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SERIES Q: SWITCHING AND SIGNALLING
Signalling requirements and protocols for IMT-2000

Network functional model for IMT-2000

ITU-T Recommendation Q.1711

(Previously CCITT Recommendation)

ITU-T Q-SERIES RECOMMENDATIONS

SWITCHING AND SIGNALLING

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ITU-T RECOMMENDATION Q.1711

NETWORK FUNCTIONAL MODEL FOR IMT-2000

Summary

This Recommendation identifies network and terminal functions that are specific for the support of IMT-2000 services, as specified in the Recommendation on the Framework for IMT-2000 Networks (Recommendation Q.1701). These functions together with other, more conventional network functions are then grouped into functional entities in a generic functional model. In the functional model, the relationships among functional entities and groups are shown.

The functional model is mapped onto a generic network reference model to illustrate possible groupings of functional entities into physical collections of entities.

Based on the functional model, global roaming requirements and network interconnection scenarios are described.

This Recommendation forms the basis for the development of information flows and the definition of functional entity actions and the development of signalling requirements for the various interfaces identified in Recommendation Q.1701.

Source

ITU-T Recommendation Q.1711 was prepared by ITU-T Study Group 11 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 15th of March 1999.

Keywords

Functional architecture, Functional entity (FE), Global roaming, Handover, IMT-2000, Mobility management, Physical reference model, Virtual home environment (VHE)

FOREWORD

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The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

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NOTE

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Introduction

IMT-2000 systems are intended to provide telecommunication services to mobile and fixed users via a wireless link, covering a wide range of user sectors (e.g. public, private, business, residential, local loop, etc.), radio technologies and coverage (cellular, satellite, cordless, etc.) and accommodating a wide range of user equipment (e.g. personal pocket terminals, vehicle mounted terminals, special mobile terminals, standard PSTN/ISDN terminal equipment connected to the mobile terminal, etc.). ITU-R Recommendation M.816-1 [2] and Recommendation F.115 [4] discuss the services in more detail. Recommendation Q.1701 [9] (Framework for IMT-2000 Networks) provides an overall view of the system architecture and service/network capabilities to be supported by IMT-2000 systems.

One of the key service objectives of IMT-2000 is to enable the provision of multimedia services (in circuit and packet-mode operation). Requirements for network functions must therefore take into account the support of multimedia services. IMT-2000 radio resources must be shared among circuit mode (voice and data) services and other mode services (e.g. packet data transfer mode).

In addition, IMT-2000 systems should support global roaming and the Virtual Home Environment concept, i.e. the user will be provided with a comprehensive set of services and features which have the same look and feel whether they are used in the Home or Visited network. The establishment of this concept realises that service provision and network operation may be separated, allowing services to be offered by organisations not explicitly being network operators. The users of these services "roam" in networks and access these services as and where commercial relationships allow it.

A number of different radio environments are involved, covering indoor "pico" cells with very high overall system capacity all the way through large outdoor terrestrial cells to satellite coverage. A major focus of the ITU standards work on IMT-2000 systems is to maximise the commonality among the various radio interfaces involved in order to simplify the task of building multi-mode mobile terminals covering more than one radio environment. A unified support of these various radio interfaces by the backbone network is therefore important. As a consequence of these requirements, a key characteristic of the modelling approach followed in this Recommendation is the following: functions which are dependent on radio access technology are identified and separated from functions which are not dependent on radio access technology. Thus, as much as possible of the network has been defined independently from the radio access technology.

The concept of IMT-2000 Family of Systems (as outlined in Recommendation Q.1701) allows multiplicity of family members. Family members therefore have the option to selectively implement only those functions which are needed to support the services they choose to offer.

IMT-2000 may be implemented as a stand alone network with gateways and interworking units towards the supporting networks, in particular PSTN, ISDN, Packet-Data Networks (e.g. Internet) and B-ISDN (Broadband ISDN). This is comparable to the current implementations of public land mobile networks and it is also a solution in cases where the fixed network and the radio network are operated by different operators. However, IMT-2000 may also be integrated with the fixed networks. In this case, the functionality required to support specific radio network requirements, e.g. location registration, paging and handover, is an integral part of the fixed network. Such integration will be more and more feasible with the development of IN and exchanges for ISDN and B-ISDN. In such an integrated case, the base stations may be connected directly to a local exchange which can support IMT-2000 traffic by locally integrated functions and by accessing functions in other network elements.

With the new mobile radio technologies there is a potential of wireless systems providing cost effective and flexible access to the global telecommunication networks as an alternative for local loop wiring. An objective is to allow for small and simple start-up systems, that can be readily expanded in capacity and can evolve in functionality as required. In a more general way, IMT-2000 radio interfaces will be applied to fixed services in all types of environment, i.e. urban, rural and remote as represented in ITU-R Recommendation M.819-2 [3]. It should also be possible to use an IMT-2000 radio connection for a residential cordless telephone application. Although IMT-2000 systems are intended primarily for public access, provision of IMT-2000 services in connection with private networks must be considered, e.g. the connection of a mobile PBX or LAN (e.g. on board a ship or train) to the public networks or the use of personal pocket terminals as extensions to a PBX. Public radio access to a PBX should also be considered (e.g. hotels, hospitals, etc.).

