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SERIES Q: SWITCHING AND SIGNALLING

Signalling requirements and protocols for IMT-2000

Functional network architecture for IMT-Advanced

Recommendation ITU-T Q.1704

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SWITCHING AND SIGNALLING

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Recommendation ITU-T Q.1704

Functional network architecture for IMT-Advanced

Summary

Recommendation ITU-T Q.1704 specifies a long-term high-level network architecture for IMT-Advanced specified in Recommendations ITU-T Q.1702, Q.1703 and ITU-R M.1645.

Source

Recommendation ITU-T Q.1704 was approved on 14 October 2008 by ITU-T Study Group 19 (2005-2008) under Recommendation ITU-T A.8 procedure.

Keywords

IMT-Advanced.

FOREWORD

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1 Scope

The scope of this Recommendation is to provide a long-term high-level network architecture for IMT-Advanced[1] as specified by [ITU-T Q.1703], [ITU-T Q.1702], and [ITU-R M.1645].

This Recommendation identifies network functions specific to IMT-Advanced and defines the corresponding network functional entities through functional models, which will form the basis for further designating reference points and developing information flows and functional entity actions.

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 M.3060] Recommendation ITU-T M.3060/Y.2401 (2006), *Principles for the management of next generation networks*.

[ITU-T Q.1701] Recommendation ITU-T Q.1701 (1999), *Framework for IMT-2000 networks*.

[ITU-T Q.1702] Recommendation ITU-T Q.1702 (2002), *Long-term vision of network aspects for systems beyond IMT-2000*.

[ITU-T Q.1703] Recommendation ITU-T Q.1703 (2004), *Service and network capabilities framework of network aspects for systems beyond IMT-2000*.

[ITU-T Y.2011] Recommendation ITU-T Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.

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

[ITU-R M.1645] Recommendation ITU-R M.1645 (2003), *Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000*.

[1] The term "IMT-Advanced" is now used in place of "systems beyond IMT-2000" per ITU-R Resolution 56 (2007).

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

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

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

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

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

3.2 Terms defined in this Recommendation

This Recommendation does not define any new terms.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3GPP	3rd Generation Partnership Project
AAA	Authentication, Authorization and Accounting
AP	Access Point
APR	Anchor Point Router
AR	Access Router
AS	Application Server
CSCF	Call Session Control Function
FE	Functional Entity
G-MM-FE	Global Mobility Management Functional Entity
HSS	Home Subscriber Server
IMT-2000	International Mobile Telecommunications-2000
IP	Internet Protocol
L2	Layer 2
L3	Layer 3
L-MM-FE	Local Mobility Management Functional Entity
NGN	Next Generation Network
P-CSC-FE	Proxy Call Session Control Functional Entity
PD-FE	Policy Decision Functional Entity

QoS	Quality of Service
RACF	Resource and Admission Control Function
RAM-FE	Radio Access Management Functional Entity
RAN	Radio Access Network
SCF	Service Control Function
S-CSC-FE	Serving Call Session Control Functional Entity
TRC-FE	Transport Resource Control Functional Entity

5 Conventions

Functional entities in this Recommendation with the same name as in [ITU-T Y.2012] follow the general concept stated in [ITU-T Y.2012]; however the former is not always identical to the latter mainly because of possible additional functionalities derived as a consequence of addressing mobility. Convergence, in a precise sense, in terms of functional entities that appear in this Recommendation and in [ITU-T Y.2012] is for further study.

6 Introduction

In defining a vision for the future of mobile telecommunications, a number of layers of detail is required. The highest layer is an overall end-user service oriented perspective. This is provided in [ITU-T Q.1701] and [ITU-T Q.1702].

[ITU-T Q.1703] provides the service and network capabilities and/or requirements framework, from the network aspect, for IMT-Advanced.

The next level of detail is the definition of the high-level network architecture for IMT-Advanced, which includes the definition of functional entities and its relationships. This level is the objective of this Recommendation.

It is expected that a future Recommendation will define how the information should flow among the functional entities in IMT-Advanced, according to the functional network architecture model adopted.

7 General principles of the functional architecture

The functional architecture incorporates the following general principles:

- Network architecture based on IP technology

  Access networks, which provide a rich set of access mechanisms using various wired and wireless access technologies, terminate layer two link characteristics and provide IP-based connection to core networks. Core networks and application servers connected to them are IP based.

