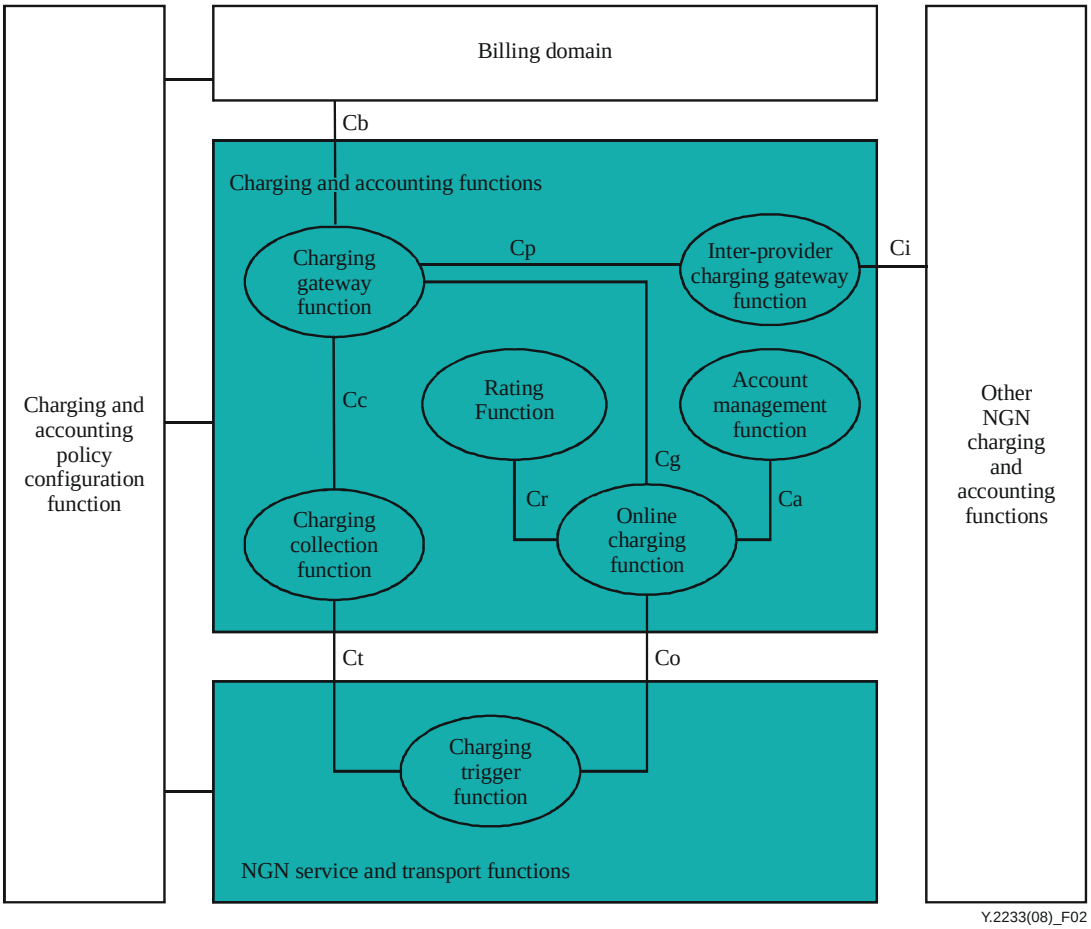


NOTE – Reference points are described in [b-ITU-T Y.2012 (2010)].

Figure 11 – Identity management functional entity

6.2.6 Charging and accounting

[b-ITU-T Y.2233] provides the technical requirements and a framework for accounting and charging capabilities within NGN. Many functional entities in NGN generate accounting and charging related information (see [b-ITU-T Y.2233]). The functional architecture for charging and accounting is shown in Figure 12.



NOTE – Reference points are described in [b-ITU-T Y.2233].

