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

Next Generation Networks – Frameworks and functional architecture models

Network attachment control functions in next generation networks

Recommendation ITU-T Y.2014

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Recommendation ITU-T Y.2014

Network attachment control functions in next generation networks

Summary

Recommendation ITU-T Y.2014 describes the network attachment control functions (NACF) component of the NGN functional architecture. This Recommendation also identifies relevant access scenarios related to the NACF.

In particular, this edition includes extensions to Recommendation ITU-T Y.2014 (2008) to address the issues related to multicast and mobility in support of IPTV service and mobility service, respectively.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2014	2008-05-07	13
2.0	ITU-T Y.2014	2010-03-16	13

Keywords

Functional architecture, network attachment, NGN.

FOREWORD

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Network attachment control functions in next generation networks

1 Scope

This Recommendation describes the network attachment control functions (NACF) component of the NGN functional architecture as defined in [ITU-T Y.2012]. This Recommendation also identifies relevant access scenarios related to the NACF.

This Recommendation includes the reference points for the interactions with other NGN components (RACF, MMCF, and SCF) in order to provide the network attachment functions for the fixed, nomadic and mobile terminal/user.

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 Q.1761] Recommendation ITU-T Q.1761 (2004), *Principles and requirements for convergence of fixed and existing IMT-2000 systems*.

[ITU-T X.800] Recommendation ITU-T X.800 (1991), *Security architecture for Open Systems Interconnection for CCITT applications*.

[ITU-T Y.1541] Recommendation ITU-T Y.1541 (2006), *Network performance objectives for IP-based services*.

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

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2006), *Functional requirements and architecture of the NGN release 1*.

[ITU-T Y.2018] Recommendation ITU-T Y.2018 (2009), *Mobility management and control framework and architecture within the NGN transport stratum*.

[ITU-T Y.2021] Recommendation ITU-T Y.2021 (2006), *IMS for Next Generation Networks.*

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

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

[ITU-T Y.2702] Recommendation ITU-T Y.2702 (2008), *Authentication and authorization requirements for NGN release 1.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 authorization [ITU-T X.800]: The granting of rights, which includes the granting of access based on access rights.

NOTE – In some contexts, authorization may be granted without requiring authentication or identification, e.g., emergency call services.

3.1.2 nomadism [ITU-T Q.1761]: Ability of the user to change his network access point after moving; when changing the network access point, the user's service session is completely stopped and then started again, i.e., there is no handover possible. It is assumed that the normal usage pattern is that users shutdown their service session before moving to another access point or changing terminal. This is the mobility alluded to in the case of fixed mobile convergence.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 authentication: A property by which the correct identifier of an entity or party is established with a required assurance. The party being authenticated could be a user, subscriber, home environment or serving network.

3.2.2 customer premises equipment (CPE): One or more devices allowing a user to access services delivered by NGN.

NOTE – This includes devices under user control commonly referred to as home gateway (HGW) or terminals (TE), etc., but not network controlled entities such as access gateways.

3.2.3 explicit authentication: Authentication that requires that the party to be authenticated performs an authentication procedure (to verify the claimed identification of the party).

3.2.4 home gateway (HGW): Gateway between the customer premises network (CPN) and the access network.

NOTE – A home gateway may be in its simplest form a bridged or routed modem, and in a more advanced form be an integrated access device.

3.2.5 implicit authentication: Authentication based on a trusted relationship already established between two parties, or based on one or more outputs of an authentication procedure already established between two parties.

3.2.6 line identification: A process that establishes the identifier of the line based on the trusted configuration.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA	Authentication, Authorization and Accounting
ABG-FE	Access Border Gateway Functional Entity
ACL	Access Control List
AM-FE	Access Management Functional Entity
AN	Access Network
AN-FE	Access Node Functional Entity
API	Application Programming Interface

AR-FE	Access Relay Functional Entity
ATM	Asynchronous Transfer Mode
CoS	Class of Service
CPE	Customer Premises Equipment
CPN	Customer Premises Network
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name Server
EAP	Extensible Authentication Protocol
EN-FE	Edge Node Functional Entity
FQDN	Fully Qualified Domain Name
FTP	File Transfer Protocol
GTP	GPRS Tunnelling Protocol
HDC-FE	Handover Decision and Control Functional Entity
HGW	Home Gateway
HGWC-FE	Home Gateway Configuration Functional Entity
HTTP	Hyper Text Transfer Protocol
ID	Identifier
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPTV	Internet Protocol TeleVision
MAC	Media Access Control
MIP	Mobile Internet Protocol
MLM-FE	Mobile Location Management Functional Entity
MLM-FE(P)	An instance of the MLM-FE performing the proxy mobile location management role
MMCF	Mobility Management and Control Functions
MPLS	Multi-Protocol Label Switching
NACF	Network Attachment Control Functions
NAC-FE	Network Access Configuration Functional Entity
NGN	Next Generation Network
NID-FE	Network Information Distribution Functional Entity
PAA	PANA Authentication Agent
PaC	PANA Client
PANA	Protocol for Carrying Authentication for Network Access
P-CSCF	Proxy-Call Session Control Function
PD-FE	Policy Decision Functional Entity
PE-FE	Policy Enforcement Functional Entity

PIA	Persistent IP Address
PPP	Point-to-Point Protocol
QoS	Quality of Service
RACF	Resource and Admission Control Functions
SADS	Service and Application Discovery and Selection
SCF	Service Control Functions
SLA	Service Level Agreement
SUP-FE	Service User Profile Functional Entity
TAA-FE	Transport Authentication and Authorization Functional Entity
TE	Terminal Equipment
TFTP	Trivial File Transfer Protocol
TIA	Temporary IP Address
TLM-FE	Transport Location Management Functional Entity
TUP-FE	Transport User Profile Functional Entity
VC	Virtual Channel
VCI	Virtual Channel Identifier
VPI	Virtual Path Identifier
VPN	Virtual Private Network
WLAN	Wireless Local Area Network

5 Conventions

This Recommendation does not make use of specific conventions.

6 General description

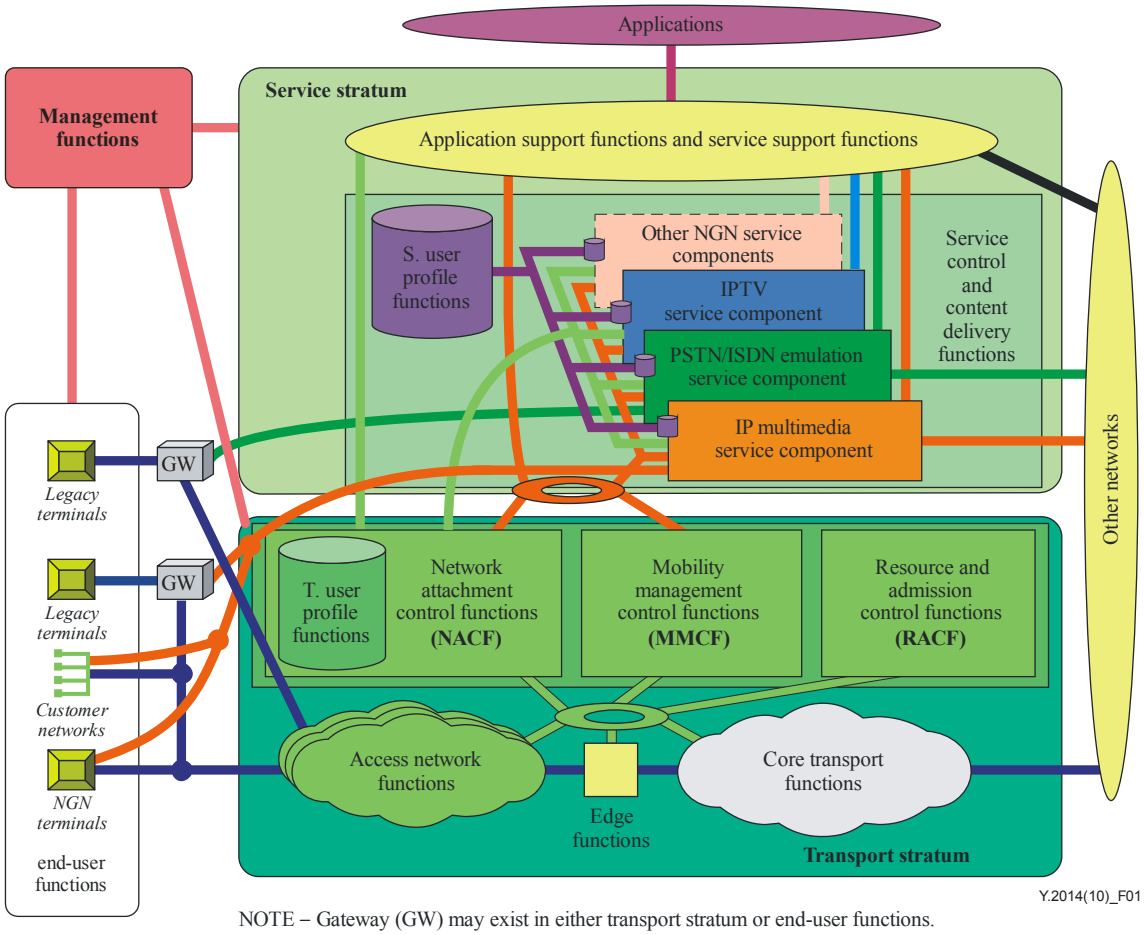
6.1 High level functional overview

The NACF provides the following functionalities:

- Dynamic provisioning of IP addresses and other CPE configuration parameters.
- By endorsement of user, auto-discovery of CPE capabilities and other parameters.
- Authentication of end user and network at the IP layer (and possibly other layers). Regarding the authentication, mutual authentication between end user and the network attachment is performed.
- Authorization of network access, based on user profiles.
- Access network configuration, based on user profiles.
- Location management at the IP layer.

The user profiles mentioned above are related to the access transport network subscription only and are referred as "Transport Subscription Profiles" in the remaining part of this Recommendation.

The location of the NACF component in the overall NGN architecture can be found in [ITU-T Y.2012] and is placed here for information in Figure 1.



NOTE – Gateway (GW) may exist in either transport stratum or end-user functions.

Figure 1 – NGN components including NACF

6.2 High level concepts of NACF

The NACF provides registration at the access level and initialization of CPE for accessing the NGN services. The NACF provides network level identification and authentication, manages the IP address space of the access network and authenticates access sessions. The NACF also announces the contact point(s) of the NGN service stratum components to the CPE.

Network attachment through NACF is based on implicit or explicit user identification and authentication credentials stored in the NACF.

6.3 Mobility, nomadism

Mobility management functions provided by the NACF in this Recommendation are limited to the abilities of a terminal to be moved to different access points and access networks (which may be owned by different access network providers) and of a user to utilize different terminal equipment, access points and access networks to retrieve his or her NGN services (even from another network operator).

The mobility in this Recommendation includes the support of handover and session continuity between access networks, as well as nomadism, and does not preclude the use of mobility capabilities provided within the access networks.

The NACF architecture does not assume any business roles. However, to cope with the requirements for nomadism, roaming as well as mobility, the NACF architecture can be mapped onto various functional network roles present in the fixed broadband access environment. The impact of nomadism, roaming as well as mobility requirements are described in Appendix I.

6.4 Access network level registration

NACF registration involves the identification, authentication, and authorization procedures between the CPE and the NACF to control the access to the NACF. Two authentication types are defined for NACF: implicit authentication, for example based on line identification, and explicit authentication, for example based on EAP [b-IETF RFC 3748]. The relationship between the identifiers and the credentials used for authentication must be known to the NACF for any authentication solution to be possible.

Explicit authentication is operating between the CPE and the NACF. It requires a signalling procedure to be performed between the CPE and the NACF. Implicit authentication may be performed by the NACF based on the line identification of the connection to the CPE. It is a matter of operator policy which form of authentication is applied.

Both implicit authentication and explicit authentication may be used independently as NACF authentication mechanisms.

6.4.1 Implicit authentication

Depending on the access network configuration, especially for wired broadband access networks, the implicit access authentication may rely only on an implicit authentication through physical or logical identification of the layer 2 (L2) transport layer. A CPE can directly access the network without an explicit authentication procedure.

Which implicit authentication method applies depends on the operator's policies.

6.4.1.1 Line authentication

Line authentication is a form of implicit authentication. Line authentication ensures that an access line is authenticated and can be accessed from the home gateway (HGW). Line authentication is based on the activation of the L2 connection between the HGW and the access network.

Line authentication ensures that an access line is authenticated and can be accessed from the HGW. The Line ID is used for line authentication. The operator's policy decides whether line authentication applies.

6.4.2 Explicit authentication

In case the HGW is a routing modem and the customer premises network (CPN) is a private IP realm, authentication is initiated from the HGW. In case the HGW is a bridge, each TE authenticates with the NACF as the IP realm in the CPN is known to the access network (AN).

The relationship between the identifiers and the credentials used for authentication must be known to the NACF for any explicit authentication solution to be possible. The identifiers used for explicit authentication may depend on the authentication mechanism applied and on the access network to which the CPE is connected. Two examples of these identifiers are:

- User identifier and credentials.
- CPE identifier.

The type of explicit authentication mechanisms used depends on the access network configuration and on the operator's policy.

6.4.3 HGW remote network configuration

This procedure is needed for the initialization of the HGWs accessing the NGN service stratum components.

6.4.4 NGN service stratum components discovery

As part of the network registration process, the NACF is required to have the possibility to announce the contact information of the NGN service stratum components to the CPE. In case the NGN service stratum component is the IMS service component [ITU-T Y.2021], the contact information provided by the NACF identifies the P-CSCF. On the other hand, in case of the IPTV service component [ITU-T Y.1910], the contact information provided by the NACF identifies the service and application discovery and selection (SADS) functional block.

The contact information provided by the NACF is recommended to be either in the form of the IP address of the contact point or in the form of the fully qualified domain name (FQDN) of the contact point (in which case the NACF provides the IP address of the DNS server that is able to resolve this FQDN into the IP address of the contact point).

Alternatively, the contact point(s) to the NGN service stratum component(s) may be statically configured in the CPE, e.g., using fully qualified domain names and DNS resolution to retrieve the IP address(es) of the contact point(s). This option applies in the non-roaming case.

7 Functional architecture

7.1 Overview

Figure 2 describes the NACF functional architecture with the functional entities and the relevant reference points. Reference points to charging functions are not represented.

Appendix II describes information flows related to network attachment while Appendix III identifies potential physical configurations in which the functional NACF architecture can be applied.