- Modular construction using expandable components

  The subsystems themselves, such as access networks, core networks, and application servers; as well as the systems built based on them are hierarchical. In particular, core networks provide universal interfaces to different access networks and to all kinds of application servers.

  Accessibility to each subsystem is separately controlled based on each operator's policy; on the other hand in particular, paths that users can control to access application servers are prepared.

- Open interfaces between various systems

  Interoperation with homogeneous networks and with heterogeneous networks is facilitated with open interfaces in various levels of subsystems.

8 Functional network architecture overview

The IMT-Advanced architecture should support multiple access networks, converged services in a converged network, enhanced security and protection, and total service accessibility, based on the services and network capabilities framework of network aspects defined in [ITU-T Q.1703] and aligned with the NGN architecture.

8.1 NGN architecture overview

The NGN architecture is based on the general principles defined in [ITU-T Y.2011]. It is further detailed in [ITU-T Y.2012] for transport and service stratum functions and in [ITU-T M.3060] for management functions that apply to both transport and service strata.

8.2 IMT-Advanced architecture overview and NGN

The IMT-Advanced architecture is based on the general principles defined in [ITU-T Y.2011]. It is not necessarily identical to the NGN architecture because of additional functions derived as a consequence of addressing mobility, recognizing that these two architectures are moving towards convergence.

9 Generalized functional architecture and functional entities

This clause identifies network functions specific to IMT-Advanced and defines the corresponding network functional entities through functional models, which will form the basis for further designating reference points and developing information flows and functional entity actions.

It is intended to link service and network capabilities defined in [ITU-T Q.1703] and specific to IMT-Advanced into functional entities defined in the NGN architecture, when possible.

The IMT-Advanced architecture that encompasses these identified functional entities is to be understood as generalized, to allow for possible plural instantiations in more specific service or technology contexts.

9.1 Network functions

9.1.1 Mobility management

The mobility management function manages mobility of terminals. In other words, it manages handover, location updating and paging for terminals. At handover and paging, the mobility management component sets routing information in entities of transport network. At location updating, the mobility management component tracks the paging area information of the terminal.

Different mechanisms are applied based on the mobility management state of the terminal; i.e., location management and handover.

9.1.1.1 Location management

When the terminal is in idle state (i.e., it is not involved in an active session and/or radio resources for the terminal have been released), the network needs to track the location of the terminal by means of location update from the terminal. The network is able to reach the idle state terminal through the paging procedure.

9.1.1.2 Handover management

When the terminal is in active state (i.e., it is involved in an active session), the mobile terminal is required to be able to communicate whilst changing its point of attachment to the network due to its movement.

9.1.2 QoS management

QoS management is meant to provide an end-to-end QoS which includes wireless and wired networks. In NGN environments, QoS management will be performed by the resource and admission control function (RACF). QoS will be based on users' preferences and/or applications. QoS management will be highly inter-related to the service control function (SCF), mobility managements and authentication, authorization and accounting (AAA).

In order to efficiently meet diverse QoS requirements from the users/applications and achieve flexibility in developing QoS-enabled applications with no knowledge of the underlying transport technology and QoS mechanisms, RACF provides its QoS management service relative to a SCF in the service stratum, through which the users/applications can communicate with RACF entities to send QoS requirements, receive results and so forth.

In order to provide an end-to-end QoS in the overall network interconnecting multiple access technologies and different operators' networks, RACF applies a distribution mechanism that distributes end-to-end QoS bearer specifications to each network and access system along the end-to-end path. Based on the information elements of the QoS specification, the RACF of each network and access system makes a local decision that is optimized for the local network domain.

When RACF receives a QoS set up request from the SCF in the service stratum, it starts to set up QoS for the session. RACF asks mobility management to give the information for the route that a user's packet passes.

Allowing differentiated QoS for different users will require the authentication and authorization of users for the requested levels of QoS, as well as accounting procedures, if the QoS is to be modified.

9.1.3 Call session control function (CSCF)

The call session control function basically handles transactions for call/session setup, termination and forwarding to other call session control functional entities. It interacts with other network functions (mobility management, QoS management, security management, etc.) in order to support the call/session.