The network functional model developed for IMT-2000 is intended to be flexible enough to cover all these application scenarios and at the same time meet all requirements outlined in Recommendation Q.1701.

Recommendation Q.1711

NETWORK FUNCTIONAL MODEL FOR IMT-2000

(Geneva, 1999)

1 Scope

The purpose of this Recommendation is to identify network functions which are specific to IMT-2000 systems (Capability Set 1) and to define a Functional Model which will form the basis for the development of information flows and the definition of functional entity actions.

Clause 4 describes the network functions which are required for the support of IMT-2000 specific network capabilities.

Clause 5 defines the generic Functional Model for IMT-2000 systems.

Clause 6 describes the IMT-2000 network references model(s) and identifies physical reference points.

Clause 7 describes some network interconnection scenarios to support global roaming and Internet interworking.

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: all 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.

[1] ITU-R Recommendation M.687-2 (1997), *International Mobile Telecommunications-2000 (IMT-2000).*

[2] ITU-R Recommendation M.816-1 (1997), *Framework for services supported on International Mobile Telecommunications-2000 (IMT-2000).*

[3] ITU-R Recommendation M.819-2 (1997), *International Mobile Telecommunications-2000 (IMT-2000) for developing countries*.

[4] ITU-T Recommendation F.115 (1995), *Service objectives and principles for future public land mobile telecommunication systems (FPLMTS).*

[5] CCITT Recommendation Q.1001 (1988), *General aspects of public land mobile networks*.

[6] ITU-T Recommendation Q.1290 (1998), *Glossary of terms used in the definition of intelligent networks*.

[7] ITU-T Recommendation Q.1224 (1997), *Distributed functional plane for intelligent network Capability Set 2*.

[8] ITU-T Recommendation Q.1541 (1998), *UPT stage 2 for Service Set 1 on INCS1 – Procedures for universal personal telecommunication functional modelling and information flows*.

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

3 Abbreviations and Definitions

3.1 Abbreviations

This Recommendation uses the following abbreviations:

AC	Authentication Centre
ADDS	Application Data Delivery Service
AMF	Authentication Management Function
AMSC	Anchor Mobile Switching Centre
ARF	Access link Relay Function
BS	Base Station
CCAF'	Call Control Agent Function (enhanced)
CCF	Call Control Function
CCF'	Call Control Function (enhanced)
CN	Core Network
CnCAF	Connection Control Agent Function
CnCF	Connection Control Function
CS	Capability Set
DFP	Distributed Functional Plane
DMSC	Drift Mobile Switching Centre
FE	Functional Entity
GII	Global Information Infrastructure
GLR	Gateway Location Register
GMSC	Gateway Mobile Switching Centre
GPCF	Geographic Position Control Function
GPF	Geographic Position Function
GPS	Global Positioning System
HLR	Home Location Register
ICMP	Internet Control Message Protocol
ID	Identity
IMUI	International Mobile User Identity
IN	Intelligent Network
IP	Intelligent Peripheral
LMF	Location Management Function
MCF	Mobile Control Function
MGPF	Mobile Geographic Position Function
MMI	Man-Machine Interface
MRTR	Mobile Radio Transmission and Reception

MSC	Mobile Switching Centre
MT	Mobile Terminal
NNI	Network to Network Interface
PDGN	Packet Data Gateway Node
PDN	Public Data Network
PDSN	Packet Data Serving Node
PIN	Personal Identification Number
PSCAF	Packet Service Control Agent Function
PSCF	Packet Service Control Function
PSGCF	Packet Service Gateway Control Function
QoS	Quality of Service
RACAF	Radio Access Control Agent Function
RACF	Radio Access Control Function
RAN	Radio Access Network
RF	Radio Frequency
RFTR	Radio Frequency Transmission and Reception
RNC	Radio Network Controller
SACF	Service Access Control Function
SCEF	Service Creation Environment Function
SCF	Service Control Function
SCP	Service Control Point
SDF	Service Data Function
SDP	Service Data Point
SIBF	System access Information Broadcast Function
SLP	Service Logic Program
SMAF	Service Management Agent Function
SMF	Service Management Function
SMS	Short Message Service
SNCF	Satellite Network Control Function
SRF	Specialized Resource Function
SS	Supplementary Service
SSD	Shared Secret Data
SSF	Service Switching Function
SSP	Service Switching Point
TMN	Telecommunications Management Network
Tx	Transit Exchange

UIM	User Identity Module
UIMF	User Identification Management Function
UPT	Universal Personal Telecommunications
VHE	Virtual Home Environment
VLR	Visitor Location Register

3.2 Definitions

For the definition of cellular terms (e.g. MSC, cell, base station, etc.), reference is made to Recommendation Q.1001 [5]. Cellular terms to be referred are as follows:

MSC, HLR, VLR, Cell, Location area, and Base station.