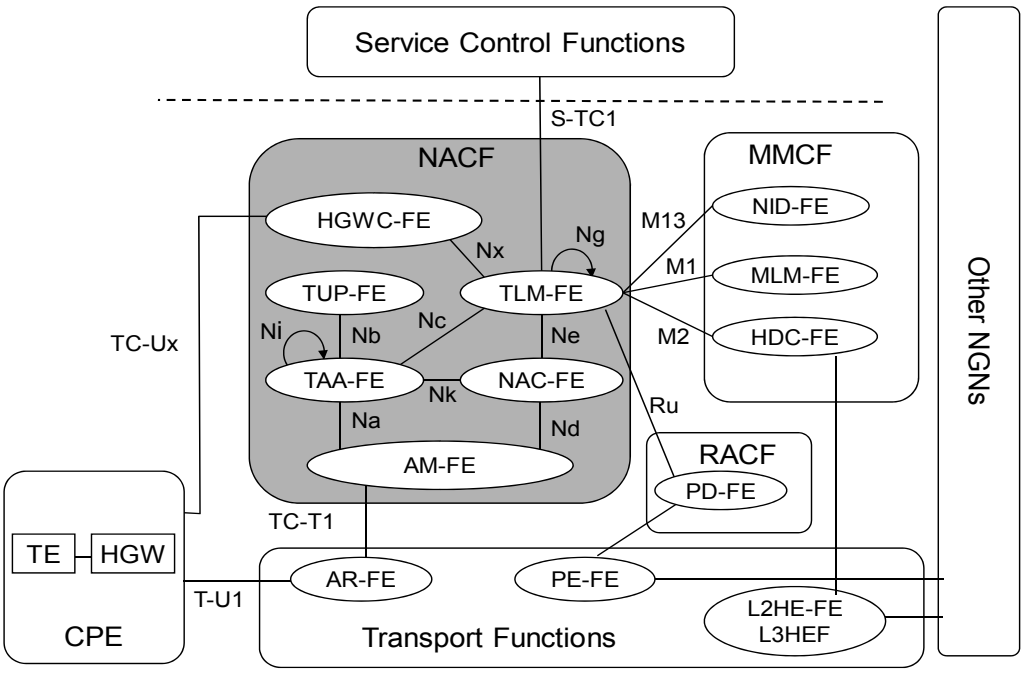


Figure 2 – NACF functional architecture

The NACF comprises the following functional entities:

- Network access control functional entity (NAC-FE)
- Access management functional entity (AM-FE)
- Transport location management functional entity (TLM-FE)
- Transport authentication and authorization functional entity (TAA-FE)
- Transport user profile functional entity (TUP-FE)
- Home gateway configuration functional entity (HGWC-FE)

The NACF has interaction with the following NGN components and entities:

- Service control functions (SCF) (e.g., such as those of the IMS service component [ITU-T Y.2021]) at the S-TC1 reference point for exporting information on access sessions;
- Resource and admission control functions (RACF) [ITU-T Y.2111] at the Ru reference point for exporting transport subscription profile information;
- Mobility management control functions (MMCF) [ITU-T Y.2018] at the M1, M2 and M13 reference points for exporting several types of information on mobility management;
- Transport functions (i.e., access relay functional entity (AR-FE) [ITU-T Y.2012]) acting as relays to/from the CPE for address allocation, authentication and authorization purposes (TC-T1 and T-U1 reference points);
- The customer premises equipment (CPE) at the TC-Ux reference point for configuration purposes.

One or more functional entities may be mapped onto a single physical entity. If one functional entity is implemented by two physical entities, the interface between these physical entities is outside the scope of standardization.

Administrative domains are not represented in Figure 2. Functional entities in the NACF may be distributed over two administrative domains. Appendix I illustrates the impacts of nomadism and roaming on the distribution of NACF, i.e., NACF distribution between visited NGN and home NGN access network domains. Note that the Ru reference point between NACF and RACF [ITU-T Y.2111], and the M1, M2 and M13 reference points between NACF and MMCF [ITU-T Y.2018] are intra-domain reference points.

The NGN architecture does not require a single NACF instance to support multiple access networks. This does not prevent operators from deploying NACF functions that are common to multiple access networks (e.g., one user profile database common to different access networks).

7.2 Functional entities

7.2.1 Network access configuration functional entity (NAC-FE)

The NAC-FE is responsible for the IP address allocation to the CPE. It may also distribute other network configuration parameters such as address of DNS server(s), address of signalling proxies for specific service stratum components (e.g., addresses of the P-CSCF and the SADS when accessing the IMS service component [ITU-T Y.2021] and IPTV service component [ITU-T Y.1910], respectively).

The NAC-FE should be able to provide the CPE access network information. This information uniquely identifies the access network to which the CPE is attached. The CPE may send this information to SCFs as a hint to locate the TLM-FE.

SCFs locate the TLM-FE based on the CPE's IP address or/and based on the information of the access network from which the SCFs receive the IP packet (for example, P-CSC-FE may have several logical/physical interfaces toward different access networks). SCFs perform a "Location

Information Query" towards the TLM-FE over the reference point S-TC1. The key for the query is the IP address used by the CPE.

The NAC-FE may be able to allocate two kinds of IP addresses, persistent IP address (PIA) and temporary IP address (TIA), to the TE in order to support mobility. A persistent IP address is not changed during the movement of TE, after it has once been allocated to TE. However, it is noted that a different persistent IP address can be allocated to the same TE in certain cases, for example, when the TE is rebooted. The home address of MIP [b-IETF RFC 3220] is an example of the persistent IP address. On the other hand, a different temporary IP address is allocated to a TE whenever the TE moves into a new subnet. The care-of address of MIP is an example of the temporary IP address. The NAC-FE may allocate IP addresses with associated TAA-FE, if an address needs to be allocated during the process of authentication.

NOTE 1 – The transport of the access network identifier to the CPE depends on extensions to existing protocols (e.g., new DHCP option or usage of DHCP option 120 [b-IETF RFC 2131]).

NOTE 2 – DHCP servers or RADIUS servers are typical implementations of the NAC-FE.

7.2.2 Access management functional entity (AM-FE)

The AM-FE terminates the layer 2 connection between the CPE and the NACF for registration and initialization of the CPE. The layer 2 connection may be used for detecting the network attachment at the network layer. In this case, the layer 2 connection between the CPE and the AM-FE can constitute a unified framework to the higher layer entities across the heterogeneous network environment to facilitate discovery and selection of multiple types of access networks existing within a geographical area. It is important to note that each of the communication relationships between the CPE and the AM-FE does not imply a particular transport mechanism.

Based on this connection, the AM-FE can collect the access network information about link identifier, link parameters, location of TEs, host configuration parameters, etc. The host configuration information may also include the previously assigned authenticated data and location management with the transport subscription profile information that has been served at the previous access network. In the larger scope, the objective of the access network information is to help the higher layer mobility management functions to acquire a global view of the heterogeneous networks in order to realize nomadism across these networks.

The AM-FE translates network access requests issued by the CPE into a format that can be understood by NACF. It forwards the requests for allocation of an IP address and possibly additional network configuration parameters to/from the TAA-FE and the NAC-FE according to the type of request. The AM-FE forwards requests to the TAA-FE to authenticate the user, authorize or deny the network access, and retrieve user specific access configuration parameters. The AM-FE may also add link layer parameters and host configuration parameters to the forwarded requests.

The access network information may help in network discovery/registration in the NAC-FE and the TAA-FE. Both the CPE and the AM-FE may make decisions about connectivity for mobility management and reuse the network registration/authentication data for fast recovery without performing the whole procedures of the registration/authentication/configuration repeatedly. The network information can be further used for the CPE to perform mobility management procedure in the CPE.

NOTE 1 – In case PPP [b-IETF RFC 1661] is applied, the AM-FE terminates the PPP connection and provides the interworking with the reference point to the NACF, e.g., using an AAA protocol (RADIUS [b-IETF RFC 2865] or Diameter [b-IETF RFC 3588]). The AM-FE acts as a RADIUS client if the TAA-FE is implemented in a RADIUS server (the AM-FE terminates the PPP and translates it to signalling information on the Na reference point).

NOTE 2 – In case IEEE 802.1X [b-IEEE 802.1X]/PANA [b-IETF RFC 4058] is applied, the line authentication may be implicitly performed. The implicit authentication may rely only on the access line to the CPE through physical or logical identification of the layer 2 transport layer.

NOTE 3 – In case a mobile access network (e.g., 3GPP access [b-3GPP TS 23.401], [b-3GPP TS 23.402]) is connected, the authentication may be performed after translating network access requests in AM-FE. The details are under study.

7.2.3 Transport location management functional entity (TLM-FE)

The TLM-FE registers the association between the IP address allocated to the CPE and related network location information provided by the NAC-FE, e.g., access transport equipment characteristics, logical connection identifier, identification of the edge PE-FE device, etc. The TLM-FE registers the association between transport location information received from the NAC-FE and geographical location information. The TLM-FE may also store identifier(s) of the user/CPE to which the IP address has been allocated (information received from the TAA-FE), as well as the transport subscription profile information and preferences regarding the privacy of location information. In case the TLM-FE does not store the identifier/profile of the user/CPE, the TLM-FE is required to be able to retrieve this information from the TAA-FE. For detailed TLM-FE information model, see clause 7.2.3.1.

In order to support hierarchical structure for location query, the TLM-FE may play several roles, i.e., the home role, the local role, or both. In its home role, the TLM-FE stores a pointer to the TLM-FE instance that is playing the local role for the attachment. The current location information of the user/CPE in the access domain is stored and bound in the local TLM-FE. So when the user/CPE moves in the same access domain, only the location binding information of the local TLM-FE needs to be updated; the location binding information of the home TLM-FE does not need to be updated.

The TLM-FE responds to location queries from service control functions. When one of these functions (e.g., P-CSCF) needs to query the location information of the terminal equipment, it will first query the home TLM-FE. The home TLM-FE will then query the local TLM-FE about the detailed location information of the terminal equipment in the network to which it is attached, based on the index of the local TLM-FE the terminal equipment belongs to. The actual information delivered by the TLM-FE may take various forms (e.g., network location, geographical coordinates, postal address etc.), depending on agreements with the requestor and on user preferences regarding the privacy of its location.

On the other hand, in order to support nomadism/roaming, SCFs of the home network access the TLM-FE in the visited network for location information via a TLM-FE-proxy in the home network as shown in Figure I.5.

In addition, to support mobility, the interaction between local TLM-FEs takes place over the Ng reference point.

NOTE 1 – The retrieval by the TLM-FE of geographical information from related user network location characteristics is outside of the scope of this Recommendation.

NOTE 2 – Geographical information may take several different forms depending on the access type and the application.

The TLM-FE identifies the current network location of a TE and keeps track of it as it moves. When the point of attachment of a TE is changed in network, TLM-FE updates the association between the IP address allocated to the TE and related network location information. At the same time, it updates the association between network location information and geographical location information.

When a TE is attached to a new access network and a new temporary IP address is allocated and the location information is stored in the new TLM-FE, the old TLM-FE may transfer the related context information to the new TLM-FE, where the context information includes QoS profile, user preference, etc. At this moment, the new TLM-FE may inform service control function of the updated binding information.

The TLM-FE could be informed of access control lists (ACLs), which are generated by service control functions and/or management entities, based on user profile in TUP-FE. Whether a user subscribes to a certain multicast group or not is an example of user profile. ACLs may consist of packet source address, packet destination address or upper-layer protocol and port number. The TLM-FE informs PD-FE of ACLs to be downloaded to the AN-FE, EN-FE and ABG-FE.

The AN-FE, EN-FE or ABG-FE decides whether to forward or block each packet based on ACLs from PD-FE. In case a user seeks to join a multicast group, the AN-FE, EN-FE or ABG-FE forwards or/and processes the request. If not, the request is discarded and the service request will eventually fail.

7.2.3.1 Information model

The TLM-FE holds a number of records representing active access sessions. These records contain information received from the NAC-FE and the TAA-FE, information on the list of SCFs having subscribed to particular events and additional statically configured data. Table 1 identifies which information elements are stored for each of these access sessions.

NOTE – In case PPP [b-IETF RFC 1661] is used, the physical connection identifier may be provided from the TAA-FE to the TLM-FE.

Table 1 – TLM-FE information model

Access session description	
Information component received from the NAC-FE	
Globally Unique IP Address Information	A set of IP address information used for locating the access network to which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Physical Connection Identifier (optional)	A local identifier for physical connection of access transport network to which the CPE is attached to (e.g., IP address of PE-FE device, and MAC address or Link ID and physical port).
Logical Connection Identifier	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS Label, GTP Tunnel and logical port). It can be used to locate the layer 2 connection and pertinent network devices for a particular attached CPE.
CPE Type	The type of CPE to which the IP address has been allocated.
Information received from the TAA-FE/TUP-FE	
Transport Subscriber Identifier	A globally unique identifier of the attached CPE. This identifier can be used for locating the transport subscription information for the CPE.
Logical Connection Identifier	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS Label, GTP Tunnel and logical port).
Mobility Service Parameters (optional) (Note 8)	
– Address of MLM-FE(C) (Note 9)	The address of the instance of the MLM-FE containing the mobile address binding information.
– Address of MLM-FE(P) (Note 9)	The address of the MLM-FE instance which sends the location registration.

Table 1 – TLM-FE information model

Access session description	
Information received from the TAA-FE/TUP-FE	
– Keying Material (Note 9)	The material used for the security association between the UE and MMCF.
– Mobility Protocol Type	The type of mobility protocol that TE or CPE could support, for example host-based or network-based mobility.
– Anchor point address (optional)	The upper tunnel end point address, from the point of view of the UE.
– Tunnel end point address (optional) (Note 10)	The tunnelling end point address for the network node which works as UE's proxy (lower tunnel end point).
Privacy Indicator (Note 1)	Indicates whether location information can be exported to services and applications.
Transport Resource Subscription (Notes 2 and 3)	
– Transport Subscription Profile ID (Note 4)	The identifier of a set of Transport Subscription Profile information.
– Transport Subscription Profile Description (Note 4)	
– Network Class of Service	Represents the network service class subscribed by a CPE (e.g., Premium, Gold, Silver, Regular, etc.). It may include the QoS performance class (e.g., class defined in [ITU-T Y.1541] class).
– Subscribed Upstream Bandwidth	The maximum bandwidth subscribed by a CPE for the upstream connections.
– Subscribed Downstream Bandwidth	The maximum bandwidth subscribed by a CPE for the downstream connections.
– Level of priority	The maximum level of priority permitted for any reservation request.
– Requestor Name	Identifies the requestor(s) that are allowed by the Transport Resource Subscription.
Default Configuration (optional)	
– Default Configuration Identifier (Note 5)	The identifier of a default configuration.
– Default Configuration Description (Note 5)	
– Default Access Control List: List of allowed destinations	The list of destination IP addresses, ports, prefixes and port ranges allowed to cut through by default. (Note 6)
– Default Access Control List: List of denied destinations as well as multicast flows	The list of destination IP addresses, ports, prefixes and port ranges to which traffic is denied by default. In case of multicast, the list of IP-Multicast group addresses and/or the list of (Source IP address, IP-Multicast group address) pairs for which traffic towards the attached user equipment must be denied. Address ranges are supported within the list. (Note 6)
– Default Upstream Bandwidth	The maximum bandwidth that can be used for the upstream connections by default.