The call session control function is realized by two functional entities, i.e., the proxy call session control functional entity (P-CSC-FE) and the serving call session control functional entity (S-CSC-FE). The P-CSC-FE acts like a proxy function to mobile terminals. The S-CSC-FE controls the call/session for the mobile terminals. It maintains a call/session state for management purposes.

9.2 Network functional entities

9.2.1 Mobility management function

9.2.1.1 Access router (AR)

The access router (AR) is an entity that connects a terminal to the network. This entity connects the terminal directly at the network layer.

It manages the entries that contain the mapping of the terminal's network layer address to a port that connects to the corresponding AP that is associated with the terminal. Packets addressed to the terminal are forwarded by referring to the entries.

It creates, updates, or deletes the entries when a RAM-FE notifies it of the AP selected by the RAM-FE.

9.2.1.2 Access point (AP)

The access point (AP) is an entity that connects terminals directly at the link layer to the network. It is connected to the AR.

It does not terminate any network or upper layer protocol. It terminates the link layer protocol.

9.2.1.3 Terminal

The terminal is a device used by service subscribers to access the network.

It is an entity that can connect directly to AP(s) at the link layer and to AR(s) at the network layer.

It sends/receives the network control requests/responses to/from network control entities.

It has two states, active and dormant, in conjunction with the routing information management in the mobility management entities.

The active and dormant states are defined as follows:

Active: The state in which the terminal is ready to send and receive packets. The transport network has the routing information of the terminal the L-MM-FE is currently serving.

Dormant: The state where the terminal is not ready to send or receive packets. The transport network is not ready to route packets to its destination.

9.2.1.4 Anchor point router (APR)

The anchor point router (APR) is a router located in the L-MM-FE domain. There may be several APRs in an L-MM-FE domain.

It will receive all packets on behalf of the terminals it is serving and forward them to the current address of the terminals through the ARs.

This function has redundancy to avoid a single point of failure and achieve load balancing, regardless of whether or not it is distributed or centralized.

Several APRs are located in the L-MM-FE domain. An APR is selected for each terminal.

The APR is selected by the L-MM-FE. The selected APR is used while the terminal moves within the L-MM-FE domain.

The area in which the APR does not change even if the terminal moves is defined as the APR domain.

9.2.1.5 Global mobility management functional entity (G-MM-FE)

The global mobility management functional entity (G-MM-FE) manages the global mobility for terminals. Global mobility is mobility between L-MM-FE domains. The G-MM-FE manages the addresses of terminals and L-MM-FE, where the terminal is located in the L-MM-FE domain. The G-MM-FE is not involved in local mobility management.

It receives updated information from L-MM-FE when the L-MM-FE of a terminal changes. It stores the address of the L-MM-FE, which is used for routing information retrieval for the terminals.

The G-MM-FE receives retrieval requests of routing information of a terminal from a router. The G-MM-FE forwards the request to the L-MM-FE that manages the routing information of the target terminal.

It manages handover between L-MM-FE domains. It receives notifications of change of the L-MM-FE domain which is currently accessed to/from a terminal, and updates routing information for the terminal in routers, if needed. The notification comes from L-MM-FE.

9.2.1.6 Local mobility management functional entity (L-MM-FE)

The local mobility management functional entity (L-MM-FE) manages the local mobility for terminals. Local mobility is mobility within an L-MM-FE domain. The L-MM-FE domain is an area where the mobility related signals are controlled by the same L-MM-FE, even if the terminal moves. The FE is also involved in global mobility, which is mobility between L-MM-FE domains.

The area of L-MM-FE domain is identical to that of APR domain. (Because one same APR is used while a terminal moves in the L-MM-FE domain.)

It receives updated information from terminals when terminal changes paging area. It stores the paging area information, which is used for paging the terminals.

The L-MM-FE receives a retrieval request from the AR and resolves the address of the G-MM-FE that manages the L-MM-FE domain of the target terminal currently located. The L-MM-FE may have the database for resolving the G-MM-FE from the address of target terminal.

The L-MM-FE receives retrieval requests of routing information of a terminal from another L-MM-FE by way of the G-MM-FE. The request may trigger the paging for the terminal. From the paging, the L-MM-FE finds the routing information of the terminal, and sends the information directly to the L-MM-FE that requested the routing information of the terminal.