For the definition of Framework of IMT-2000 Networks related terms, reference is made to Recommendation Q.1701 [9]. Related terms to be referred are as follows:

UIM, MT, RAN, CN, and NNI.

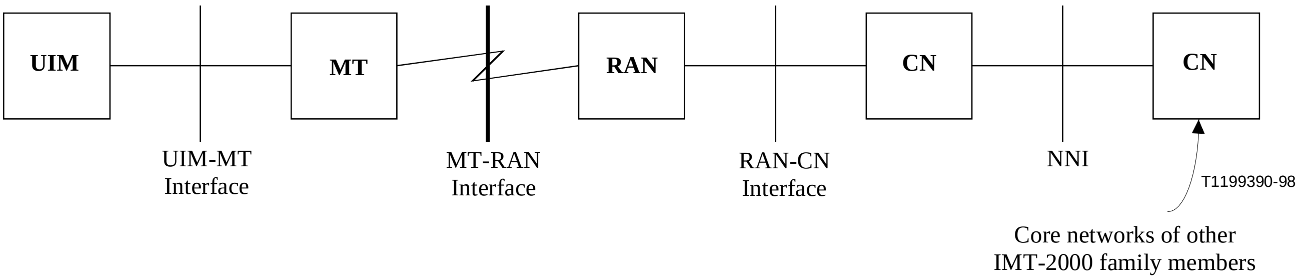


Figure 3-1/Q.1711 – Physical interfaces of an IMT-2000 family member system

The following definitions are based on Recommendation Q.1290 [6] and have been modified for use in this Recommendation:

3.2.1 Call control: The set of functions used to process a call, i.e. service negotiation, set-up, modification and release of single or multiple-connection calls, used in conjunction with the service request from the user. There may be zero, one or several connections established for one call.

3.2.2 Connection: An end-to-end association of transmission channels or circuits, switching and other functional units set up to provide a means for a transfer of information between two or more points in a telecommunications network. A connection is composed of several connection links. There are one or more connections for each media component of a call.

3.2.3 Connection control: The set of functions used for setting up, maintaining and releasing a communication path between two or more users or a user and a network entity, e.g. a dual tone multi-frequency receiver.

3.2.4 Connection link: A part of a connection between a pair of connection control functions which control it. A union of connection links forms a connection.

In addition, the following terms have been defined for use in this Recommendation:

3.2.5 Access link: Aggregation of all logical channels for the support of a connection link between the Mobile Terminal (MT) and the Core Network (CN) via the Radio Access Network (RAN) (see Figure 3-2).

3.2.6 Access radio link: The portion of access link which is supported by radio (see Figure 3-2).

3.2.7 Aggregated radio channel: The aggregated, multiplexed information bitstream that is carried over the radio interface as a single physical entity for a single mobile terminal.

3.2.8 Association between an IMT-2000 terminal/user and the network (Terminal/User Association): Association between an IMT-2000 terminal/user and the network is a logical relation between the IMT-2000 terminal/user and the network which is used by the network to identify a certain IMT-2000 terminal/user from all the IMT-2000 terminals/users having control relationships with it. The association is established when the IMT-2000 terminal/user originates the first call (i.e. outgoing call at idle state) or signalling connection or when the network originates the first call to the IMT-2000 terminal/user (i.e. incoming call at idle state). In the latter case, the association is established by a paging procedure. The association is kept active until all the calls and connections on the terminal are released.

3.2.9 Authentication data: Set of data related to authentication. They include authentication parameters and authentication information.

3.2.10 Authentication parameter: A secret data prepared for individual user authentication. A typical permanent user secret data is a user authentication key. A session user secret data may be used as an authentication parameter, referred to as shared secret data (SSD).

3.2.11 Authentication information: Information which is used for user authentication. In a challenge-response based authentication mechanism, typical authentication information is a set of challenge, response and ciphering key, referred to as a triplet.

3.2.12 Bearer: The communication path between two adjacent nodes which is associated with one connection.

3.2.13 Bearer control: Supports the control of network resources on a network link by network link scale (i.e. node to node) to support the end to end carriage of information.

3.2.14 BS approach link: The portion of access link which is not the access radio link (see Figure 3-2).

3.2.15 Call: An end-to-end logical relationship between two or more parties, established on behalf of an initiating party, associated with a service invocation.

3.2.16 Camp on cell: The mobile terminal has completed the cell selection/re-selection process and has chosen a cell, from which it plans to receive available services. The network may not be aware of the existence of the mobile terminal within the chosen cell.

3.2.17 Diversity convergence point: The merging point of more than one physical bit streams into a logical information stream, using diversity technique (see Figure 3-2).

3.2.18 Diversity handover: Diversity handover is a type of handover that makes use of macro-diversity techniques.

3.2.19 Diversity link: Aggregation of diversity paths between two corresponding diversity convergence points. One or more diversity paths compose a diversity link (see Figure 3-2).

3.2.20 Diversity path: A connection of link elements between two corresponding diversity convergence points is called a diversity path. A diversity path constitutes one branch of a diversity link. Using diversity technique, diversity paths may be combined to form a diversity path (see Figure 3-2).