Table 1 – TLM-FE information model

Access session description	
– Default Downstream Bandwidth	The maximum bandwidth that can be used for the downstream connections by default.
Static information derived from the physical connection identifier	
Location Information	
Default Transport Subscriber Identifier	
Static information derived from the logical connection identifier	
RACF point of contact	The address of the RACF element where the Transport Subscription Profile is to be pushed.
Type of access network	The type of access network to which the CPE is attached.
Attached access domain name	The access domain name or the provider's name to which the CPE is attached.
Event management information	
Event Management Information (Note 7)	
– Event	The type of event to be monitored.
– SCF Identities	The list of SCF to be notified of the occurrence of this event.
NOTE 1 – An indication whether applications can access location information, depending on their security level. NOTE 2 – The access session may contain the description of multiple transport resource subscriptions. NOTE 3 – The actual available bandwidth is not known by the NACF. This information can be derived by the RACF based on the logical connection identifier. NOTE 4 – Either the transport subscription profile ID or the transport subscription profile description may be included, but not both at the same time. NOTE 5 – Either the default configuration identifier or the default configuration description may be included, but not both at the same time. NOTE 6 – If a destination does not appear in either of the two lists, gate setting decisions for those addresses is subject to control by RACF. NOTE 7 – More than one event and associated SCF identities may be stored. NOTE 8 – It is available only if the mobility service is applied. NOTE 9 – It is available only if the host-based mobility is applied. NOTE 10 – If the tunnel end point address is statically provisioned or the MLM-FE can obtain it with its own mechanisms, this information is not required. It is available only if the network-based mobility is applied.	

Several records may contain the same physical connection identifier and/or logical connection identifier and/or transport subscriber identifier, as a subscriber may establish more than one IP access session, over the same or different access logical connection (e.g., ATM VC) using the same or different access physical connection. The TLM-FE does not need to establish any link between such records, although it may do it for the purpose of optimizing its storage capacity.

7.2.3.2 TLM-FE state model

The behaviour of the TLM-FE when managing access records can be represented by the state model described in this clause. This state model is not intended to constrain implementations of a TLM-FE. Implementations may use a different model as long as they exhibit the same external behaviour.

This state model defines a session state machine (SSM) that comprises five states:

– *Null*: This state represents a non-existing access record.

– *Wait_For_Bind_Indication_and_Profile*: This state is entered when an access record is created as a result of receiving a request for subscription to an event (e.g., the logon event) while no session record exists for the associated transport subscriber identifier or globally unique IP address information. A partial record is created and the TLM-FE waits for a Bind_Indication event.

– *Wait_For_Bind_Indication*: This state is entered when an access record is created as a result of receiving transport subscription profile information while no session record exists for the associated transport subscriber identifier or globally unique IP address information. A partial record is created and the TLM-FE waits for a Bind_Indication event.

– *Wait_For_Profile_Information*: This state represents a partial session record where transport subscription profile information is missing.

– *Active_Session*: This state represents a session record where the full description of an access session is available.

The TLM-FE sends and receives information flows at the S-TC1, Ru, Ne and Nc reference points. Incoming information flows are routed to session state machines (SSM) based on the transport subscriber identifier or the globally unique IP address information they contain.

An SSM instance is created when a Bind_Indication or an Event_Subscription_Indication event indicating an unknown transport subscriber identifier or globally unique IP address information occurs.

The following events are handled by the TLM-FE session state machine and cause transition between the states:

– *Event_Subscription_Indication*: This event occurs when an event registration request information flow (see clause 8.3.1) is received from an SCF.

NOTE – When the actual TLM-FE event occurs, a notification event request information flow is sent back to the AF. This does not cause any state transition.

– *Bind_Indication*: This event occurs when the bind indication information flow is received at the Ne reference point (see clause 8.1.2).

– *Unbind_Indication*: This event occurs when the unbind indication information flow is received at the Ne reference point or when a negative acknowledgement is received in response to a bind information query (see clause 8.1.2).

– *Subscription_Profile_Received*: This event occurs when a transport resource information indication information flow is received at the Nc reference point asynchronously or as a result of sending a transport resource information request information flow, or when internal configuration data indicate that a default transport subscriber profile applies.

– *Subscription_Profile_Removed*: This event occurs when a transport resource release notification information flow is received at the Nc reference point.

– *Session_Data_Requested*: This event occurs when a transport resource information request information flow is received at the Ru reference point or an information query request information flow is received at the S-TC1 reference point. It causes an information query response or a transport resource information indication information flow to be sent over the S-TC1 or Ru reference point.

Figure 3 provides an overview of the state transitions based on the above events.

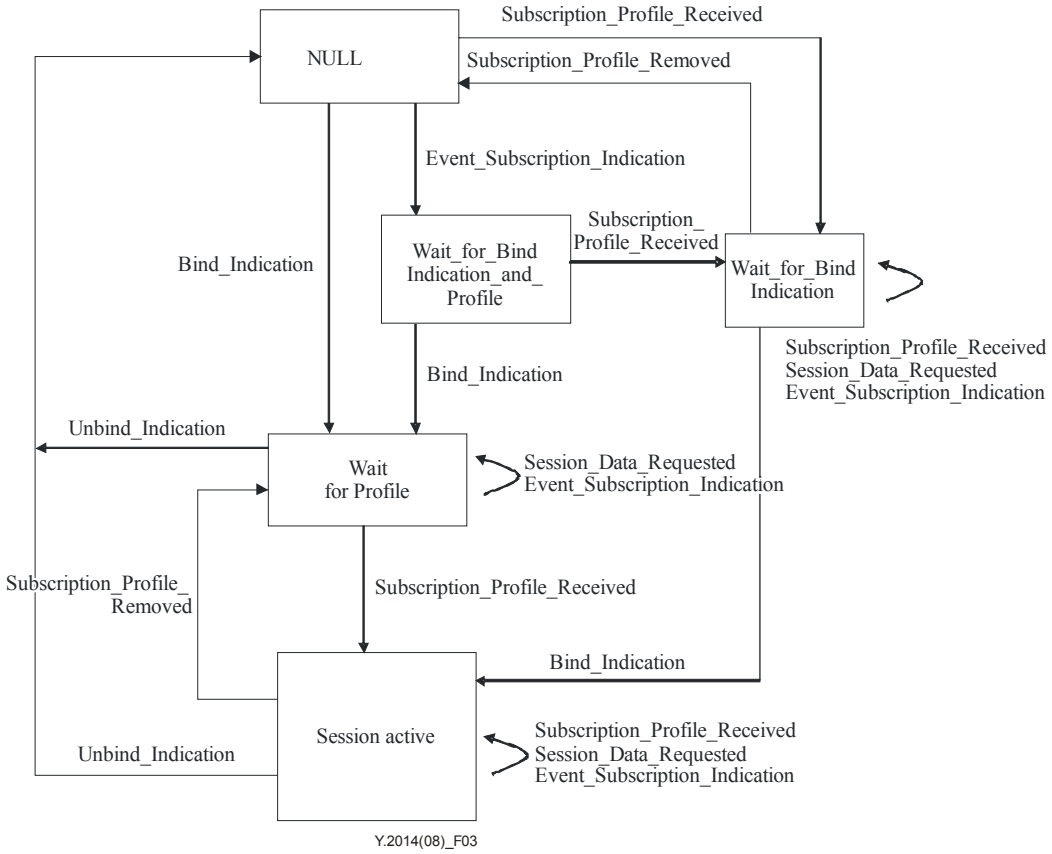


Figure 3 – TLM-FE state model for access records management

7.2.4 Transport authentication and authorization functional entity (TAA-FE)

The TAA-FE performs user authentication, as well as authorization checking, based on transport subscription profiles, for network access. For each user, the TAA-FE retrieves authentication data and access authorization information from the transport subscription profile information contained in the TUP-FE. The TAA-FE may also perform the collection of accounting data for each user authenticated by NACF.

For the TE, TAA may support the allocation of an IP address or IP prefix. The IP address and IP prefix may be required to be allocated in the authentication process for the host-based mobility architecture and the network-based mobility architecture, respectively. For the host-based mobility, TAA-FE may request NAC-FE for IP allocation. And for both the host-based and network-based mobility, TAA may just use IP address or IP prefix which is maintained as user profile information in TUP-FE. In order to allocate the IP address dynamically, TAA-FE may request NAC-FE to allocate the IP address. In that case, the IP address may be changed whenever the address is requested even from the same TE. However, in order to allocate the IP address or IP prefix statically, TAA-FE may use the IP address or IP prefix which is maintained in TUP-FE as user profile information.

The TAA-FE can also act as a proxy. When acting as a proxy the TAA-FE can locate and communicate with the TAA-FE acting as server which contains the TUP-FE subscription authentication data. The TAA-FE proxy can forward access and authorization requests, as well as accounting messages, received from the AM-FE, to the TAA-FE acting as server. Responses received back from the TAA-FE acting as server will be returned to the AM-FE via the TAA-FE-proxy. Communication between the TAA-FE proxy and the TAA-FE server passes across the Ni reference point.

NOTE – In case PPP [b-IETF RFC 1661] is applied, the AM-FE terminates the PPP and translates it to signalling information on the Na reference point. The TAA-FE is assumed to be able to contact the NAC-FE

via an internal reference point to obtain an IP address (TAA-FE and NAC-FE are in the PPP case internal functions). The Nd reference point does not carry DHCP signalling [b-IETF RFC 2131], instead the Na reference point is used to give the IP configuration information to the AM-FE.

7.2.5 Transport user profile functional entity (TUP-FE)

The TUP-FE is the functional entity that contains subscription authentication data (transport subscriber identifier, list of supported authentication methods, key materials etc.) and information related to the required network access configuration: this data is called "Transport Subscription Profile". The transport subscription profile may include network configuration information for TE such as IP address or IP prefix. By maintaining the IP address or IP prefix in TUP-FE, the IP address or IP prefix may be uniquely allocated to TE instead of dynamically allocated by NAC-FE. The transport subscription profile may be subdivided into sub-profiles (see Figure 4), each of which is associated to one or more logical connection identifiers. Support of the logical connection identifier is optional.

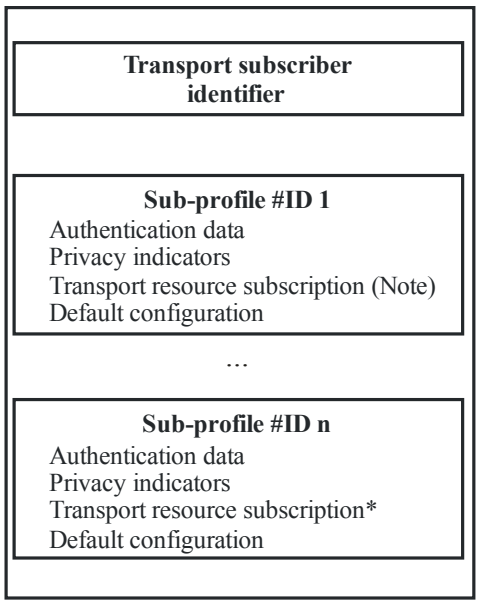


Figure 4 – Transport subscription profile in the TUP-FE

The TUP-FE responds to queries from the TAA-FE on the full profile or on a particular sub-profile. In the latter case, it is the responsibility of the TAA-FE (or the TAA-FE-proxy) to derive a sub-profile identifier from the logical connection identifier.

The TUP-FE can be co-located with the SUP-FE (as described in [ITU-T Y.2012]).

7.2.6 Home gateway configuration functional entity (HGWC-FE)

The HGWC-FE is used during initialization and updating of the HGW. It also provides the HGW with additional configuration information (e.g., configuration of a firewall internally in the HGW, QoS marking of IP packets, etc.). These data differ from the network configuration data provided by the NAC-FE.

Functions of the HGWC-FE also include:

– The HGWC-FE controls and monitors the current configuration of HGW.

– The HGWC-FE stores various configuration data, so it can decide which configuration parameters or profiles to be set or downloaded to the HGW. HGWC-FE is aware of the

association between HGW and configuration profile based on subscriber information and/or application classes.

– The HGWC-FE has mechanisms to SET/GET configuration parameters to/from HGW.

The HGWC-FE is recommended to have a mechanism to facilitate profile downloads for a variety of purposes such as firmware upgrade or vendor-specific configuration profiles.

The HGWC-FE may also handle notifications from the HGW on TE availability. The HGWC-FE may indeed provide configuration information for the TEs, indirectly via the HGW or directly to the TEs. It may also trigger maintenance tests and process results sent by the HGW or by the TEs.

The HGWC-FE may also interface with the TLM-FE in order to retrieve information on the HGW and on the access it is connected to. In such cases, the HGWC-FE uses the procedures described in clause 8.1.7. The information retrieved from the TLM-FE (e.g., physical connection identifier and/or transport subscriber identifier) may be used as input to the selection of configuration data to be delivered to the HGW.

7.2.6.1 Optimized authentication in NACF

During the network attachment procedure, the HGW initiates access request to NACF, and TAA-FE performs the network access level authentication and authorization. If successful, security association (SA) used for protection between the HGW and the HGWC-FE can be negotiated between TAA-FE and the HGW.

Then the TAA-FE pushes the SA to the TLM-FE via the Nc reference point and then the TLM-FE notifies the SA to the HGWC-FE via the Nx reference point.

The management information exchange between the HGW and the HGWC-FE is bi-directionally authenticated by the SA.

Note that this procedure is optional.

7.2.7 Access relay functional entity (AR-FE)

The AR-FE acts as a relay between the CPE and the NACF. It receives network access requests from the CPE and forwards them to the NACF. Before forwarding a request, the AR-FE may also insert local configuration information. The functionality of AR-FE is described in [ITU-T Y.2012].

NOTE – When using PPP [b-IETF RFC 1661], the AR-FE may act as a PPPoE relay. When using DHCP [b-IETF RFC 2131], the AR-FE acts as a DHCP relay agent.

8 Reference points

8.1 Internal NACF reference points

8.1.1 Reference point AM-FE – NAC-FE (Nd)

The Nd reference point allows the AM-FE to request the NAC-FE for the allocation of an IP address to a CPE as well as other network configuration parameters.

8.1.2 Reference point NAC-FE – TLM-FE (Ne)

The Ne reference point allows the NAC-FE to register in the TLM-FE the binding between an allocated IP address and a CPE as well as other transport related information, such as logical/physical port addresses.

The following information flows are used on the TLM-FE to NAC-FE reference point:

– Bind indication

– Bind acknowledgement

– Unbind indication

– Bind information query
– Bind information query acknowledgement

8.1.2.1 Bind indication

Table 2 describes the elements contained in the bind indication information flow.