Figure 12 – Functional architecture for charging and accounting in NGN

The charging triggering function (CTF) generates charging events based on the observation of network resource usage. In every network and service element that provides charging information, the CTF is the focal point for collecting information pertaining to chargeable events within the network element, assembling this information into matching charging events, and sending these charging events to the charging collection function. The CTF is therefore a necessary component in all network elements that provide offline-charging functionality. The CTF also creates the charging events used for online charging. The charging events are forwarded to the online charging function (OCF) in order to obtain authorization for the chargeable event or network resource usage requested by the user.

The charging collection function (CCF) receives charging events from the CTF that it then uses to construct charging information records (CIRs). The CCF also supports NGN services that cannot simply be charged by event-based or session-based charging schemes. Some examples of additional charging schemes are data volume-based, flow-based, QoS-based and content-type-based. The CCF is used for offline charging.

The OCF receives charging events from the CTF and provides near real-time authorization for the chargeable event or network resource usage requested by the user. The OCF supports session-based, event-based, and flow-based charging functions.

The rating function (RF) determines the value of the network resource usage (described in the charging event received by the OCF from the network) on behalf of the OCF. To this end, the OCF furnishes the necessary information to the RF and receives the rating output.

The RF also works with the offline-charging module as it determines the value of the network resource usage (described in the charging event received by the CCF from the network). For this, it calculates and reserves a number of non-monetary units such as service units, data volume, flow volume, time and events. It then determines the price by calculating monetary units for a given number of non-monetary units. Finally, it determines tariff information based on the subscribers contractual terms and the service being requested.

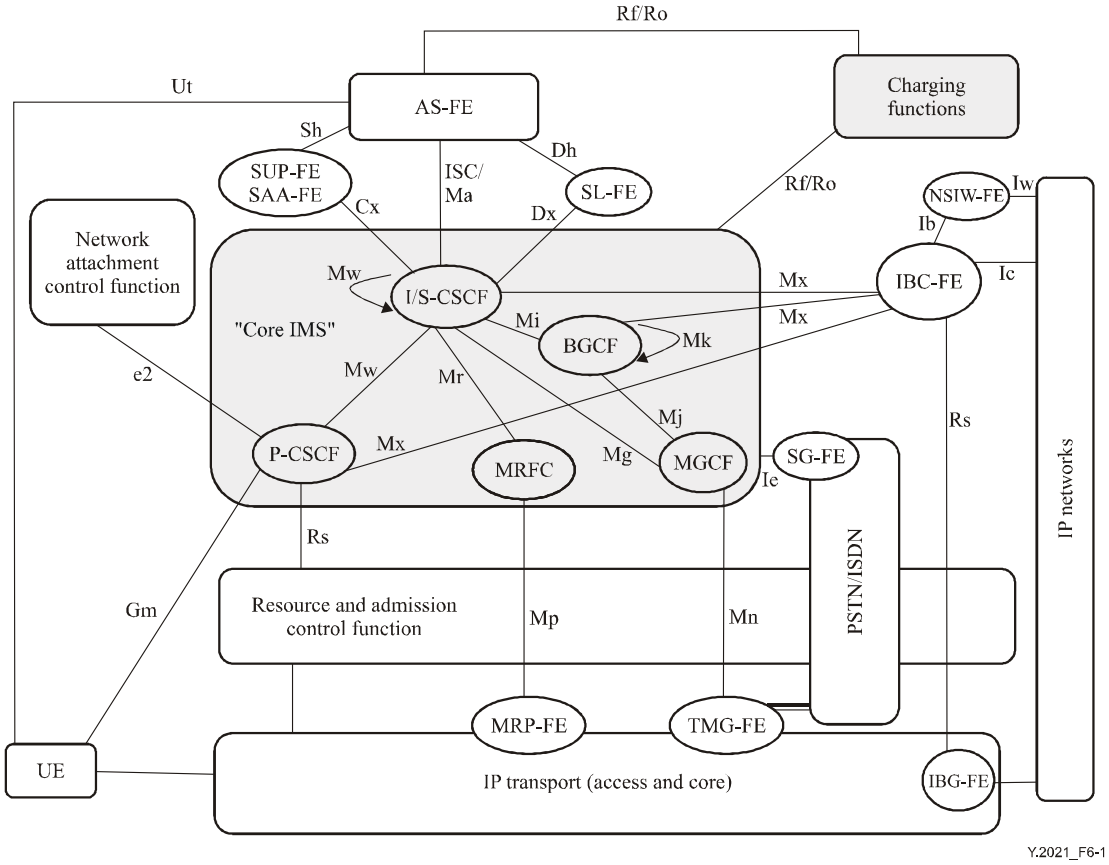
The account management function (AMF) stores the subscriber's account balance within the online charging system. The subscriber's account balance can be represented by the remaining available traffic volume (e.g., bytes), time (e.g., minutes for calling), or content (e.g., a movie), as well as credit. The AMF checks, updates, and reserves the account balance. It may also manage counters for online charging.