3.2.21 Diversity branch: Diverging path of a link spreading from the diversity point (see Figure 3-2).

3.2.22 Global roaming (general): Global roaming refers to the ability to roam between one IMT-2000 system and any other IMT-2000 systems.

3.2.23 Global roaming routing/addressing: The ability of the network to address and route communications and services to roaming IMT-2000 users rather than to a geographic location or a physical device.

3.2.24 Global roaming service portability: The ability of the network to allow subscribers to access customized communications services anywhere, in accordance with his/her service profile, within and between IMT-2000 systems.

3.2.25 Global roaming UIM portability: The ability of a user to transfer her/his identity between IMT-2000 mobile terminals.

3.2.26 Global roaming terminal mobility: Terminal Mobility is the ability of a terminal to access telecommunications services from different locations and while in motion, and the capability of the network to identify and locate that terminal on its associated User Identity Module (UIM).

3.2.27 Global roaming user profile accessibility/transportability: The ability of the network to readily access, transfer/download, and modify, the user's service profile from anywhere, subject to business and security considerations.

3.2.28 Handover branch: Branch of an access radio link participating in a handover (see Figure 3-3).

3.2.29 Handover path: A sequence of link elements participating in a handover (see Figure 3-3).

3.2.30 Link element: A logical channel between two adjacent functional nodes (see Figure 3-2).

3.2.31 Logical radio channel: A logical radio channel is an information stream dedicated to the transmission of a certain type of information, e.g. signalling data or user data. Multiple logical channels can be mapped onto a single physical radio channel. One logical channel can also be mapped or duplicated on multiple physical radio channels.

3.2.32 Macro-diversity: Macro-diversity is a family of diversity techniques where diversity is provided by using multiple physical channels forming, in the general case, a point-to-multipoint (multiple base stations) RF connection in the up-link and a multipoint-to-point connection in the down-link carrying a single data transmission (which is combined at the receiving end). The links from/to the multiple base stations (i.e. the branches of the BS approach link) are also combined in the fixed part of the network. Such techniques include base station diversity, diversity handover, simulcast, etc.

3.2.33 Physical radio channel: A radio communication path defined in frequency, code and/or time, which is established for a given period of time. Multiple physical radio channels can be mapped onto a single radio frequency channel. One physical radio channel can also be mapped or duplicated on multiple radio frequency channels.

3.2.34 Radio frequency channel: A radio frequency (RF) channel represents a specified portion of the RF spectrum with a defined bandwidth and a carrier frequency and is capable of carrying information over the radio interface.

3.2.35 Radio resource: A portion of spectrum available in a limited geographical area (cell). This portion of spectrum can be further divided into radio frequency channels.

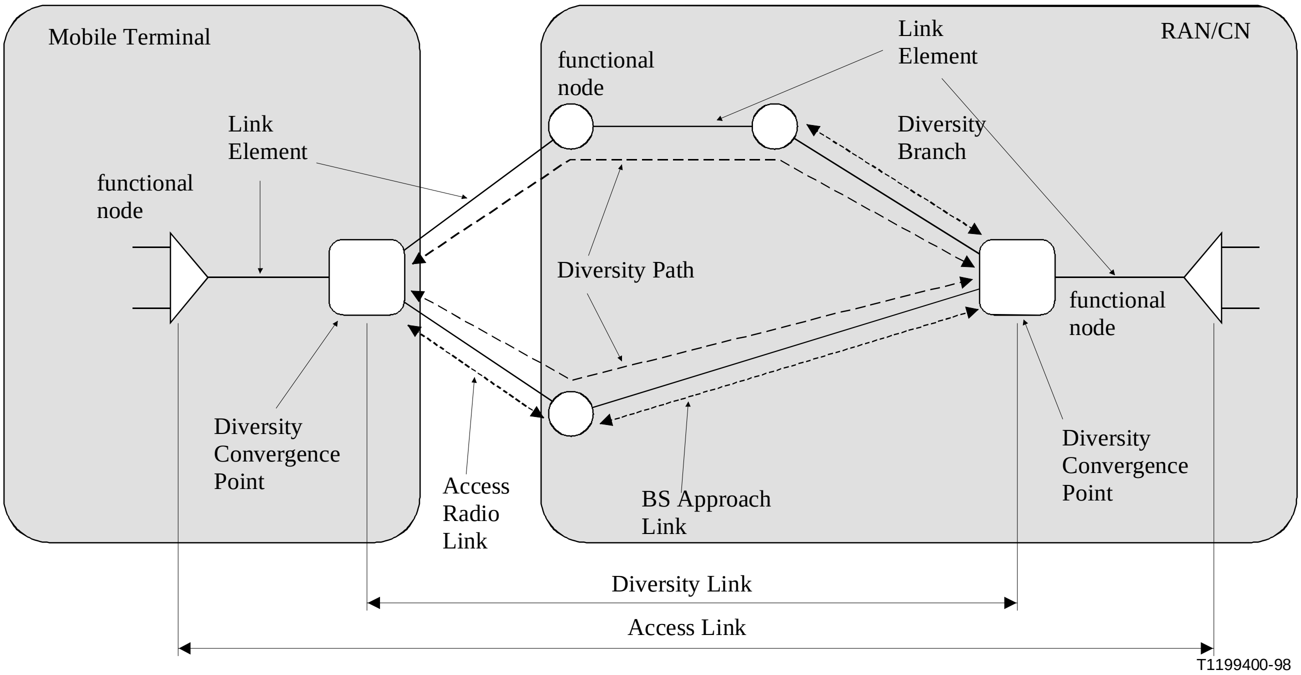


Figure 3-2/Q.1711 – Naming of the elements associated with the MT-RAN/CN access related communication