Table 2 – Bind indication (NAC-FE → TLM-FE)

Globally Unique IP Address Information	A set of IP address information used for locating the access network to which the CPE is attached.
– Unique IP Address	The IP address allocated to the attached CPE.
– Address Realm	The addressing domain in which the IP address is significant.
Physical Connection Identifier (optional)	A local identifier for physical connection of the access transport network to which the CPE is attached (e.g., IP address of PE-FE device, and MAC address or link ID and physical port ID).
Logical Connection Identifier (Note 1)	A local identifier for logical connection of the access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS label, GTP tunnel or logical port).
CPE Type (optional) (Note 2)	The type of CPE.
NOTE 1 – If the NAC-FE is implemented as a DHCP server, this parameter is mapped to the DHCP option 82, sub-options 1 and 2 [b-IETF RFC 2131]. NOTE 2 – If the NAC-FE is implemented as a DHCP server, this parameter is mapped to the DHCP option 77 [b-IETF RFC 2131].	

8.1.2.2 Bind acknowledgement

The bind acknowledgement information flow conveys information that may be sent back to the CPE. The information returned by the TLM-FE in response to a bind indication is received from the TAA-FE or retrieved by the TLM-FE from the TUP-FE, via the TAA-FE.

Table 3 describes the elements contained in the bind acknowledgement information flow.

Table 3 – Bind acknowledgement (TLM-FE → NAC-FE)

HGWC-FE address (optional)	The address of the HGWC-FE entity from which configuration data may be retrieved by the CPE.
Geographic Location Information (optional)	Geographic location information.
P-CSCF Identity (optional)	The identifier of the P-CSCF for accessing IMS services [ITU-T Y.2021].
SADS Identity (optional)	The identifier of the SADS for accessing IPTV services [ITU-T Y.1910].

8.1.2.3 Unbind indication

The unbind indication information flow is sent by the NAC-FE on expiry of the binding between an IP address and a CPE or when an underlying PPP connection or layer 2 connection is released.

Table 4 describes the elements contained in the unbind indication information flow.

Table 4 – Unbind indication (NAC-FE → TLM-FE)

Globally Unique IP Address Information	A set of IP address information used for locating the access network to which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).

8.1.2.4 Bind information query

The bind information query information flow is used by the TLM-FE to request bind information (e.g., in the context of recovery procedures) from the NAC-FE.

Table 5 describes the elements contained in the bind information query information flow.

Table 5 – Bind information query (TLM-FE → NAC-FE)

Globally Unique IP Address information	A set of IP address information used for locating the access network to which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Adress Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).

8.1.2.5 Bind information query acknowledgement

The bind information query acknowledgement information flow is used by NAC-FE to inform the TLM-FE of the result of a bind information query request. When the information query is successful, the acknowledgement information flow contains the information described in Table 6.

Table 6 – Bind information query acknowledgement (NAC-FE → TLM-FE)

Physical Connection Identifier (optional)	A local identifier for physical connection of the access transport network to which the CPE is attached to (e.g., IP address of PE-FE device, and MAC address or link ID and physical port ID).
Logical Connection Identifier (Note 1)	A local identifier for logical connection of the access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS Label, GTP tunnel or logical port).
CPE Type (optional) (Note 2)	The type of CPE.
NOTE 1 – If the NAC-FE is implemented as a DHCP server, this parameter is mapped to the DHCP option 82, sub-options 1 and 2 [b-IETF RFC 2131]. NOTE 2 – If the NAC-FE is implemented as a DHCP server, this parameter is mapped to the DHCP option 77 [b-IETF RFC 2131].	

8.1.2.6 Mobility service parameters indication

The mobility service parameters indication information flow is used to push mobility service information from the TLM-FE to the NAC-FE, upon successful authentication of the user.

Table 7 describes the elements contained in the mobility service parameters indication information flow.

Table 7 – Mobility service parameters indication (TLM-FE → NAC-FE)

Transport Subscriber Identifier	A globally unique identifier of the attached CPE. This identifier can be used for locating the transport subscription information for the CPE.
Globally Unique IP Address Information (Note 1)	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Mobility Service Parameters (optional) (Note 2)	
– Address of MLM-FE(C) (Note 3)	The address of the instance of the MLM-FE containing the mobile address binding information.
– Address of MLM-FE(P) (Note 3)	The address of the MLM-FE instance which sends the location registration.
– Keying Material (Note 3)	The material used for the security association between the UE and MMCF.
– Mobility Protocol Type	The type of mobility protocol that TE or CPE could support, for example host-based or network-based mobility.
– Anchor point address (optional)	The upper tunnel end point address, from the point of view of the UE.
– Tunnel end point address (optional) (Note 4)	The tunnel end point address for the network node which works as UE's proxy (lower tunnel end point).
NOTE 1 – The globally unique IP address information is included if it is retrieved by the TAA-FE. It is identical to the persistent IP address from the viewpoint of MMCF. NOTE 2 – It is available only if the mobility service is applied. NOTE 3 – It is available only if the host-based mobility is applied. NOTE 4 – If the tunnel end point address is statically provisioned or the MLM-FE can obtain it with its own mechanisms, this information is not required. It is available only if the network-based mobility is applied.	

8.1.3 Reference point AM-FE – TAA-FE (Na)

The Na reference point allows the AM-FE to request the TAA-FE for user authentication and transport subscription information checking.

8.1.4 Reference point TAA-FE – TLM-FE (Nc)

The Nc reference point allows the TLM-FE to register the association between a subscriber and the corresponding preferences regarding the privacy of location information provided by the TAA-FE. Reference point Nc is also used to register transport resource subscription information. The TLM-FE may retrieve the transport resource subscription information from the TAA-FE.

The relationship between TAA-FE – TLM-FE may be operated in pull mode or push mode. The push mode is used when the TAA-FE is involved in the processing of network access requests in order to authorize or deny access to the network (e.g., when explicit authentication is used). The pull mode is used when implicit authentication is used or in support of TLM-FE recovery procedures.

The following information flows are used on the Nc reference point:

– Transport Resource Information Indication
– Transport Resource Information Request
– Transport Resource Information Response
– Transport Resource Release Notification

8.1.4.1 Transport resource information indication

The transport resource information indication information flow is used to push transport subscription information from the TAA-FE to the TLM-FE, upon successful authentication of the user. The TAA-FE may decide to send in the same transport resource information indication information flow some transport subscription profiles in the form of a profile identifier (because the actual transport subscription profile information is assumed to be available in the TLM-FE) and some other transport subscription profiles in the form of full profile descriptions. This information is retrieved from the TUP-FE by the TAA-FE.

Table 8 describes the elements contained in the transport resource information indication information flow.

NOTE – In case PPP [b-IETF RFC 1661] is applied, the TAA-FE may provide the physical connection identifier to the TLM-FE.

Table 8 – Transport resource information indication (TAA-FE → TLM-FE)

Transport Subscriber Identifier	A globally unique identifier of the attached CPE. This identifier can be used for locating the transport subscription information for the CPE.
Globally Unique IP Address Information (Note 1)	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Logical Connection Identifier	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS Label, GTP Tunnel and logical port).
Mobility Service Parameters (optional) (Note 7)	
– Address of MLM-FE(C) (Note 8)	The address of the instance of the MLM-FE containing the mobile address binding information.
– Address of MLM-FE(P) (Note 8)	The address of the MLM-FE instance which sends the location registration.
– Keying Material (Note 8)	The material used for the security association between the UE and MMCF.
– Mobility Protocol Type	The type of mobility protocol that TE or CPE could support, for example host-based or network-based mobility.
– Anchor point address (optional)	The upper tunnel end point address, from the point of view of the UE.
– Tunnel end point address (optional) (Note 9)	The tunnel end point address for the network node which works as UE's proxy (lower tunnel end point).
Home TLM-FE contact point	FQDN or IP address of home TLM-FE.
Local TLM-FE contact point	FQDN or IP address of local TLM-FE.

Table 8 – Transport resource information indication (TAA-FE → TLM-FE)

Privacy Indicator	Indicates whether location information can be exported to services and applications.
Security Association (optional)	The security association negotiated between the HGW and the TAA-FE during the network access authentication and authorization procedure.
Transport Resource Subscription (optional) (Note 2)	
– Transport Subscription Profile ID (Note 3)	The identifier of a set of transport subscription profile information.
– Transport Subscription Profile Description (Note 3)	
– Network Class of Service	Represents the network service class subscribed by a CPE (e.g., premium, gold, silver, regular, etc.). It may include the QoS performance class (e.g., class defined in [ITU-T Y.1541]).
– Subscribed Upstream Bandwidth	The maximum bandwidth subscribed by a CPE for the upstream connections.
– Subscribed Downstream Bandwidth	The maximum amount of bandwidth subscribed by a CPE for the downstream connections.
– Level of Priority	The maximum level of priority permitted for any reservation request.
– Requestor Name	Identifies the requestor(s) that are allowed by the transport resource subscription.
Default Configuration (optional) (Note 4)	
– Default Configuration Identifier (Note 5)	The identifier of a default configuration.
– Default Configuration Description (Note 5)	
– Default Access Control List: allowed destinations as well as multicast flows	The list of default destination IP addresses and/or ports and/or prefixes and/or port ranges to which traffic can be sent. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs which traffic can be received from by the attached user equipment. Address ranges are supported within the list. (Note 6)
– Default Access Control List: denied destinations as well as multicast flows	The list of default destination IP addresses, ports, prefixes and port ranges to which traffic is denied. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs for which traffic towards the attached user equipment must be denied. Address ranges are supported within the list. (Note 6)
– Default Upstream Bandwidth	The maximum bandwidth that can be used for the upstream connections by default.
– Default Downstream Bandwidth	The maximum bandwidth that can be used for the downstream connections by default.

Table 8 – Transport resource information indication (TAA-FE → TLM-FE)

NOTE 1 – In case PPP [b-IETF RFC 1661] is applied, the TAA-FE is required to provide the globally unique IP address information to the TLM-FE. When DHCP [b-IETF RFC 2131] is applied this parameter is optional. NOTE 2 – The transport resource subscription may contain multiple transport subscription profiles. NOTE 3 – Either the transport subscription profile ID or the transport subscription profile description may be included, but not both at the same time. NOTE 4 – This information is used by the RACF to configure the transport functions, before resource reservation requests are received from services/applications. NOTE 5 – Either the default configuration identifier or the default configuration description may be included, but not both at the same time. NOTE 6 – If a destination does not appear in either of the two lists, gate setting decisions for those addresses is subject to control by RACF. NOTE 7 – It is available only if the mobility service is applied. NOTE 8 – It is available only if the host-based mobility is applied. NOTE 9 – If the tunnel end point address is statically provisioned or the MLM-FE can obtain it with its own mechanisms, this information is not required. It is available only if the network-based mobility is applied.

8.1.4.2 Transport resource information request

The transport resource information request information flow is used by the TLM-FE to request the transport subscription profile information from the TAA-FE. This information flow is used when the relationship between TLM-FE and TAA-FE operates in pull mode or in the context of TLM-FE recovery procedures.

Table 9 describes the elements contained in the transport resource information request information flow.

Table 9 – Transport resource information request (TLM-FE → TAA-FE)

Globally Unique IP Address Information (Note 1)	A set of IP address information used for locating the access network to which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Logical Connection Identifier	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS label, GTP tunnel and logical port).
Transport Subscriber Identifier (Note 2)	A globally unique identifier for the attached CPE. This identifier can be used for locating the transport subscription information for the CPE.
NOTE 1 – If the information flow is used for supporting recovery procedures and the reference point operates in push mode, the globally unique IP address information is required to be included. NOTE 2 – If the reference point operates in pull mode, the transport subscriber identifier is required to be included.	

8.1.4.3 Transport resource information response

The transport resource information response information flow is used to provide transport subscription information from the TAA-FE to the TLM-FE in response to a transport resource information request.

Table 10 describes the elements contained in the transport resource information response information flow.

NOTE – In case PPP [b-IETF RFC 1661] is applied, the TAA-FE may provide the physical connection identifier to the TLM-FE.

Table 10 – Transport resource information response (TAA-FE → TLM-FE)

Transport Subscriber Identifier	A globally unique identifier of the attached CPE. This identifier can be used for locating the transport subscription information for the CPE.
Globally Unique IP Address Information (Note 1)	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Logical Connection Identifier	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS label, GTP tunnel and logical port).
Mobility Service Parameters (optional) (Note 7)	
– Address of MLM-FE(C) (Note 8)	The address of the instance of the MLM-FE containing the mobile address binding information.
– Address of MLM-FE(P) (Note 8)	The address of the MLM-FE instance which sends the location registration.
– Keying Material (Note 8)	The material used for the security association between the UE and MMCF.
– Mobility Protocol Type	The type of mobility protocol that TE or CPE could support, for example host-based or network-based mobility.
– Anchor point address (optional)	The upper tunnel end point address, from the point of view of the UE.
– Tunnel end point address (optional) (Note 9)	The tunnel end point address for the network node which works as UE's proxy (lower tunnel end point).
Privacy Indicator	Indicates whether location information can be exported to services and applications.
Security Association (optional)	The security association negotiated between the HGW and the TAA-FE during the network access authentication and authorization procedure.
Transport Resource Subscription (optional) (Note 2)	
– Transport Subscription Profile ID (Note 3)	The identifier of a set of transport subscription profile information.
– Transport Subscription Profile Description (Note 3)	
– Network Class of Service	Represents the network service class subscribed by a CPE (e.g., premium, gold, silver, regular, etc.). It may include the QoS performance class (e.g., class defined in [ITU-T Y.1541]).
– Subscribed Upstream Bandwidth	The maximum bandwidth subscribed by a CPE for the upstream connections.

Table 10 – Transport resource information response (TAA-FE → TLM-FE)

– Subscribed Downstream Bandwidth	The maximum amount of bandwidth subscribed by a CPE for the downstream connections.
– Level of Priority	The maximum level of priority permitted for any reservation request.
– Requestor Name	Identifies the requestor(s) that are allowed by the transport resource subscription.
Default Configuration (optional) (Note 4)	
– Default Configuration Identifier (Note 5)	The identifier of a default configuration.
– Default Configuration Description (Note 5)	
– Default Access Control List: allowed destinations as well as multicast flows	The list of default destination IP addresses and/or ports and/or prefixes and/or port ranges to which traffic can be sent. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs which traffic can be received from by the attached user equipment. Address ranges are supported within the list. (Note 6)
– Default Access Control List: denied destinations as well as multicast flows	The list of default destination IP addresses, ports, prefixes and port ranges to which traffic is denied. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs for which traffic towards the attached user equipment must be denied. Address ranges are supported within the list. (Note 6)
– Default Upstream Bandwidth	The maximum bandwidth that can be used for the upstream connections by default.
– Default Downstream Bandwidth	The maximum bandwidth that can be used for the downstream connections by default.

NOTE – In case PPP [b-IETF RFC 1661] is applied, the TAA-FE is required to provide the globally unique IP address information to the TLM-FE. When DHCP [b-IETF RFC 2131] is applied, this parameter is optional.

NOTE 2 – The transport resource subscription may contain multiple transport subscription profiles.