The charging gateway function (CGF) receives CIRs generated by the CCF and plays a gateway role between the NGN network and the billing domain or another NGN CGF.

The inter-provider charging gateway function (IPCGF) receives CIRs and other processed information from the CGF. It adds any additional information needed for inter-provider charging information exchanges. It allows NGN providers exchange CIRs in real-time over a standardized interface.

7 Physical realization of the NGN functional architecture

Implementation of NGN services involves the realization of a number of functional entities. IMS, for example, is a collection of core network functional entities for the support of SIP-based services (see Figure 13) that may be realized in a single system along with other functional entities, such as those concerned with transport control.



NOTE – Reference points are described in [b-ITU-T Y.2021].

Figure 13 – IMS and its environment (see [b-ITU-T Y.2021] for further information)

Another example is that of session border controllers (SBCs) that enable communication across the borders or boundaries of disparate networks. They incorporate both media and signalling path functions and so combine NGN service and transport stratum functions.[1]

SBCs therefore represent a grouping of NGN service control functionalities, transport control functionalities and transport functional entities. The SBC controls the media path using the corresponding functionalities of the NGN transport stratum and controls the signalling path using the corresponding functionalities of the NGN service stratum. This correspondence is shown in Figure 14.

1 [b-ITU-T Y.Sup2] describes how session/border controllers can be implemented within the NGN architecture.