When locating a particular terminal, the L-MM-FE can look for the appropriate RAM-FE or for multiple RAM-FEs whose addresses are in correspondence to the terminal, and request the RAM-FE or multiple RAM-FEs to page the terminal.

The L-MM-FE manages the APRs and decides upon the appropriate APR when a terminal activates at paging or when initiating a communication.

The L-MM-FE manages the inter-AR terminal handover within the L-MM-FE domain. It receives notifications of change of the AR that is currently connected to a terminal, and updates the routing information for the terminal in the APR and/or other routers, if needed. The notification may come from a RAM-FE or an AR.

In case of intra-AR handovers, the RAM-FE only notifies the selected AP to the AR to which the terminal is connected and it does not notify any information to the L-MM-FE. Therefore, the L-MM-FE does not engage in intra-AR handover for terminals.

The L-MM-FE manages addresses of terminals and RAM-FE.

When the terminal moves from one L-MM-FE domain to another, the communication quality during handover and handover mechanisms should be equivalent to the case of inter-AR handover.

The L-MM-FE has redundancy to avoid a single point of failure and achieve load balancing. There are several L-MM-FEs in a L-MM-FE domain.

An L-MM-FE is selected when the terminal comes to a new L-MM-FE domain (i.e., active terminals perform handover from one domain to another and dormant terminals perform location registration to the new L-MM-FE domain).

9.2.1.7 Radio access management functional entity (RAM-FE)

The radio access management functional entity (RAM-FE) provides common interfaces to the L-MM-FE and the PD-FE.

The RAM-FE receives the location update request from each radio system via control signalling in the radio systems. It sends the location update request with the addresses of terminals, the addresses of RAM-FE and location information of terminals to the L-MM-FEs via the common interface.

The RAM-FE receives the paging request from the L-MM-FE and starts the paging procedure for each relevant radio system. The RAM-FE manages L3/L2 addresses of terminals and/or the addresses of radio systems. Even if the RAM-FE receives the control signal updating the location information from the RAN, the RAM-FE does not send the signalling to the L-MM-FE if that RAM-FE has already sent the same information to L-MM-FE. RAM-FEs can select the most appropriate radio system or the radio system's AP based on user's preference, QoS profile negotiated, and radio resource usage of the candidate APs when starting the paging procedure or handover, by performing (resource and QoS) coordination among the radio systems with the PD-FE.

The RAM-FE can be accommodated in an AR or in multiple ARs.

RAM-FE notifies the AP to the relevant entities as follows:

When the RAM-FE selects the AP, the RAM-FE checks the AR that accommodates the selected AP. If the selected AP and the AP currently used are accommodated by the same AR, the RAM-FE notifies it to the AR.

If the selected AP and the AP currently used are not accommodated in the same AR, the RAM-FE notifies the AR that accommodates the selected AP and notifies the new AR to PD-FE.

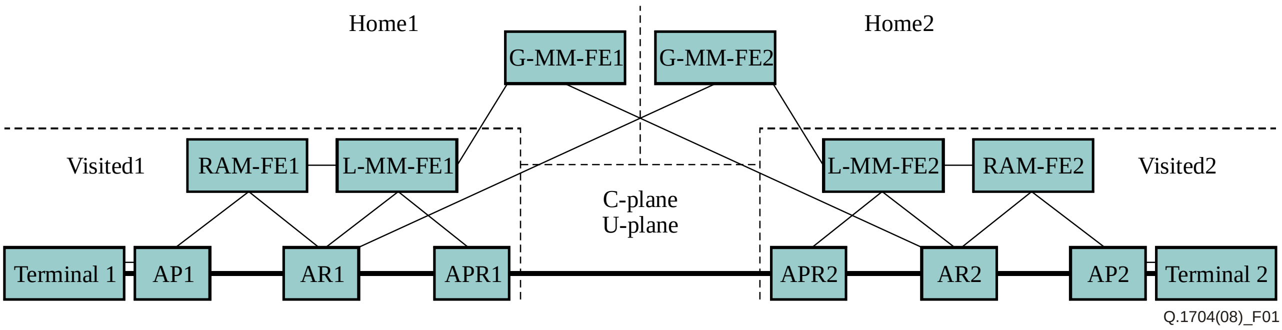

Figure 1 – Functional model for mobility management

9.2.2 QoS management function

In the NGN environment, QoS management will be performed by resource and admission control functions (RACF). The RACF executes policy-based transport resource control upon request of the SCF, determines transport resource availability, makes admission decisions, and applies controls to transport functions for enforcing the policy decisions. The RACF consists of two types of resource and admission control functional entities: the PD-FE (policy decision functional entity) and the TRC-FE (transport resource control functional entity). This decomposition of PD-FE and TRC-FE enables the RACF to support a variety of accesses and core networks (e.g., fixed and mobile access networks).