NOTE 3 – Either the transport subscription profile ID or the transport subscription profile description may be included, but not both at the same time.

NOTE 4 – This information is used by the RACF to configure the transport functions, before resource reservation requests are received from services/applications.

NOTE 5 – Either the default configuration identifier or the default configuration description may be included, but not both at the same time.

NOTE 6 – If a destination does not appear in either of the two lists, gate setting decisions for those addresses is subject to control by RACF.

NOTE 7 – It is available only if the mobility service is applied.

NOTE 8 – It is available only if the host-based mobility is applied.

NOTE 9 – If the tunnel end point address is statically provisioned or the MLM-FE can obtain it with its own mechanisms, this information is not required. It is available only if the network-based mobility is applied.

8.1.4.4 Transport resource release notification

The transport resource release notification information flow is used by the TAA-FE to request the TLM-FE to delete the information it held about a CPE. This event occurs as a result of network management actions.

Table 11 describes the elements contained in the transport resource release notification information flow.

Table 11 – Transport resource release notification (TAA-FE → TLM-FE)

Globally Unique IP Address Information (Note)	A set of IP address information used for locating the access network to which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Logical Connection Identifier (optional)	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS label, GTP tunnel and logical port).
Transport Subscriber Identifier (Note)	A globally unique identifier for the attached CPE. This identifier can be used for locating the transport subscription information for the CPE.
NOTE – Either the globally unique IP address information or the transport subscriber identifier is included.	

8.1.5 Reference point NAC-FE – TAA-FE (Nk)

The Nk reference point is not specified in this Recommendation.

8.1.6 Reference point TAA-FE – TAA-FE (Ni)

This reference point is intended to be used between a TAA-FE-proxy and a TAA-FE-server, which may be in different administrative domains. This reference point allows the TAA-FE-proxy to request the TAA-FE-server for user authentication and authorization, based on transport subscription profiles. It also allows the TAA-FE-proxy to forward accounting data for the particular user session to the TAA-FE-server or to forward requests received from a TLM-FE.

The TAA-FE-proxy will forward access and authorization requests, as well as accounting messages, received over the Na reference point from the AM-FE, to the TAA-FE-server over the Ni reference point. Responses received back in return from the TAA-FE-server over the Ni reference point will be forwarded to the AM-FE over the Na reference point. A bilateral trust relationship will need to be setup between the TAA-FE-proxy and the TAA-FE-server in order to facilitate this exchange.

This reference point supports AAA message exchange between the TAA-FE-proxy and the TAA-FE-server.

NOTE – RADIUS [b-IETF RFC 2865] and Diameter [b-IETF RFC 3588] are two possible options for protocols on this reference point.

8.1.6.1 Information exchanged on Ni

Table 12 identifies the information components exchanged on the Ni reference point.

Table 12 – Ni reference point

Information component	Description
Transport Subscriber Identifier	A globally unique identifier of the CPE requesting IP connectivity. This identifier can be used for locating the transport subscription information for the CPE.
Privacy Indicator	Indicates whether location information can be exported to services and applications.
Globally Unique IP Address Information	A set of IP address information used for locating the access network to which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Mobility Service Parameters (optional) (Note 6)	
– Address of MLM-FE(C) (Note 7)	The address of the instance of the MLM-FE containing the mobile address binding information.
– Address of MLM-FE(P) (Note 7)	The address of the MLM-FE instance which sends the location registration.
– Keying Material (Note 7)	The material used for the security association between the UE and MMCF.
– Mobility Protocol Type	The type of mobility protocol that TE or CPE could support, for example host-based or network-based mobility.
– Anchor point address (optional)	The upper tunnel end point address, from the point of view of the UE.
– Tunnel end point address (optional) (Note 8)	The tunnel end point address for the network node which works as UE's proxy (lower tunnel end point).
Home TLM-FE contact point	FQDN or IP address of home TLM-FE.
Interworking Information (optional)	A set of interworking information used for identifying the network and service attachment information when the CPE is attached to a visited network (for example, IPTV service control protocol, SADS identity, etc.).
Transport Resource Subscription (optional) (Note 1)	
– Transport Subscription Profile ID (Note 2)	The identifier of a set of transport subscription profile information.
– Transport Subscription Profile Description (Note 2)	
– Network Class of Service	Represents the network service class subscribed by the attached CPE (e.g., premium, gold, silver, regular, etc.). It may include the QoS performance class (e.g., class defined in [ITU-T Y.1541]).
– Subscribed Upstream Bandwidth	The maximum bandwidth subscribed by a CPE for the upstream connections.
– Subscribed Downstream Bandwidth	The maximum amount of bandwidth subscribed by a CPE for the downstream connections.

Table 12 – Ni reference point

Information component	Description
– Level of priority	The maximum level of priority permitted for any reservation request.
– Requestor Name	Identifies the requestor(s) that are allowed by the transport resource subscription.
Default Configuration (optional) (Note 3)	
– Default Configuration Identifier (Note 4)	The identifier of a default configuration.
– Default Configuration Description (Note 4)	
– Default Access Control List: allowed destinations as well as multicast flows	The list of destination IP addresses, ports, prefixes and port ranges allowed to cut through by default. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs which traffic can be received from by the attached user equipment. Address ranges are supported within the list. (Note 5)
– Default Access Control List: denied destinations as well as multicast flows	The list of destination IP addresses, ports, prefixes and port ranges denied to cut through by default. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs for which traffic towards the attached user equipment must be denied. Address ranges are supported within the list. (Note 5)
– Default Upstream Bandwidth	The maximum bandwidth that can be used for the upstream connections by default.
– Default Downstream Bandwidth	The maximum bandwidth that can be used for the downstream connections by default.

NOTE 1 – The transport resource subscription may contain multiple profiles.

NOTE 2 – Either the transport subscription profile ID or the transport subscription profile description may be included, but not both at the same time.

NOTE 3 – This information is used by the RACF to configure the transport functions, before resource reservation requests are received from services/applications.

NOTE 4 – Either the default configuration identifier or the default configuration description may be included, but not both at the same time.

NOTE 5 – If a destination does not appear in either of the two lists, gate setting decisions for those addresses is subject to control by RACF.

NOTE 6 – It is available only if the mobility service is applied.

NOTE 7 – It is available only if the host-based mobility is applied.

NOTE 8 – If the tunnel end point address is statically provisioned or the MLM-FE can obtain it with its own mechanisms, this information is not required. It is available only if the network-based mobility is applied.

8.1.7 Reference point HGWC-FE – TLM-FE (Nx)

The Nx reference point enables the HGWC-FE to retrieve information from the TLM-FE. Note that the Nx reference point is similar in nature to the S-TC1 reference point (see clause 8.3.1), the HGWC-FE behaving in this case as a special type of service control function.

8.1.7.1 Information query request

Table 13 describes the information contained in the information query request information flow.

Table 13 – Information query request (HGWC-FE → TLM-FE)

Globally Unique IP Address Information	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
SCF Identity	Indicates the home gateway configuration application.

8.1.7.2 Information query response

Table 14 describes the information contained in the information query response information flow.

Table 14 – Information query response (TLM-FE → HGWC-FE)

Transport Subscriber Identifier	A globally unique identifier for the attached CPE. This identifier can be used for locating the transport subscription information for the CPE.
Physical Connection Identifier	A local identifier for physical connection of the access transport network to which the CPE is attached (e.g., IP address of PE-FE device, and MAC address or link ID and physical port ID).
Logical Connection Identifier	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS label, GTP tunnel and logical port).

8.1.8 Reference point TLM-FE – TLM-FE (Ng)

The Ng reference point enables communication between local and home TLM-FEs.

Five operations may occur: location registration, location query and remove location information, in the direction from local TLM-FE to home TLM-FE, and location query, in the direction from home TLM-FE to local TLM-FE, and location context indication, in the direction from local TLM-FE to local TLM-FE.

8.1.8.1 Location registration

Table 15 describes the content of the location registration information flow.

Table 15 – Location registration (local TLM-FE → home TLM-FE)

Globally Unique IP Address Information	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Transport Subscriber Identifier	A globally unique identifier for the CPE requesting the IP connectivity.
Attached Access Domain Name	The access domain name or the provider's name to which the CPE is attached.
Local TLM-FE contact point	FQDN or IP address of local TLM-FE.

8.1.8.2 Location query

Table 16 describes the content of the location query information flow.

Table 16 – Location query (home TLM-FE → local TLM-FE)

Globally Unique IP Address Information	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Transport Subscriber Identifier	A globally unique identifier for the attached CPE.
Attached Access Domain Name	The access domain name or the provider's name to which the CPE is attached.
Local TLM-FE contact point	FQDN or IP address of local TLM-FE.

8.1.8.3 Location query response

The location query response information flow is identical to the information query response on the S-TC1 reference point (see clause 8.3.1.2).

8.1.8.4 Remove location information

Table 17 describes the content of the remove location information flow.

Table 17 – Remove location (local TLM-FE → home TLM-FE)

Globally Unique IP Address Information	Globally unique address that corresponds to the UNI associated to the user attached to the network.
– Unique IP Address	The IP address for identifying the CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Transport Subscriber Identifier	A globally unique identifier for the CPE requesting the transport resource. This identifier can be used for locating the transport subscription information for the CPE.

8.1.8.5 Location context indication

Table 18 describes the content of the location context switching information flow.

Table 18 – Location context indication (local TLM-FE → local TLM-FE)

Globally Unique IP Address Information	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Transport Subscriber Identifier	A globally unique identifier for the attached CPE.
Attached Access Domain Name	The access domain name or the provider's name of the visited network.
Local TLM-FE contact point	FQDN or IP address of local TLM-FE.

Table 18 – Location context indication (local TLM-FE → local TLM-FE)

Privacy Indicator (Note 1)	Indicates whether location information can be exported to services and applications.
Transport Resource Subscription (Notes 2 and 3)	
– Transport Subscription Profile ID (Note 4)	The identifier of a set of transport subscription profile information.
– Transport Subscription Profile Description (Note 4)	
– Network Class of Service	Represents the network service class subscribed by a CPE (e.g., premium, gold, silver, regular,etc.). It may include the QoS performance class (e.g., class defined in [ITU-T Y.1541] class).
– Subscribed Upstream Bandwidth	The maximum bandwidth subscribed by a CPE for the upstream connections.
– Subscribed Downstream Bandwidth	The maximum bandwidth subscribed by a CPE for the downstream connections.
– Level of Priority	The maximum level of priority permitted for any reservation request.
– Requestor Name	Identifies the requestor(s) that are allowed by the transport resource subscription.
Default Configuration (optional)	
– Default Configuration Identifier (Note 5)	The identifier of a default configuration.
– Default Configuration Description (Note 5)	
– Default Access Control List: List of allowed destinations as well as multicast flows	The list of destination IP addresses, ports, prefixes and port ranges allowed to cut through by default. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs which traffic can be received from by the attached user equipment. Address ranges are supported within the list. (Note 6)
– Default Access Control List: List of denied destinations as well as multicast flows	The list of destination IP addresses, ports, prefixes and port ranges to which traffic is denied by default. In case of multicast, the list of IP-multicast group addresses and/or the list of (source IP address, IP-multicast group address) pairs for which traffic towards the attached user equipment must be denied. Address ranges are supported within the list. (Note 6)
– Default Upstream Bandwidth	The maximum bandwidth that can be used for the upstream connections by default.
– Default Downstream Bandwidth	The maximum bandwidth that can be used for the downstream connections by default.

Table 18 – Location context indication (local TLM-FE → local TLM-FE)

NOTE 1 – An indication whether applications can access location information, depending on their security level.
NOTE 2 – The transport resource subscription may contain multiple transport subscription profiles.
NOTE 3 – Either the transport subscription profile ID or the transport subscription profile description may be included, but not both at the same time.
NOTE 4 – This information is used by the RACF to configure the transport functions, before resource reservation requests are received from services/applications.
NOTE 5 – Either the default configuration identifier or the default configuration description may be included, but not both at the same time.
NOTE 6 – If a destination does not appear in either of the two lists, gate setting decisions for those addresses is subject to control by RACF.

8.1.9 Reference point TUP-FE – TAA-FE (Nb)

The Nb reference point is not specified in this Recommendation, i.e., TAA-FE and TUP-FE are either co-located or connected by a non-standardized interface.

8.2 Reference point between NACF and the resource and admission control functions (RACF)

8.2.1 Reference point between TLM-FE and RACF (Ru)

The Ru reference point allows PD-FE to interact with the NACF for checking on CPE transport subscription profile information and the binding information of the logical/physical port address to an assigned IP address.

The Ru reference point is an intra-domain reference point.

The Ru reference point allows information exchange as follows:

– The transport subscription profile information is pushed by the NACF to PD-FE.

– The transport subscription profile information is pulled by PD-FE from the NACF.

For further information, refer to clause 8.4 of [ITU-T Y.2111].

8.3 Reference points between NACF and the service control functions

8.3.1 Reference point between TLM-FE and the service control functions (S-TC1)

The S-TC1 reference point enables the service control functions (SCF) to retrieve information about the characteristics of the IP-connectivity session used to access such service control functions (e.g., network location information) from the TLM-FE. The form of location information that is provided by the TLM-FE depends on the requestor.

The following information flows are used on the S-TC1 reference point:

– Information query request

– Information query response

– Event registration request

– Event registration response

– Notification event request

– Notification event response

8.3.1.1 Information query request

Table 19 describes the information contained in the information query request information flow.

Table 19 – Information query request (SCF → TLM-FE)

Globally Unique IP Address Information (Note 1)	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID). (Note 2)
Transport Subscriber Identifier (Note 1)	A globally unique identifier of the attached CPE.
SCF Identity	The identifier of the requesting service control function.
NOTE 1 – Either the globally unique IP address information or the transport subscriber identifier is included. NOTE 2 – The addressing domain is known by the SCF either using configuration data (in which case all terminal equipment served by the SCF belong to the same addressing domain) or from the physical or logical interface over which was received the service request that triggered the location query.	

8.3.1.2 Information query response

Table 20 describes the information contained in the information query response information flow.

Table 20 – Information query response (TLM-FE → SCF)

Transport Subscriber Identifier (optional)	A globally unique identifier for the attached CPE. (Note 1)
Location Information (optional) (Note 2)	Location information (or a pointer to such information) in a form that is suitable for the requesting service control function.
RACF contact point (optional)	The FQDN or IP address of the RACF entity where resource request is sent (i.e., PD-FE address).
CPE Type (optional)	The type of CPE.
Type of Access Network (optional)	The type of access network to which the CPE is attached.
Physical Connection Identifier (optional)	A local identifier for physical connection of access transport network to which the CPE is attached (e.g., IP address of PE-FE device, and MAC address or link ID and physical port).
Logical Connection Identifier (optional)	A local identifier for logical connection of access transport network to which the CPE is connected (e.g., ATM VPI/VCI, PPP, MPLS label, GTP tunnel and logical port).
NOTE 1 – This identifier may be used by the SCF when interacting with the RACF. NOTE 2 – Location information disclosure depends on the requesting application and the subscriber's privacy restrictions. Privacy restrictions are defined in the privacy indicator stored in the TLM-FE.	