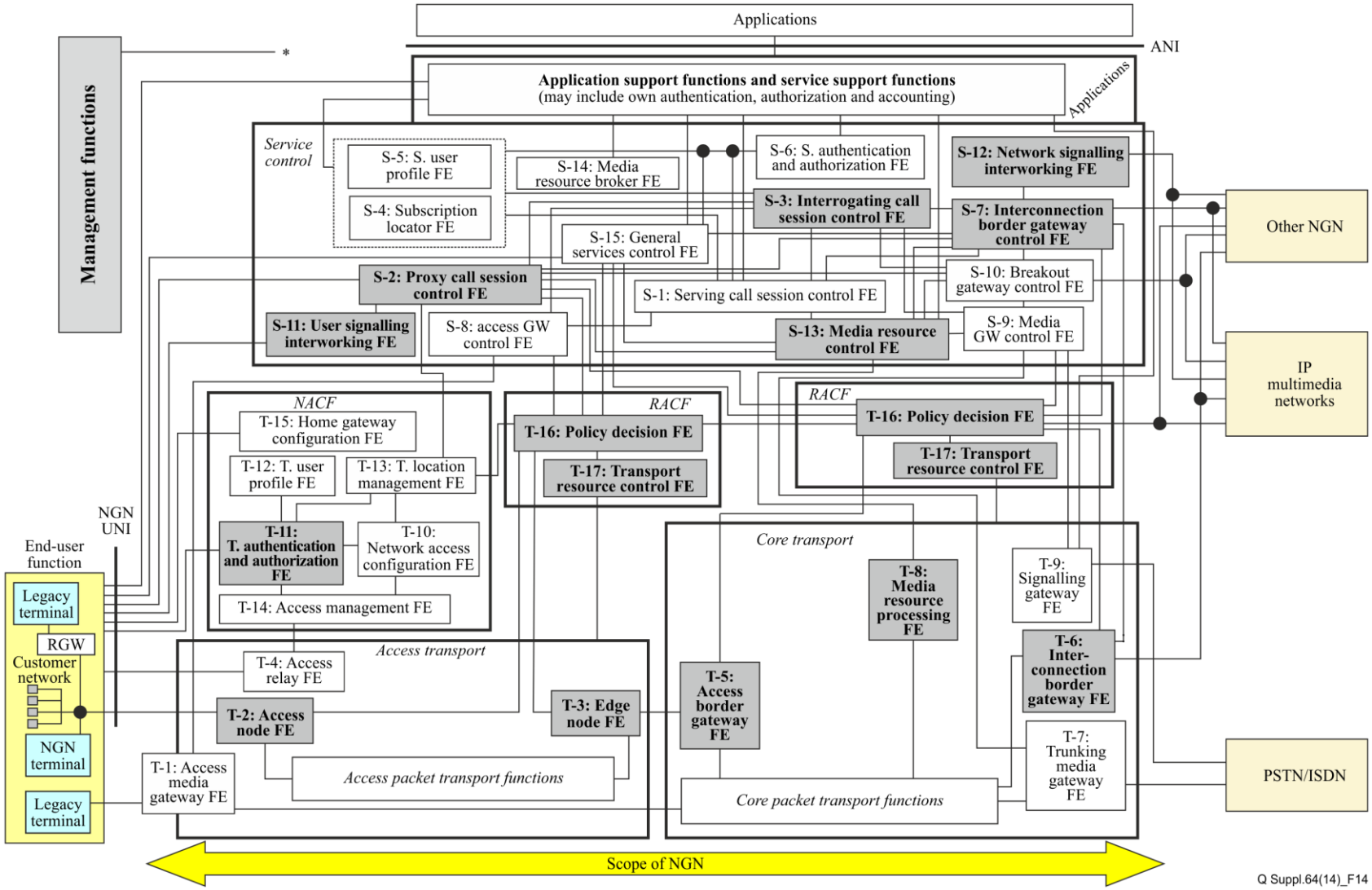


Figure 14 – Functional entities corresponding to S/BC (highlighted)

As noted earlier, [b-ITU-T Q.3030] describes the protocols that are used on all of the various interfaces of the NGN architecture for service control. [b-ITU-T Q.3050] refines this description by specifying a number of physical entities that represent a number of functional entities. Interfaces are defined between these physical entities with corresponding protocols. The physical entities defined are shown in Table 1 (Table 8-1 of [b-ITU-T Q.3050]) and the interfaces between these physical entities in Table 2 (derived from Tables 8-2 and 9-1 of [b-ITU-T Q.3050]).

Table 1 – Mapping functions and functional blocks into physical entities

Physical entities	Functions and functional blocks included
AF-PE	Application functions
ASS-PE	Application support functions, service support functions, etc.
SC-PE	Service control functional, service user profile functional block
CD-PE	Content distribution and location control functions, content delivery and storage functions
NAC-PE	Network attachment control functions (NACF)
PD-PE	Policy decision functional entity
TRC-PE	Transport resource control functional entity
T-PE	Access network functions, edge functions, core transport functions
PE-PE	Policy enforcement functional entity
UE	Application client functions, session client functional block, SCP client functions, content delivery client functions, home network functions

Table 2 – Internal NGN Interfaces

Interface	Interface between	Reference points in NGN architecture	Protocol	Recommendation
Ia-s	ASS-PE & SC-PE	A-S1, A-S2, A-S3, A-S4, A-S5, A-S6, A-S7	SIP	ITU-T Q.1741.6
Ia-c	ASS-PE & CD-PE	A-C1, A-C2, A-C3	SIP	ITU-T Q.1741.6
Is-c	SC-PE & CD-PE	S-C1, S-C2, S-C3, S-C4	SIP	ITU-T Q.1741.6
Is-n	SC-PE & NAC-PE	S-TC1	Diameter	ITU-T Q.3221
Ic-t	CD-PE & T-PE	C-T1, C-T2	For further study	–
In-t	NAC-PE & T-PE	TC-T1	For further study	–
Rs	SC-PE & PD-PE	S-TC2, S-TC3, S-TC4, S-TC5	Diameter	ITU-T Q.3301.1
Rt	PD-PE & TRC-PE	–		
Rw	PD-PE & PE-PE	TC-T1, TC-T2, TC-T5, TC-T6, TC-T9	COPS-PR/H.248/ Diameter	ITU-T Q.3303.0 to Q.3303.3
Rc	TRC-PE & T-PE	TRC-PE & T-PE	COPS-PR/SNMP	ITU-T Q.3304.1 & Q.3304.2
Rp	TRC-PE & TRC-PE		RCIP	ITU-T Q.3302.1