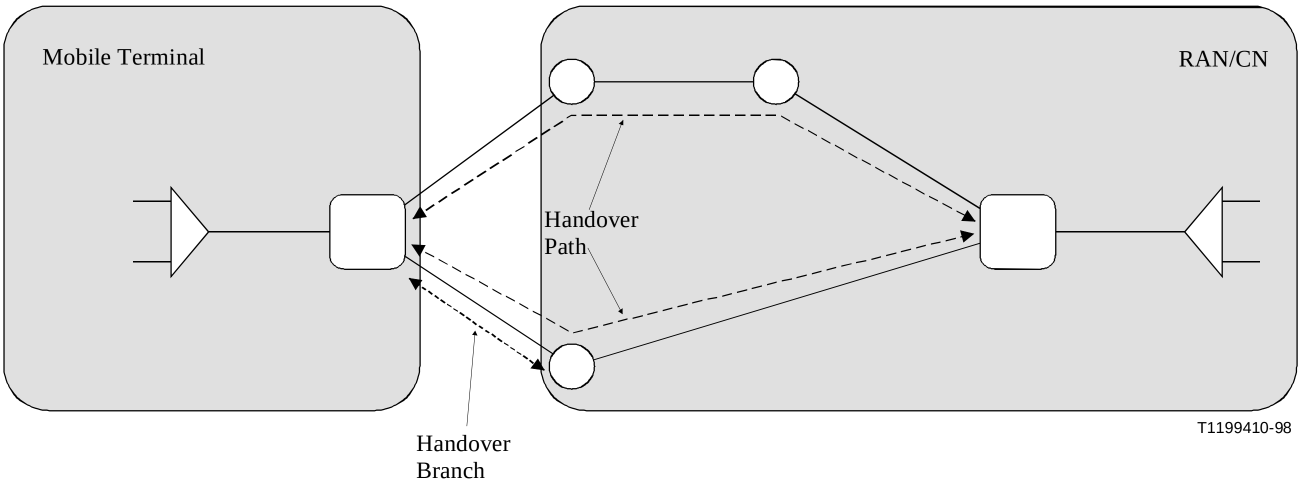


Figure 3-3/Q.1711 – Naming of elements associated with diversity handover

4 IMT-2000 Specific Functions

This clause identifies some of the network functions that are needed to support IMT-2000 CS1 capabilities. The functions are grouped according to their relationships to overall service and network capabilities. Family members have the option to selectively implement only those functions that are needed to support the services they choose to offer.

4.1 Functions related to overall system access control

System access is the means by which an IMT-2000 user is connected to IMT-2000 in order to use IMT-2000 services and/or facilities. System access may start from either the mobile side, e.g. a mobile originated call, or the network side, e.g. a mobile terminated call.

System access information broadcasting: This function provides the mobile terminal with information which may include access rights, network identification, frequency bands used, configuration of logical channels, etc. This information enables the mobile terminal to configure itself so that it can camp on a cell, register, and initiate and receive calls.

System access information monitoring and analysis: This function monitors and analyses system access related information transmitted from the network to one or more mobile terminals. The functionality required for analysing this information resides in the mobile terminal.

The purpose of the monitoring process is to determine which networks, network operators, and/or service providers are available, and what service capabilities they support. Monitoring the system access information forms the basis for the analysis related to which cell a mobile terminal shall camp on, and which physical radio channel(s) it will occupy once engaged in dedicated communications. Monitoring for relevant parameters implies that the mobile terminal must be able to scan IMT-2000 frequency bands for necessary information.

Once the mobile terminal has gathered system access related information, the information is analysed to determine which cell the mobile terminal should camp on.

Selection of service provider, network and network operator is governed by user's choice, i.e. by subscription or by real-time choice according to, for instance, service capabilities, charges, access rights, etc.

Since several network operators may share the same infrastructure, the selection of network operator and selection of network are logically distinct processes.

The *System access information monitoring and analysis* function generates appropriate control information to ensure that the mobile terminal camps on a suitable cell, belonging to a suitable network or network operator, where the user has access to the services subscribed to.

Cell selection in idle mode: This function is performed in idle mode only. It controls the tracking of the active cell by the mobile terminal. Based on the selection of network operator made by the *System access information monitoring and analysis* function and based on the radio channel measurements of the appropriate physical channels and broadcast control channels of the available cells, the mobile terminal selects a cell to camp on (the active cell). The mobile terminal will scan and decode the appropriate logical channels at this cell, and also access the network (whenever appropriate) via this cell.