8.3.1.3 Event registration request

Table 21 describes the information contained in the event registration request information flow. This information flow is not applicable if the SCF is a P-CSCF [ITU-T Y.2021].

Table 21 – Event registration request (SCF → TLM-FE)

Subscription Duration	Duration for which the subscription for a particular event will be active.
Transport Subscriber Identifier (optional) (Note 1)	A globally unique identifier of the attached CPE.
Event	Event-type (e.g., user logon event) and format for event relay/ notification description.
Globally Unique IP Address Information (optional) (Note 1)	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID). (Note 2)
SCF Identity (optional)	The identifier of the requesting service control function.
NOTE 1 – At least one of the two identifiers ("Transport Subscriber Identifier" or "Globally Unique IP Address Information") is required to be supplied. NOTE 2 – The addressing domain is known by the SCF either using configuration data (in which case all user equipment served by the SCF belongs to the same addressing domain) or from the physical or logical interface over which a related service request was received.	

8.3.1.4 Event registration response

Table 22 describes the information contained in the event registration response information flow. This information flow is not applicable if the SCF is a P-CSCF [ITU-T Y.2021].

Table 22 – Event registration response (TLM-FE → SCF)

Update Action	Administrative action/information for an event: e.g., ACTIVATED (event registration successfully received and event notification for "Event" activated).
Transport Subscriber Identifier (Note)	A globally unique identifier for the attached CPE.
Event	Event-type (e.g., user logon event).
Globally Unique IP Address Information (Note)	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
NOTE – At least one of the two identifiers ("Transport Subscriber Identifier" or "Globally Unique IP Address Information") is required to be supplied.	

8.3.1.5 Notification event request

Table 23 describes the information contained in the notification event request information flow. This information flow is not applicable if the SCF is a P-CSCF [ITU-T Y.2021].

Table 23 – Notification event request (TLM-FE → SCF)

Globally Unique IP Address Information	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Transport Subscriber Identifier	A globally unique identifier for the attached CPE.
Event	Event-type (e.g., user logon event).

8.3.1.6 Notification event response

Table 24 describes the information contained in the notification event response information flow. This information flow is not applicable if the SCF is a P-CSCF [ITU-T Y.2021].

Table 24 – Notification event response (SCF → TLM-FE)

Globally Unique IP Address Information	A set of IP address information used for locating the access network in which the CPE is attached.
– Unique IP Address	The IP address for identifying the attached CPE.
– Address Realm	The addressing domain of the IP address (e.g., Subnet prefix or VPN ID).
Transport Subscriber Identifier	A globally unique identifier for the attached CPE.
Event	Event-type.
Result	Result code (e.g., success, permanent failure, etc.).

8.4 Reference points between NACF and CPE

8.4.1 Reference points for authentication and IP address allocation (T-U1 and TC-T1)

There is no direct reference point between the NACF and the CPE for supporting authentication and IP address allocation. Communication between the NACF and the CPE takes place via the access relay functional entity (AR-FE) in the transport functions and involves both the T-U1 reference point between the CPE and the AR-FE, and the TC-T1 reference point between the AR-FE and the NACF.

The T-U1 reference point at the CPE side may either be terminated on a HGW or a TE. The latter case applies when the TE has direct connectivity to the AR-FE.

The T-U1 reference point enables the CPE to initiate requests for IP address allocation and possible other network configuration parameters in order to access the network. These requests are received by the AR-FE and are relayed to the AM-FE in the NACF via the TC-T1 reference point.

Requests for IP address allocation and network configuration parameters are either in the form of a DHCP [b-IETF RFC 2131] or PPP [b-IETF RFC 1661] request.

In case DHCP is used, the transport functions include an access relay functional entity (AR-FE) that is acting as a DHCP relay between the DHCP clients in the CPE and the DHCP server in the NACF.

Before sending a request to the NACF on the TC-T1 reference point, the AR-FE may add network location information to the information received from the CPE on the T-U1 reference point. The T-U1 reference point enables the CPE to provide user credentials (password, token, certificate etc.) to the NACF in order to perform network access authentication. The T-U1 reference point may also enable the NACF to provide authentication parameter to the CPE to perform the network authentication when mutual authentication procedure is required. Based on the authentication result, the AM-FE authorizes or denies the network access to the CPE.

NOTE – When DHCP is used for IP address allocation and CPE configuration between the NACF and the CPE, IEEE 802.1X [b-IEEE 802.1X] and PANA [b-IETF RFC 4058] are candidate protocols for authentication between the NACF and CPE.

8.4.2 Reference point between HGWC-FE and CPE (TC-Ux)

The TC-Ux reference point allows the HGWC-FE to configure the HGW, trigger maintenance tests, monitor the performance, and receive notifications. The TC-Ux reference point is used during initialization and update of the HGW to provide the HGW additional network configuration information when this information is not available over the T-U1 reference point, in order to allow the HGW to access to the NGN service control functions.

The HGWC-FE may also manage the TE devices connected to a HGW, indirectly via the HGW or directly to the TEs, for configuration, maintenance, performance monitoring, and notification purposes.

The TC-Ux reference point supports the following procedures:

– HGW identification/authentication to the HGWC-FE (e.g., in order to send appropriate configuration information (firmware upgrade) from the HGWC-FE.
– HGWC-FE authentication to the HGW before one HGW accepts a remote configuration for instance.
– Trigger maintenance tests from the HGWC-FE and report test results from the HGW.
– Configure the HGW.
– Notify the HGWC-FE about TE availability.
– Provide configuration and upgrade for the TEs.
– Trigger maintenance tests from the HGWC-FE and report test results from the TEs.

NOTE – TR-069 [b-DSL Forum TR-069], HTTP [b-IETF RFC 2616], FTP [b-IETF RFC 959] and TFTP [b-IETF RFC 783] are candidate protocols for this reference point.

8.5 Reference points between NACF and the mobility management and control functions (MMCF)

8.5.1 Reference point between TLM-FE and MLM-FE(P) (M1)

The M1 reference point allows the TLM-FE to interact with the MLM-FE(P) for pushing mobility service parameters such as keying material, anchor address, etc.

The M1 reference point is an intra-domain reference point.

The M1 reference point allows information exchange as follows:

– The mobility service parameters information is pushed by the TLM-FE to MLM-FE(P).

For further information, refer to clause 6.5 of [ITU-T Y.2018].

8.5.2 Reference point between TLM-FE and HDC-FE (M2)

The M2 reference point allows TLM-FE to interact with the HDC-FE for pushing mobility service parameters such as keying material, in support of the security association required between the HDC-FE and the UE.

The M2 reference point is an intra-domain reference point.

The M2 reference point allows information exchange as follows:

– The mobility service parameters information is pushed by the TLM-FE to HDC-FE.

For further information, refer to clause 6.5 of [ITU-T Y.2018].

8.5.3 Reference point between TLM-FE and NID-FE (M13)

The M13 reference point allows TLM-FE to interact with the NID-FE for pushing mobility service parameters such as keying material, in support of the security association required between the NID-FE and the UE.

The M13 reference point is an intra-domain reference point.

The M13 reference point allows information exchange as follows:

– The mobility service parameters information is pushed by the TLM-FE to NID-FE.

For further information, refer to clause 6.5 of [ITU-T Y.2018].

9 Security considerations

The security requirements within the functional requirements and architecture of the NACF are addressed by the security requirements for NGN [ITU-T Y.2701] as well as the security requirements for NGN authorization and authentication [ITU-T Y.2702].

Appendix I

Mapping to network roles

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

The NACF architecture does not assume any business roles. However, to cope with the requirements for nomadism and roaming, the NACF architecture can be mapped onto various functional network roles present in the fixed broadband access environment as shown in Figure I.1.

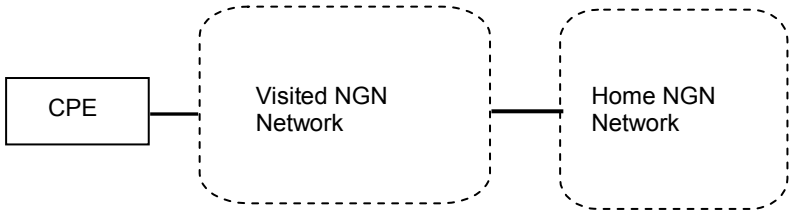


Figure I.1 – Functional network roles in NGN

Figures I.2 and I.3 give the mapping of NACF. Example of the access network in these figures is xDSL access network or a WLAN hotspot.

Figure I.2 shows the scenario 1 whereby the service control functions are (partly) provided by the visited NGN network. Figure I.3 clarifies a scenario 2 in which the home NGN network provides the service control functions.

Figures I.4 and I.5 both represent scenarios 3 and 4 in which a visiting CPE does not perform access authentication. In Figure I.4, the visiting CPE is able to access its home services via roaming agreement at the level of the service control functions. The definition of this is however outside the scope of this Recommendation. Figure I.5 gives a scenario in which service control functions of the home network access the TLM-FE in the visited network for location information via a TLM-FE-proxy in the home network. The Ng reference point is used here as a TLM-FE to TLM-FE reference point.

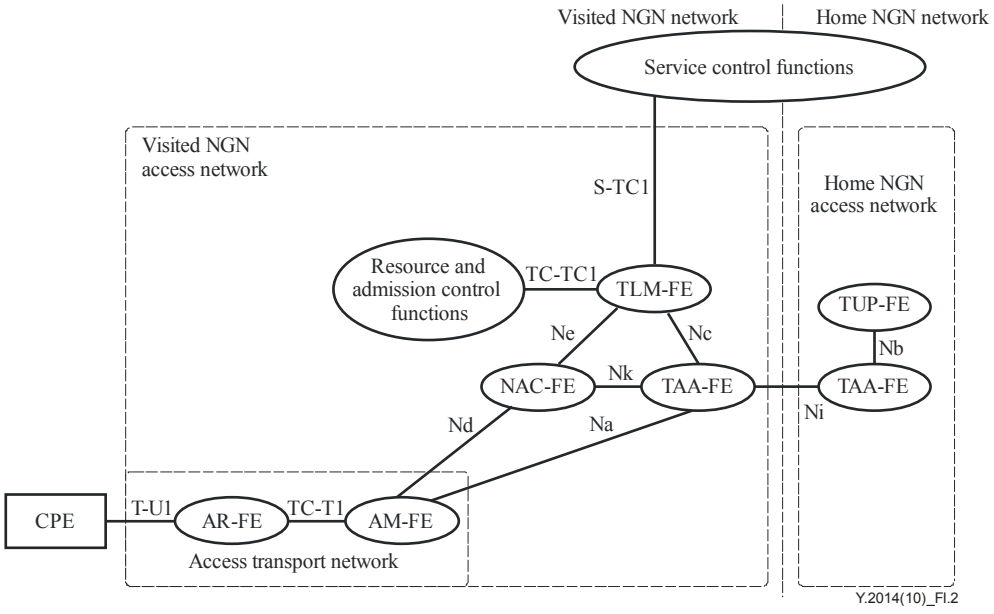


Figure I.2 – NACF mapped on functional network roles – scenario 1

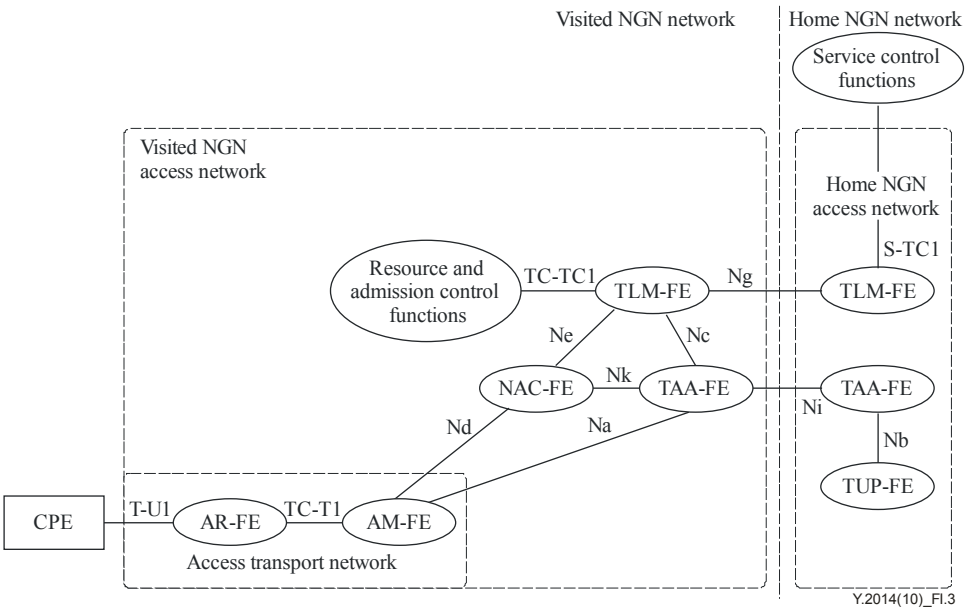


Figure I.3 – NACF mapped on functional network roles – scenario 2 (NGN services from the home network)