External interfaces are defined in [b-ITU-T Q.3050] from the user equipment to the network (i.e., UNI), between networks (i.e., NNI), between applications and the network (i.e., application network interface (ANI)) and services and the network (i.e., service network interface (SNI)).

[b-ITU-T Q.3040] describes the signalling architecture of the control plane for IPTV. When implementing the IPTV architecture some of the functional entities may be grouped and implemented in a limited number of physical entities. [b-ITU-T Q.3040] gives examples of how the functional entities can be grouped for both IMS and non-IMS based NGN IPTV implementations and specifies the protocols to be used on the interfaces between the physical entities.

[b-ITU-T Q.3900] describes a number of possible physical entities for the realization of NGN. These are shown in Table 3 along with the corresponding NGN functional entities[2].

Table 3 – Correspondence of NGN functional entities with possible NGN system implementation components

Physical component	Functional Entities
Call/session control system	
Media gateway controller (MGC)	S-3, S-7, S-9, S-10, S-12
	T-10, T-11, T-12, T-13
SIP proxy server (PS)	S-2, S-3, S-7, S-11, S-12
	T-10, T-11, T-12, T-13
IP multimedia subsystem (IMS)	S-1, S-3, S-7, S-8, S-10, S-12, S-13
	T-10, T-11, T-12, T-13, T-14, T-15, T-16, T-17
Voice and signalling transmission system	
Media gateway (GW)	T-7, T-8
Signalling gateway (SG)	T-8, T-9
Transport network environment (TNE)	T-5, T-6, T-8
Application servers	
Application server (AS)	S-4, S-5, S-6, S-14, S-15
Media server (MDS)	S-4, S-5, S-6, S-14, S-15
Messaging server (MeS)	S-4, S-5, S-6, S-14, S-15
Management and billing system	
Management system (MS)	Error processing management Equipment configuration management Billing system management Service management Security management
Billing system (BS)	
Access environment	
NGN integrated access device (NGN-IAD)	T-2, T-3, T-4, T-5, T-14, T-15
Media gateway for legacy terminal equipment (GW-LTE)	T-1, T-2, T-3, T-4, T-5

[2] This table has the same contents as Table 7-1 of [b-ITU-T Q.3900] but uses different terminology. The term "physical component" is used instead of the equivalent term "NGN technical means" in [b-ITU-T Q.3900] and "functional entities" instead of "NGN functionality". The title of the table has also been changed accordingly.

Table 4 indicates possible physical component realizations for each functional entity. It includes the information given in Table 7-1 of [b-ITU-T Q.3900] and [b-ITU-T Y.Sup2]. The physical components are as specified in [b-ITU-T Q.3900] as NGN technical means with the addition of the physical components of the session border controller (SBC), which refers to the session/border control (S/BC) as defined in [b-ITU-T Y.Sup2].

NOTE – [b-ITU-T Y.Sup2] defines S/BC as follows: Session/border control (S/BC) is a set of functions that enables interactive communication across the borders or boundaries of disparate IP networks. It provides sessions of real-time IP voice, video and other data across borders between IP networks and provides control over security, QoS, service level agreements and other functions using IP signalling protocols.

Those functional entities for which no description of a physical realization is specified in an ITU-T Recommendation are marked as for further study.