It may be necessary to select a new active cell, e.g. if the mobile terminal moves, or if the radio channel performance degrades below an acceptable threshold. Therefore, the mobile terminal may require knowledge of broadcast channels of surrounding cells, at least such knowledge may simplify the scanning process.

Acquisition and selection of surrounding cells involves scanning and decoding the appropriate physical channels and relevant control channels of neighbouring cells within the same network as the currently active cell.

Cell selection in packet data transfer mode: When a mobile terminal is engaged in a packet data transaction but not engaged in a circuit-switched connection, it is in packet data transfer mode.

The *Cell selection in packet data transfer mode* function enables the mobile terminal to select the best cell to use in establishing a communication path. This involves the measurement and evaluation of signal quality from neighbouring cells, as well as the detection and avoidance of congestion within candidate cells which the mobile terminal may use.

4.2 Functions related to radio resource management and control

Radio resource management is concerned with the allocation and maintenance of physical channels. Logical channels are logical paths to support specific access radio link. IMT-2000 radio resources must be shared between circuit mode (voice and data) services and other modes of services (e.g. packet data transfer mode).

4.2.1 Synchronization control

This function evaluates the information provided by the *System access information monitoring and analysis* and ensures correct synchronization of the mobile terminal with the network.

4.2.2 Functions related to access radio link control

Access radio link set-up and release: This function is responsible for the control of connection element set-up and release of the access radio link. The purposes of this function are

a) to participate in the processing of an end-to-end connection set-up and release which will be activated by a request from other functional entities at call set-up/release; and

b) to manage and maintain the access radio link after an end-to-end connection has been established. (It may also be invoked to cater for in-call service modification or at handover execution.)

Reservation and release of physical radio channels: This function consists of translating the access radio link set-up or release requests into physical radio channel requests, reserving or releasing the corresponding physical radio channels and acknowledging this reservation/release to the requesting entity. Acceptability of such physical radio channel requests is determined by the *Radio resource request acceptability judgement* function.

This function may also perform physical channel reservation and release in the case of a handover. Moreover, the amount of radio resource required may change during a call, due to service requests from the user or macro-diversity requests. Therefore, this function must also be capable of dynamically reserving or releasing physical channels during a call.

Allocation and de-allocation of physical radio channels: This function is responsible, once physical radio channels have been reserved, for actual physical radio channel usage, allocating or de-allocating the corresponding physical radio channels for information transfer.

Packet data transfer over radio function: This function provides packet data transfer capability across the IMT-2000 radio interface. This function includes procedures which:

a) provide packet access control over radio channels;

b) provide packet multiplexing over common physical radio channels;

c) provide packet discrimination within the mobile terminal;

d) provide error detection and correction;

e) provide flow control procedures;

f) provide load balancing across RF channels.

4.2.3 Functions related to RF power control management

RF power control: In order to minimise the level of interference (and thereby maximise the re-use of radio spectrum), it is important that the radio transmission power is not higher than what is required for the requested service quality. Based on assessments of radio channel quality, this function controls the level of the transmitted power from the mobile terminal as well as the base station.

RF power setting: This function adjusts the output power of a radio transmitter according to control information from the *RF power control* function. The function forms an inherent part of any power control scheme, whether closed or open loop.

4.2.4 Functions related to random access

Random access initiation: This function is used by a mobile terminal when it accesses the network. Due to the multiple access nature of the radio interface (many mobile terminals attempting to access common resources in an independent and random way), a specific random access procedure may have to be used when the mobile terminal accesses the network for the setting up of a connection or other applications. This function will start this procedure when required.

Random access detection and handling: This function in the network detects the random access initiation attempt by the mobile terminal and responds appropriately. The handling of the random access may include procedures for a possible resolution of colliding attempts, etc. The successful result will be the generation of a request for allocation of appropriate resources for the requesting mobile terminal.

4.2.5 Functions related to radio resource request acceptability

Radio resource request acceptability information setting: This function sets and updates the information on possibility of radio resource allocation based on the radio resource availability in a cell. This information is used by the *Radio resource request acceptability judgement* function.

Radio resource request acceptability information broadcasting: This function broadcasts, in a cell, the radio resource request acceptability information obtained from the *Radio resource request acceptability information setting* function.

Radio resource request acceptability judgement: This function can be implemented in the network as well as in mobile terminals. In the network, this function judges the possibility of radio resource allocation upon each request of such a resource based on the radio resource request acceptability information obtained from the *Radio resource request acceptability information setting* function. In the mobile terminal, this function judges the radio resource request acceptability information broadcast by the *Radio resource request acceptability information broadcasting* function. Based on the result, this function permits the initiation of service request from the mobile terminal which requires radio resources (e.g. call origination) only when positive result is obtained from the judgement.

4.3 Functions related to channel coding

Radio channel source and error protection coding and decoding: This function is to protect data from transmission errors on the radio channels by attached specific coding. Major coding schemes include:

a) Convolutional code which is used for both error detecting and correcting;

b) Cyclic Redundancy Check which is used only for error detecting;

c) Interleave which is used for error protecting.