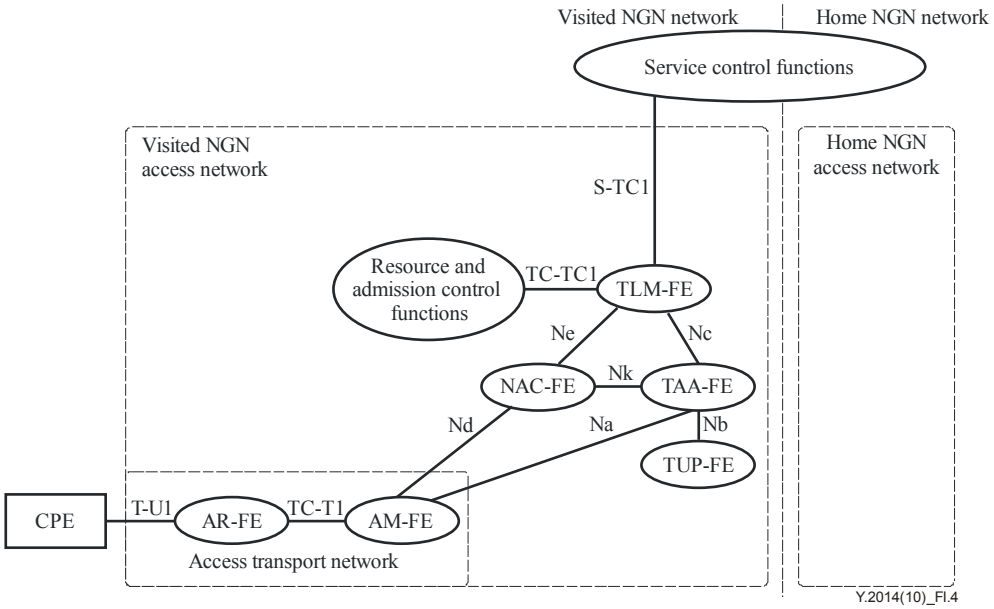


Figure I.4 – NACF mapped on functional network roles – scenario 3

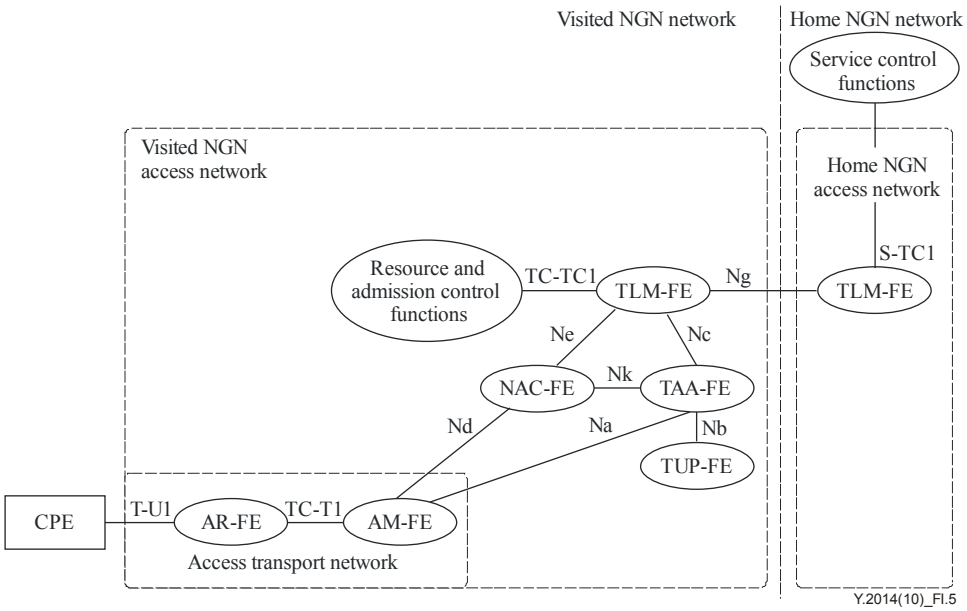


Figure I.5 – NACF mapped on functional network roles – scenario 4

Appendix II

Information flows

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

II.1 High level information flows

This clause provides high level information flows that define the network attachment process and the distribution of transport subscription profile information in the NACF and towards the RACF.

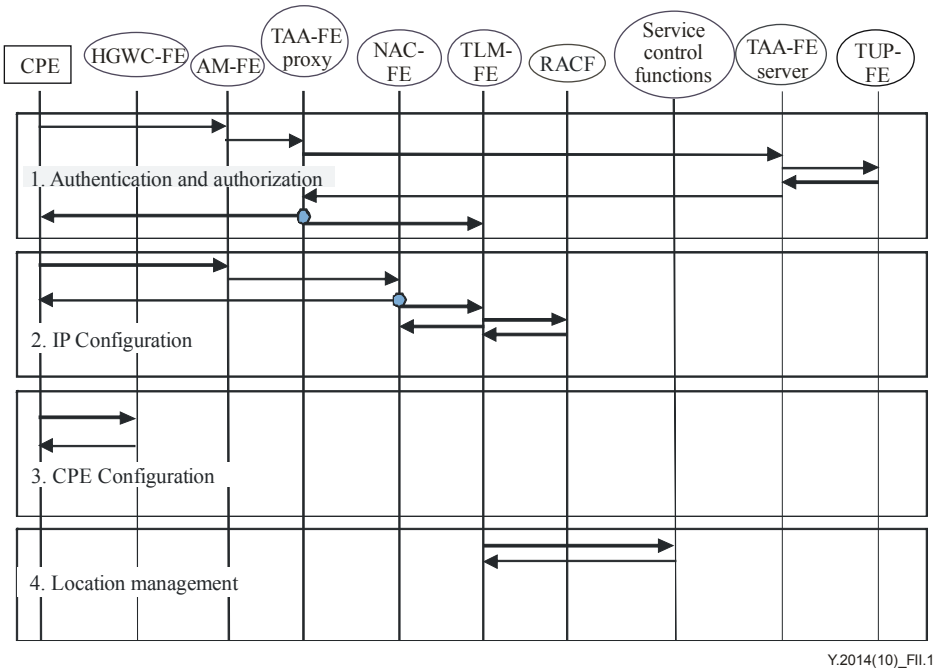


Figure II.1 – High level information flows

The NACF relies on several stages in the network attachment process. Figure II.1 shows the high level information flows and the different procedures of NACF. Depending on the technology (e.g., [b-IEEE 802.1X], [b-IETF RFC 4058], etc.) and configuration used these stages can be applied in a different order than presented in Figure II.1:

1. In the first stage of the network attachment process, the CPE will be authenticated and authorized. The authentication process relies on the mechanisms and identities described in clauses 6, 7 and 8. This implies that line authentication and/or access authentication is used. The applicable identifiers are: user identifier and credentials provided by the user or CPE identifier. Step 1 also involves the authorization for access to the network based on the transport subscription profile. A specific transport subscription profile, related e.g., to QoS, may be downloaded from the home NGN network to the visited NGN network (from the TAA-FE-server to the TAA-FE-proxy mode). When the authentication is successful and the CPE is authorized to use access network resources, configuration of access network based on transport subscription profile is performed. This implies also that the transport subscription profile information specific for the authenticated user is required to be forwarded to the TLM-FE via the Nc reference point. The profile information includes at least the logical connection identifier (i.e., line ID), transport subscriber identifier and the transport resource subscription information, which may be the QoS profile downloaded from the home NGN network or a default configuration profile, and the identification of the edge PE-FE device.

NOTE 1 – Step 1 may occur prior or during the IP address allocation procedure (step 2).

2. Dynamic provision of IP address and provisioning of IP configuration information to the CPE. During step 2 the NAC-FE allocates the IP configuration information. The NAC-FE receives from signalling via TC-T1 reference point the logical connection identifier (i.e., Line ID) and establishes the mapping between the allocated IP configuration information and the logical connection identifier. This mapping information is forwarded to the TLM-FE (via the Ne reference point), which correlates this with the transport subscriber identifier and the transport subscription profile and pushes this information to RACF via Ru reference point. The RACF configures its functionality in line with the transport subscription profile information it receives from TLM-FE.
3. The HGWC-FE may configure HGW parameters.
4. The NGN service control functions retrieve location information from the TLM-FE via the S-TC1 reference point. In case the NGN service control functions need to access location information in a different domain, the signalling to retrieve the location information is required to be forwarded via a TLM-FE proxy, which is located in the same network as the NGN service control functions that retrieves the information. The primary parameter to retrieve the location information is the transport subscriber identifier and/or the IP address allocated to the CPE by NACF.

NOTE 2 – For further information about the procedure of mobility attachment, refer to clause 7.2 of [ITU-T Y.2018].

II.2 PPP based authentication

This clause provides example information flows of NACF in case PPP is applied [b-IETF RFC 1661]. These examples are not intended to cover the complete functionality of NACF in case of PPP-based authentication.

NOTE – This is intended as an example only.

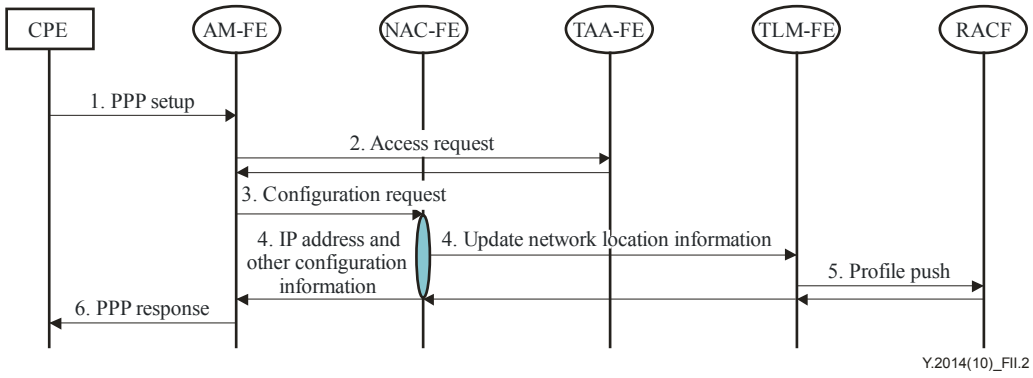


Figure II.2 – PPP based network attachment

1. CPE initiates a PPP request to apply for an IP address. PPP is used for access and line authentication.
2. AM-FE relays translates PPP request to an access request to the TAA-FE for authentication.
3. AM-FE sends the configuration request to NAC-FE to obtain IP address and other parameters including in this scenario the IP address of a NGN service control function (e.g., P-CSCF).
4. The NAC-FE allocates an IP address and replies to the AM-FE. The NAC-FE also sends to the TLM-FE the binding information of allocated IP address, line ID and identification of the edge PE-FE device.

5. The TLM-FE pushes the binding information to the RACF via the Ru reference point.

6. The AM-FE sends a PPP response to the CPE including the allocated IP address as other parameters including the IP address of a NGN service control function (e.g., P-CSCF).

II.3 DHCP mode

This clause provides example information flows of NACF in case DHCP is used. These examples are not intended to cover the complete functionality of NACF in case of DHCP mode.

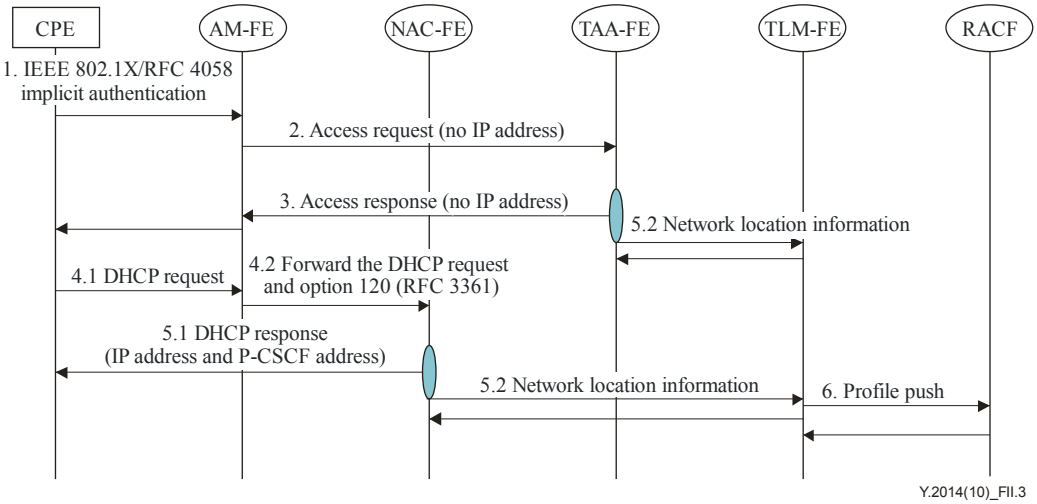


Figure II.3 – DHCP based network attachment with [b-IEEE 802.1X]/ [b-IETF RFC 4058]/implicit access authentication

1 CPE initiates authentication based on [b-IEEE 802.1X]/[b-IETF RFC 4058]. Alternatively, line authentication may be implicitly performed in case no nomadism applies.

2. The AM-FE contacts the TAA-FE for authentication.

3. After successful authentication, the TAA-FE responds with the authentication result. The TAA-FE informs the TLM-FE that a CPE is authenticated.

4. DHCP request is used by CPE to request an IP address (as per flow 4.1) and through DHCP option No. 120 the address of a NGN service control function (e.g., P-CSCF) (as per flow 4.2). This request is relayed by the AM-FE to the NAC-FE, which operates a DHCP server.

5. The NAC-FE allocates an IP address and replies to the CPE. The NAC-FE also informs the TLM-FE that an IP address is allocated to the CPE indicated in 3).

6. The TLM-FE pushes the binding information between the allocated IP address, line ID and identification of edge PE-FE device to the RACF via the Ru interface.

NAC-FE provides the FQDN or IP address of the NGN service control function contact point (e.g., P-CSC-FE), which is relayed by the AM-FE to the CPE.

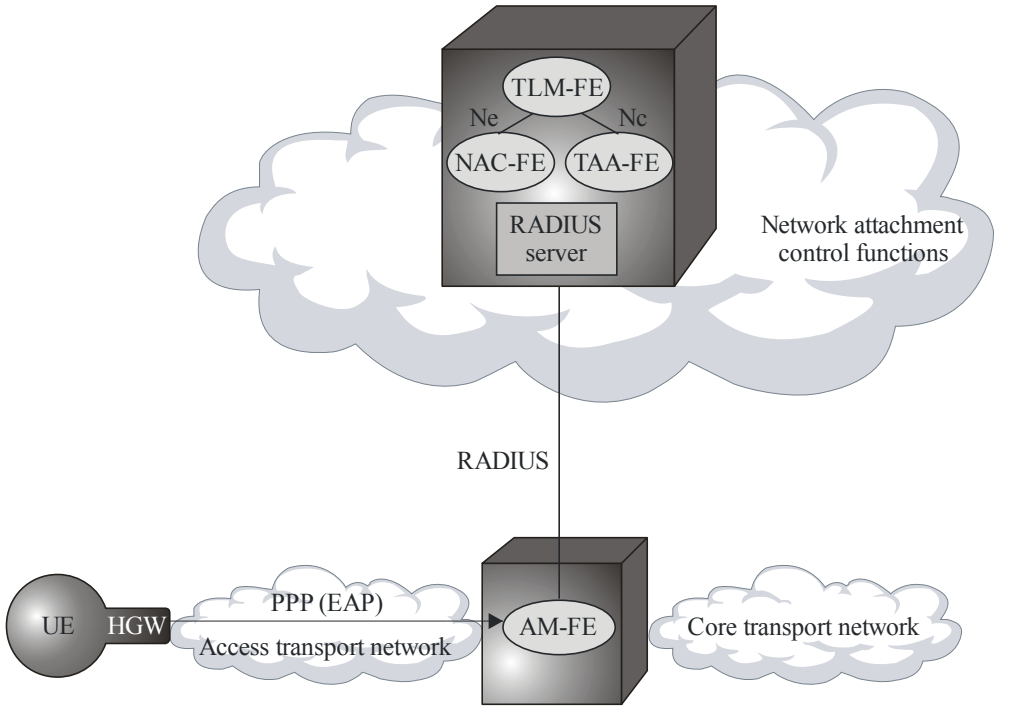
Appendix III

Physical configurations

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

In this appendix, reference is made to EAP [b-IETF RFC 3748] as an authentication method. Which authentication mechanism is used for NACF is for further study.

III.1 PPP case



NOTE – For the sake of simplicity, interfaces to the RACF are not represented.