9.2.2.1 Transport function

The transport function executes QoS policies to the IP flows based on the end-to-end QoS specifications instructed by PD-FE. That is, it marks the QoS class for packets and allocates the bandwidth to the flow. These instructions are directly sent to each transport function by the PD-FE.

If the transport function does not have enough bandwidth to receive the instruction from PD-FE, it notifies the PD-FE that it cannot guarantee the required QoS for the communication, and then the PD-FE denies the communication.

9.2.2.2 Policy decision functional entity (PD-FE)

This function acts as an end-to-end QoS allocation function and coordination function. It is in charge of performing the negotiations with mobile terminals trying to access the network (by means of a call initiation or a handoff) or P-CSC-FE, and routers and access systems via RAM-FE to provide the resources according to the network service level policies. To identify the routers that the users' packet passes, the PD-FE inquires the user's address to mobility management functions. It is also in charge of instructing the transport function to execute QoS policies based on the result of the negotiation.

If the IP flow for the user data transfer expands to another network domain, PD-FEs in different networks negotiate with each other for inter-QoS allocation.

In inter-AR handover cases, the PD-FE is notified of the new AR by the RAM-FE. The PD-FE inquires the new user's address to mobility management and instructs QoS execution to transport functions.

9.2.2.3 Transport resource control functional entity (TRC-FE)

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

9.2.2.4 Radio access management functional entity for QoS

Radio access management functional entity (RAM-FE) for QoS supports an interworking function between IMT-Advanced and various access systems. It converts each access system QoS signalling to/from common QoS signalling. In this negotiation, it asks the access system (e.g., radio resource management in 3GPP RAN) to setup radio bearer based on the request from the PD-FE.

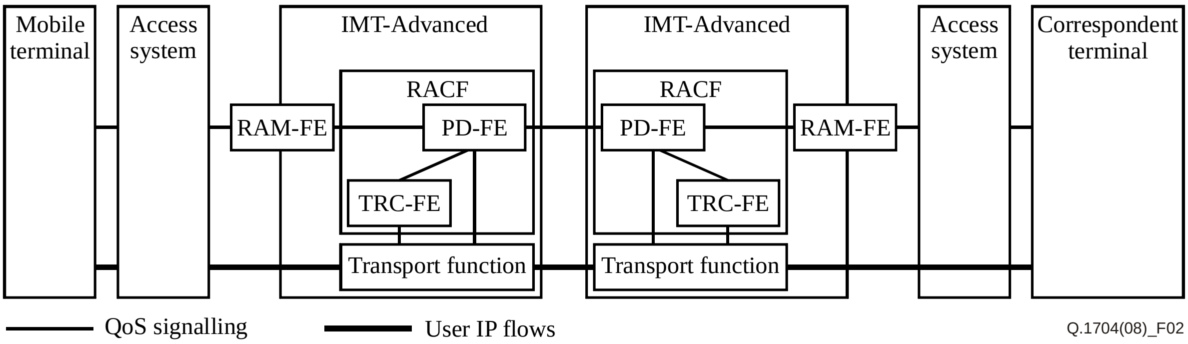

Figure 2 – Functional model for QoS management

9.2.3 Call session control function (CSCF)

The call session control function basically handles transactions for call/session setup, termination and forwarding to other call session control functional entities. It interacts with other network functions (mobility management, QoS management, security management, etc.) in order to support the call/session.

The call session control function is realized by two functional entities, i.e., the proxy call session control functional entity (P-CSC-FE) and the serving call session control functional entity (S-CSC-FE). The P-CSC-FE acts like a proxy function to mobile terminals. The S-CSC-FE controls the call/session for the mobile terminals. It maintains a call/session state for management purposes.