The coding is performed independently of the content or meaning of the data.

4.4 Functions related to handover

Radio channel quality estimation: This function performs measurements on radio channels (current and surrounding cells) and translates these measurements into radio channel quality estimates. Measurements may include:

a) received signal strengths (current and surrounding cells);

b) estimated bit error ratios;

c) estimation of propagation environments (e.g. high-speed, low-speed, satellite, etc.);

d) transmission range (e.g. through timing information);

e) Doppler spread;

f) synchronization status.

In order for these measurements and the subsequent analysis to be meaningful, some association between the measurements and the channels to which they relate should be made in the analysis. Such association may include the use of identifiers for the network, the base station, the cell (base station sector) and/or the radio channel.

Cell selection in dedicated mode: When a mobile terminal is engaged in a circuit-switched connection, it is in dedicated mode. When a mobile terminal is in dedicated mode, it may additionally be engaged in a packet data transaction.

The *Cell selection in dedicated mode* function enables the mobile terminal to select the preferred cell to which a circuit-switched connection may be accessed or handed over. The cell is selected from a candidate list which the network sends to the mobile terminal. The function involves the measurement and evaluation of signal quality from neighbouring cells, as well as the detection and avoidance of congestion within candidate cells to which access or handover may be requested.

Quality of service assessment: This function assesses the overall quality of service. This may take into account radio channel quality estimates (including estimates from surrounding cells), packet throughput, delay, and other quality of service metrics. The overall quality of service is compared with requested limits and with estimates from surrounding cells. Depending on the outcome of this comparison, the *Resource re-allocation* function, the *Macro-diversity control* function or the *Handover execution* function may be activated.

Resource reallocation: A network always monitors the status of how the resources are used. When a network detects the insufficiency of available resources, it may perform inter or intra cell handover sequence, or reallocation of other resources being used in order to get different available resources.

Handover decision

– **initiated by the terminal**: This function results from the *Quality of service assessment* function and generates a request for new resources. In this case the terminal uses a resource reallocation or handover strategy to select new resources. When required, it may also request that the network combine the diversity paths.

– **initiated by the network**: This function results from the *Quality of service assessment* function or the *Resource reallocation* function and generates a request for different resources. In this case the network uses a resource reallocation or handover strategy to select new resources and coordinates assignment of the new resource. When required, it may also request that the terminal combine the diversity paths.

Macro-diversity control: Upon request from the *Handover decision* function or the *Quality of service assessment* function, this function controls the duplication/replication of information streams to receive/transmit the same information through multiple physical radio channels (possibly in different cells) from/towards a single mobile terminal.

This function also controls the combining of information streams generated by a single source, but conveyed via several diversity sub-links. The *Macro diversity control* function controls macro-diversity execution (i.e. distribution and combination of the information stream) which is located at the two endpoints of the connection link on which macro-diversity is applied. Such points exist both in the network and in the mobile terminal.

Handover execution: This function is in control of the actual handing over of the communication path. It comprises two sub-processes: handover resource reservation and handover path switching. The handover resource reservation process will reserve and activate the new radio and wireline resources that are required for the handover. When the new resources are successfully reserved and activated, the handover path switching process will perform the final switching from the old to the new resources, including any intermediate path combination required, e.g. handover branch addition and handover branch deletion in the diversity handover case.

Handover completion: This function will free up any resources that are no longer needed. A re-routing of the call may also be triggered in order to optimize the new connection.

Handover trigger: This function identifies cells that may be added or deleted from the access link. This information is used by the *Handover decision* function.

4.5 Functions related to location management & geographic position finding

4.5.1 Functions related to terminal paging

Terminal paging is a feature by which the mobile terminal is finally located within its current cell for the establishment of a network initiated (mobile terminated) connection to the terminal for the purpose of signalling, or packet delivery. In case of packet delivery, terminal paging may transfer user data.

Paging decision and control: This function will initiate identification of the location area of the mobile terminal and its status (e.g. busy, idle, registered active). Paging of the mobile terminal may or may not be performed depending on the mobile terminal status [e.g. if the mobile is already active (in a call or exchanging packets), paging may not be needed] or other factors decided by the network operator of the serving system where the mobile is located (e.g. network management conditions such as no available channels, emergency conditions). The *Paging decision and control* function will also process the paging response from the mobile terminal.

Paging execution: This function will execute the terminal paging within its area of responsibility (e.g. group of cells), based on information received from the *Paging decision and control* function. The execution includes identification of radio cells in which paging is broadcast. It may involve repetitions of the paging.

Paging detection: This function detects the paging and processes the mobile terminal response to the page in the mobile terminal.

4.5.2 Functions related to location data management, registration and deregistration

4.5.2.1 Location data management

Location data management is a grouping of features/functions necessary to enable the network to locate a mobile terminal in order to establish a connection or to deliver packets to it. The location information may be provided with different accuracy, depending on the current mode of operation of the terminal (active circuit-switched connection, stand-by packet-data connection, etc.).