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Figure III.1 – PPP-based configuration

III.2 PPP with DHCP configuration

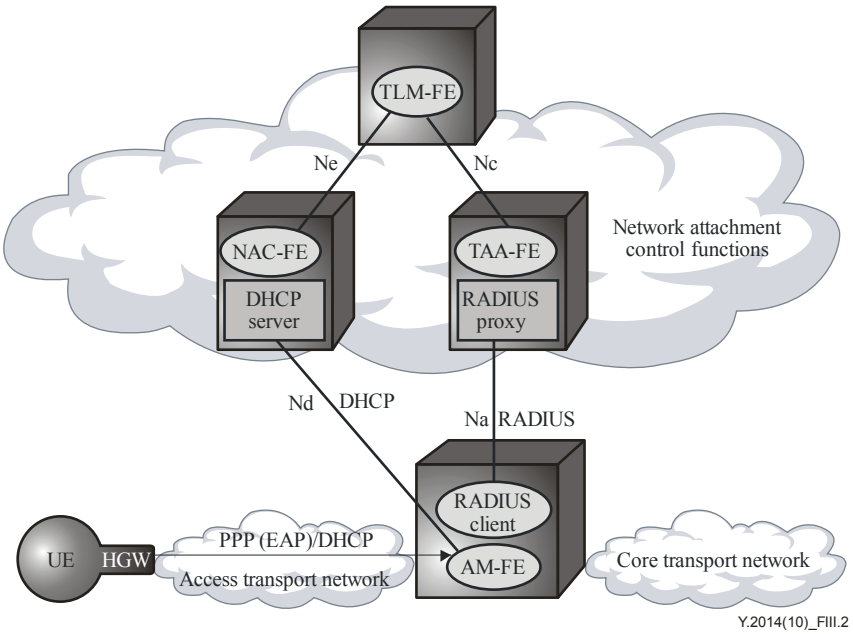

Figure III.2 – PPP-based configuration with DHCP based IP configuration (allocation of the NGN service control functions contact point to the HGW)

III.3 DHCP (option 1)

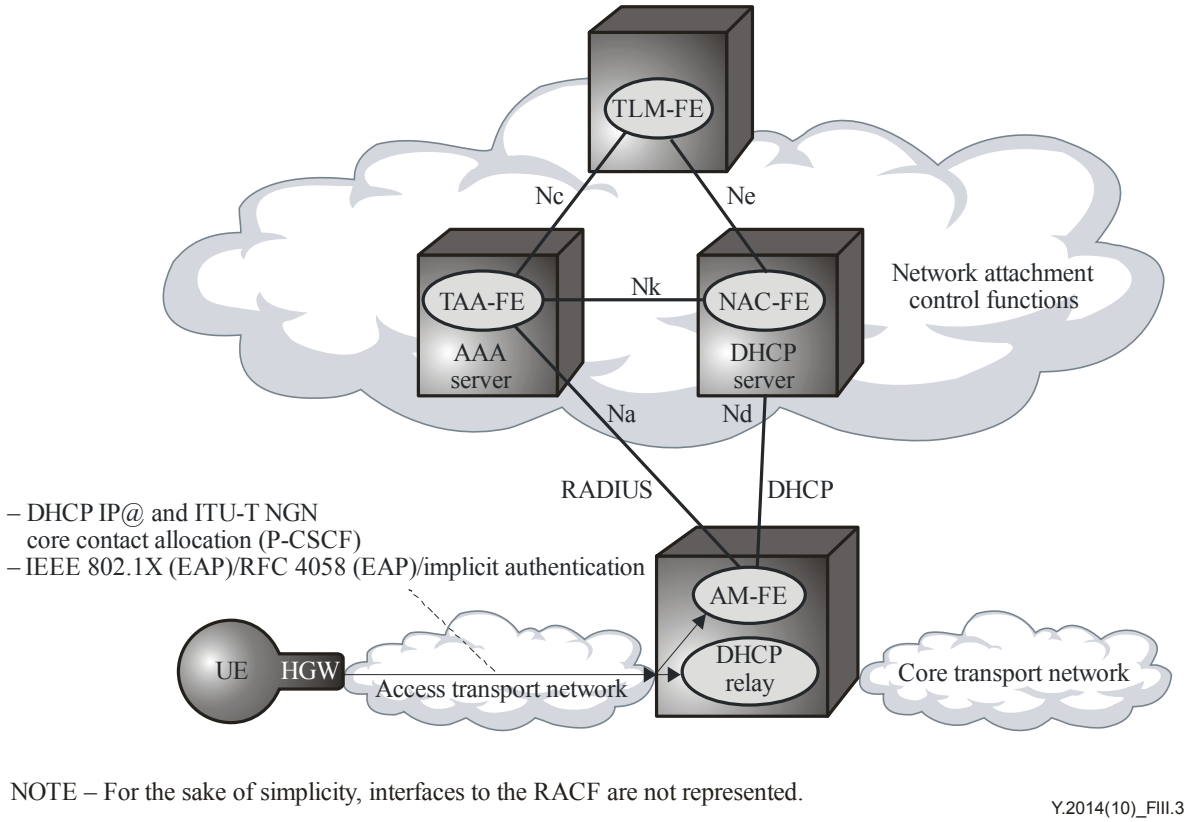

Figure III.3 – DHCP-based configuration (option 1)

III.4 DHCP (option 2)

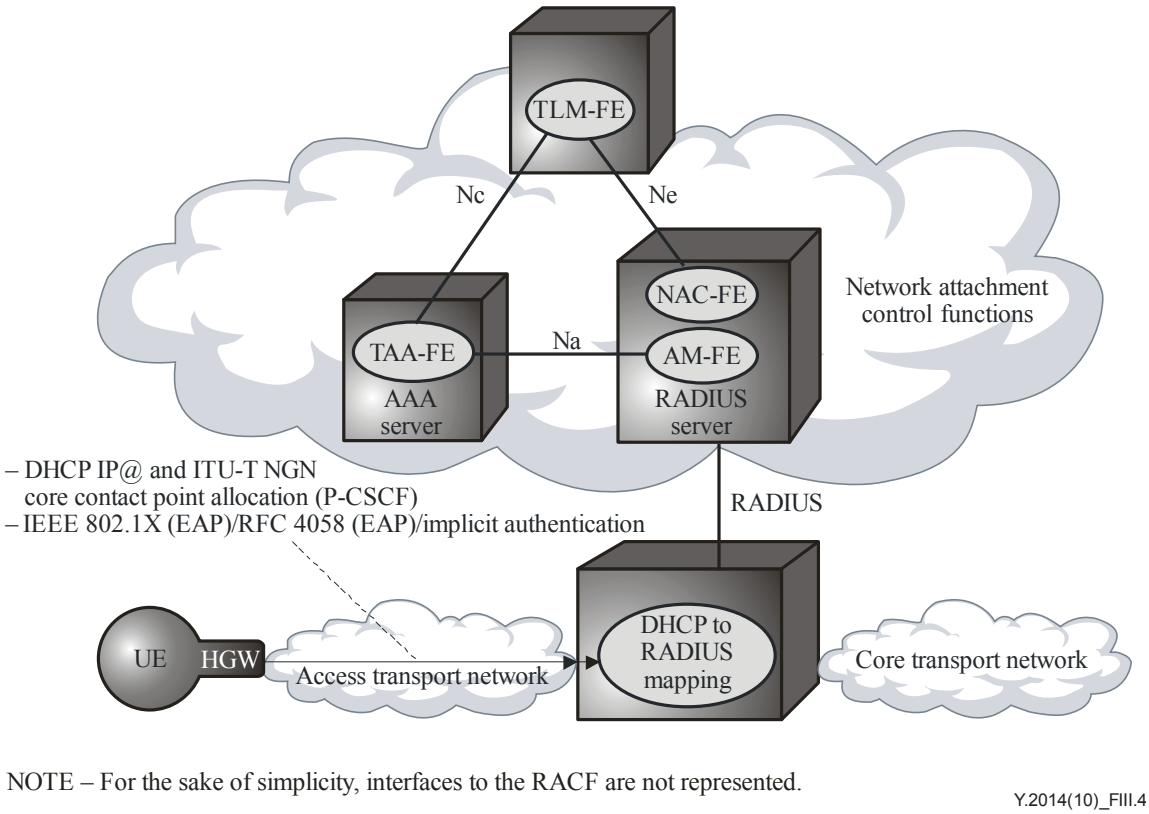

Figure III.4 – DHCP-based configuration (option 2)

III.5 PANA-based configuration

With a DHCP-based implementation, the user authentication may be provided at the IP layer by using PANA (Protocol for carrying Authentication for Network Access) defined within IETF [IETF RFC 4058]. This IP protocol carries EAP [b-IETF RFC 3748] between a PANA client (PaC) residing in the end user equipment and a PANA authentication agent (PAA) in the transport plane. This PANA signalling goes through an enforcement point (EP) that controls the access of unauthorized users to the network.

The PAA consults an authentication server in order to verify the credentials and rights of a PaC. If the authentication server resides on the same physical equipment as the PAA, an API is sufficient for this interaction. When they are separated, RADIUS or Diameter may be used for this purpose.

Once the user is successfully authenticated and authorized to access to the network, the PAA sends to the EP configuration information to modify the per-packet enforcement policies (i.e., filters) applied on the inbound and outbound traffic of the end user equipment.

Figure III.5 describes a PANA-based implementation for the physical configuration of NACF:

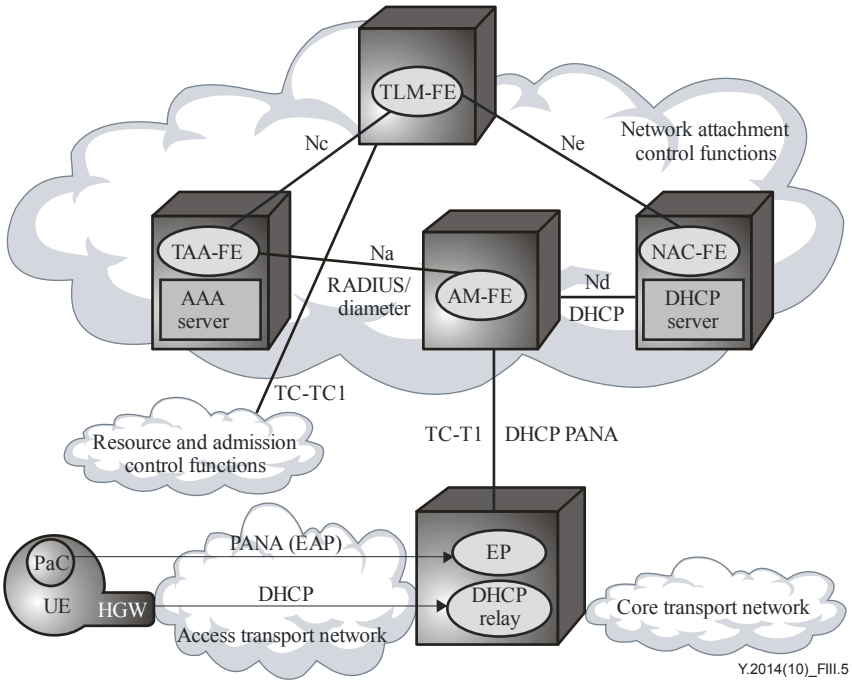

Figure III.5 – PANA-based configuration

Appendix IV

Overall mapping between Recommendation ITU-T Y.2014 and ETSI ES 282 004 v2.0.0

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

The following table provides a high level mapping between NACF as specified in this Recommendation and the network attachment sub-system (NASS) as specified in [b-ETSI ES 282 004].

Table IV.1

ETSI ES 282 004 v2.0.0	Recommendation ITU-T Y.2014
Functional entities	
ARF	AR-FE [ITU-T Y.2012]
AMF	AM-FE
NACF	NAC-FE
UAAF	TAA-FE
PBDF	TUP-FE
CLF	TLM-FE
CNGCF	HGWC-FE
CNG	HGW
Reference points	
NACF-AMF: a1	NAC-FE/AM-FE: Nd
NACF-CLF: a2	NAC-FE/TLM-FE: Ne
AMF-UAAF: a3	AM-FE/TAA-FE: Na
UAAF-CLF: a4	TAA-FE/TLM-FE: Nc
UAAF-PBDF: not defined	TAA-FE/TUP-FE: Nb. Details are for further study.
NACF-UAAF: not defined	NAC-FE/TAA-FE: Nk. Details are for further study.
ARF-AMF: e1	AR-FE-AM-FE: TC-T1
UE-ARF: e1	CPE/AR-FE: T-U1 [ITU-T Y.2012]
AF (e.g., P-CSCF)-CLF: e2	Service Control Functions (SCF)/TLM-FE: S-TC1
CLF-CLF: e2	TLM-FE/TLM-FE: Ng
CNGCF-CLF: e2	HGWC-FE/TLM-FE: Nx
CNGCF-UE: e3	HGWC-FE/CPE: TC-Ux
CLF-RACS: e4	TLM-FE/RACF: Ru
UAAF-UAAF: e5	TAA-FE/TAA-FE: Ni

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[b-3GPP TS 23.401] 3GPP TS 23.401 (in force), *General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access*.

[b-3GPP TS 23.402] 3GPP TS 23.402 (in force), *Architecture enhancements for non-3GPP accesses*.

[b-DSL Forum TR-069] DSL Forum TR-069 (2006), *CPE WAN Management Protocol* v1.1.

[b-IEEE 802.1X] IEEE 802.1X – 2004, *IEEE Standard for Local and Metropolitan Area Networks – Port-Based Network Access Control.*

[b-IETF RFC 4058] IETF RFC 4058 (2005), *Protocol for Carrying Authentication for Network Access (PANA) Requirements*.

[b-ETSI ES 282 004] ETSI ES 282 004 v2.0.0 (2008-02), *Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); NGN Functional Architecture; Network Attachment Sub System (NASS)*.

[b-IETF RFC 783] IETF RFC 783 (1981), *The TFTP Protocol (Revision 2)*.

[b-IETF RFC 959] IETF RFC 959 (1985), *File Transfer Protocol (FTP)*.

[b-IETF RFC 1661] IETF RFC 1661 (1994), *The Point-to-Point Protocol (PPP)*.

[b-IETF RFC 2131] IETF RFC 2131 (1997), *Dynamic Host Configuration Protocol*.

[b-IETF RFC 2616] IETF RFC 2616 (1999), *Hypertext Transfer Protocol – HTTP/1.1*.

[b-IETF RFC 2865] IETF RFC 2865 (2000), *Remote Authentication Dial In User Service (RADIUS)*.

[b-IETF RFC 3220] IETF RFC 3220 (2002), *IP Mobility Support for IPv4*.

[b-IETF RFC 3588] IETF RFC 3588 (2003), *Diameter Base Protocol*.

[b-IETF RFC 3748] IETF RFC 3748 (2004), *Extensible Authentication Protocol (EAP)*.

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