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

The proxy call session control functional entity forwards call/sessions to the serving call session control functional entity from mobile terminals and vice versa. When the call/session control signalling cannot be sent to the correspondent node, the P-CSC-FE requests for mobility management to activate the terminal. When QoS is requested from the terminal, the P-CSC-FE directs QoS management to reserve the required resource.

The P-CSC-FE controls the call/session for a given user. The call/session is initiated by a mobile terminal or the P-CSC-FE itself.

The P-CSC-FE and the mobile terminal send and receive the call/session via the radio access management functional entity, which converts from access specific signalling to common network session signalling.

The P-CSC-FE determines a change related to an active mobile terminal, and/or to the content that is being provided to that terminal and controls the changes.

The P-CSC-FE holds the S-CSC-FE address, mobility management address and QoS management address for a given user.

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

The serving call session control functional entity performs call/session control and service initiation for a given terminal.

The session initiation may be authenticated and authorized by security management (e.g., HSS in 3GPP networks).

When the S-CSC-FE receives call/session signals from the P-CSC-FE, it resolves the correspondent's S-CSC-FE address by inquiring mobility management, and then forwards the session signal to the correspondent's S-CSC-FE.

The parties of the call/session may be identified by a string of alphabet letters, E.164 numbers or others. The S-CSC-FE may retrieve the address of the parties' mobile terminal with the identifier from directory manager.

The S-CSC-FE collects the relevant data; static data (user profile, mobile terminal profile) from the global database (e.g., HSS in 3GPP systems) and dynamic data of mobile terminals (service processing status, etc.) from the mobile terminals.

The S-CSC-FE may send a trigger to a media converter, when the mobile terminals in use change.

The S-CSC-FE holds the P-CSC-FE address where the terminal is accommodated.

9.2.3.3 Global database for CSCF

Global database is a master database that manages the S-CSC-FE address of each mobile terminal. When an S-CSC-FE inquires a correspondent's S-CSC-FE address, it answers the correspondent S-CSC-FE address. When global database has no information of a mobile terminal, it returns null information, which means that the mobile terminal has not yet registered itself.

9.2.3.4 Radio access management functional entity for CSCF

Radio access management functional entity for the CSCF supports an interworking function between IMT-Advanced and various access systems. It converts each access system session signalling to/from common session signalling.

9.2.3.5 Application server (AS)

An application server (AS) offers value-added services. To this end, it interacts with the S-CSC-FE and global database. The application server may host and execute services with service logics.

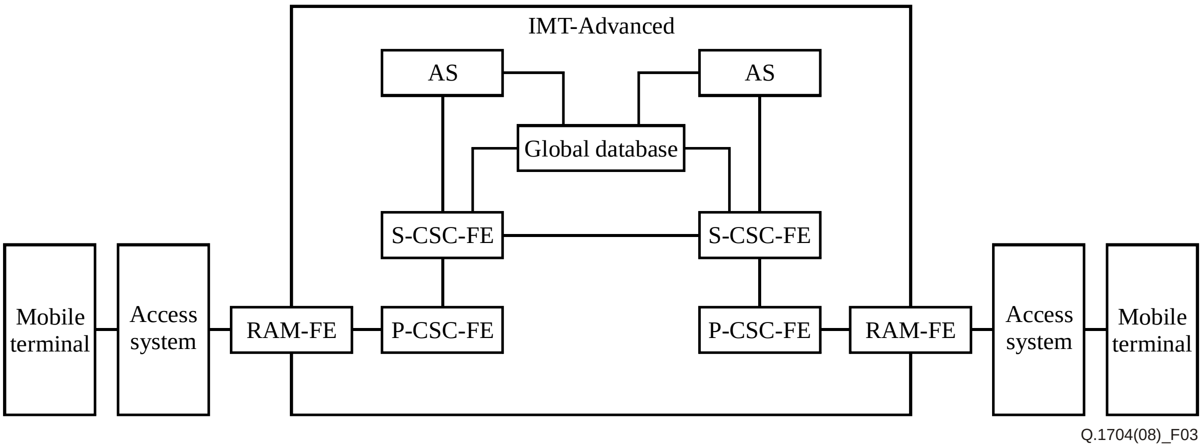

Figure 3 – Functional model for call session control function

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