Table 4 – Possible physical component realizations for each NGN functional entity

Functional Entity	Physical Component
T-1 access media gateway (AMG-FE)	GW-LTE
T-2 access node (AN-FE)	GW-LTE, NGN-IAD, SBC
T-3 edge node (EN-FE)	GW-LTE, NGN-IAD, SBC
T-4 access relay (AR-FE)	GW-LTE, NGN-IAD
T-5 access border gateway (ABG-FE)	GW-LTE, NGN-IAD, SBC, TNE
T-6 interconnection border gateway (IBG-FE)	SBC, TNE
T-7 trunking media gateway (TMG-FE)	GW
T-8 media resource processing (MRP-FE)	TNE, GW, SG, SBC
T-9 signalling gateway (SG-FE)	SG
Policy Enforcement	For further study. SBC
Transport Resource Enforcement	For further study. SBC
T-10 network access configuration (NAC-FE)	MGC, PS, IMS
T-11 transport authentication and authorization (TAA-FE)	MGC, SBC, PS, IMS
T-12 transport user profile (TUP-FE)	MGC, PS, IMS
T-13 transport location management (TLM-FE)	MGC, PS, IMS
T-14 access management (AM-FE)	NGN-IAD, IMS
T-15 home gateway configuration (HGWC-FE)	NGN-IAD, IMS
T-16 policy decision (PD-FE)	SBC, IMS
T-17 transport resource control (TRC-FE)	SBC, IMS
T-18 mobile location management (MLM-FE)	For further study
T-19 handover decision and control (HDC-FE)	For further study
T-20 network information distribution (NID-FE)	For further study
T-21 network information repository (NIR-FE)	For further study
T-22 layer 2 handover execution (L2HE-FE)	For further study
S-1 serving call session control (S-CSC-FE)	IMS
S-2 proxy call session control (P-CSC-FE)	SBC, PS
S-3 interrogating call session control (I-CSC-FE)	MGC, SBC, PS, IMS
S-4 subscription locator (SL-FE)	AS, MDS, MeS
S-5 service user profile (SUP-FE)	AS, MDS, MeS

Table 4 – Possible physical component realizations for each NGN functional entity

Functional Entity	Physical Component
S-6 service authentication and authorization (SAA-FE)	IMS, AS, MDS, MeS
S-7 interconnection border gateway control (IBC-FE)	MGC, SBC, PS, IMS
S-8 access gateway control (AGC-FE)	IMS
S-9 media gateway control (MGC-FE)	MGC
S-10 breakout gateway control (BGC-FE)	MGC, IMS
S-11 user signalling interworking (USIW-FE)	SBC, PS
S-12 network signalling interworking (NSIW-FE)	MGC, SBC, PS, IMS
S-13 media resource control (MRC-FE)	SBC, IMS
S-14 media resource broker (MRB-FE)	AS, MDS, MeS
S-15 general services control (GSC-FE)	AS, MDS, MeS
C-1 content distribution & location control (CD&LC-FE)	For further study.
C-2 content delivery control (CDC-FE)	For further study.
C-3 content delivery processing (CDP-FE)	For further study.
A-1 application support (AS-FE)	For further study.
A-2 application gateway (APL-GW-FE)	For further study.
A-3 application service coordination manager (APL-SCM-FE)	For further study.
A-4 service switching (SS-FE)	For further study
A-5 application support user profile (ASUP-FE)	For further study.
A-6 application provisioning (APP-FE)	For further study.
A-7 content preparation (CPR-FE)	For further study.
A-8 service and content protection (SCP-FE)	For further study.
U-1 CPN gateway service control (CGSC-FE)	For further study.
U-2 CPN gateway network attachment (CGNA-FE)	For further study.
U-3 CPN gateway configuration and management (CGCM-FE)	For further study.
U-4 CPN gateway policy decision (CGPD-FE)	For further study.
U-5 CPN gateway policy enforcement (CGPE-FE)	For further study.
I-1 IdM coordination and control (IdMCC-FE)	(Note).
NOTE – The IdMCC-FE interacts with many functional entities that use identity information (A-1, A-2, A-3, A5, A-8, S-1, S-2, S-3, S-4, S-5, S-6, S-7, S-15, C-1, C-2, T-5, T-6, T-10, T-11, T-12, T-13, T-14, T-16, T-18, T-21, U-1, U-2, U-3, U-4 and U-5) and there are therefore identity management aspects involved in realizing those functional entities in system components.	

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