Location data management initiation: By assessing the result of *System access information monitoring and analysis* function and/or taking into account location management status, this function will request location management related service features (e.g. terminal location updating, detach, attach) toward the network. This function may also request the features periodically or on demand of the network.

Location data management: This function controls procedures of the location management related service features. The procedures include updates of location information and/or MT status information (i.e. whether terminal is reachable or not) in data base. This includes updating of old and new location data storage entities as well as initiating the erasure of location data from storage entities that are no longer needed. This function may also enable the network to initiate location management related service features to update its data base.

To categorise how the network recognises the mobile terminal location, several location management states may be introduced, for example:

Location unknown states: the network has no knowledge about mobile terminal location.

Location known states: the network has some kind of knowledge about mobile terminal location. In this state, different accuracy of mobile terminal location could exist.

Accuracy of mobile terminal location*:* to categorise how precise the mobile terminal location of "Location known" state is recognised by the network, several kinds of location accuracy may be introduced, for example:

Location area accuracy: the accuracy is composed of multiple cell areas that would be sufficient to perform terminal paging to locate the mobile terminal.

Cell area accuracy: the accuracy is composed of a single cell or a limited number of cells through which the terminal communicates with the network.

In case of different operation modes (i.e. circuit-switched operation and packet-data operation) of a terminal, mobile terminal location may be recognised with different accuracy independently for each operation mode. To reduce the network load due to location updates, in the case of parallel operation of circuit-switched and packet-data communication, location update information is shared.

Terminal initiated location update is a function by which a mobile terminal will notify a network of its existence and of its location within the network and by which the location information of the terminal within the network is continuously updated when required. It is normally used when a terminal first appears in a network domain or when no previous location details are known (e.g. after terminal or network failure) or when the terminal moves into a new location area or when the terminal has not interacted with the network within a period of time.

Network initiated location update is a function by which the network requests a terminal to identify itself to the network and thus its location within the network can be established. This is normally used when a terminal has not interacted with the network within a period of time and the network wants to determine if the terminal is still reachable or not.

4.5.2.2 Location registration for call and service delivery

Location update of terminal location in the Serving network is updating the Home network mobility functions of the location of the terminal for routing of incoming calls. The internetwork signalling capability allows a service provider and a Serving network operator to communicate both the capabilities of the Serving network and the service capabilities of the subscriber in order to enable service transparency.

Service profile downloading from the Home network to the Serving network includes some of the following possible location registration scenarios:

For IMT-2000 standardized services, the following approaches may be considered:

a) the Home network downloads the subscriber profile to the Visited network; the profile will be used by the Visited network for the originating communication service, without requesting further information, other than (maybe) authentication information, to the Home network;

b) the Home network does not download the subscriber profile to the Visited network; for originating communication service, the Visited network will request instructions to the Home network.

For non-IMT-2000 standardized services, the following approaches may be considered:

c) in association with case a) above, the Home network downloads a VHE subscription information to the Visited network as part of the service subscriber profile; originating and/or terminating communication service will cause the Visited network to contact the Home network for instructions;

d) in association with case b) above, the Home network does not download any information to the Visited network to indicate VHE subscription information; as in case c) above, originating and/or terminating communication service causes the Visited network to contact the Home network to request instructions.

From the location registration procedure it is possible to invoke IN services and the location registration procedure can be modified according to the service logic of the invoked IN services.

4.5.2.3 IMT-2000 subscriber de-registration

An IMT-2000 subscriber may explicitly de-register or leave the task of de-registration to the network (implicit de-registration). When an IMT-2000 subscriber leaves a system, its associated profile may also be removed through either explicit or implicit de-registration.

4.5.3 Functions related to geographic position finding

Geographic position determination: This function will enable the IMT-2000 network and/or the mobile terminals to compute the geographical position of mobile terminals based on dynamic information (e.g. characteristics of the RF signals received such as timing, signal strength, angle of incidence) and prior knowledge of relevant information (e.g. stored information such as time reference, geographic position of the network elements, etc.). Both the IMT-2000 network and the mobile terminals may have the capability to effect the characteristics of the RF signals in a manner that will improve the quality of the reception such that meaningful results can be obtained.

Geographic position notification: This function will enable the IMT-2000 network and/or the mobile terminals to notify interested and authorised functional entities of the network or mobile terminals of the geographical position of a mobile terminal, once this position has been determined.

4.6 Functions related to mobile call handling (including routing)

4.6.1 Common functions

Service feature analysis: This function will check whether the requested service is compatible with the current subscription. It may also include compatibility checking of the requested service against the capabilities of the terminal.

Provision of terminal capability information: This function will provide the necessary information (terminal capabilities) required by the network to identify what functions and features are supported by this terminal.

Negotiation of data rates and quality of service: Various data rates should be available to the user depending on the environment in which the user is operating. The environments and data rates are provided in ITU-R Recommendation M.816-1, Framework for Services Supported on IMT-2000 [2].

Negotiation for the data rate and quality of service to be used between the user and the network needs to be possible. The negotiation may be at the beginning of the call/packet data instance and/or at subsequent points in the call/packet data instance depending on current network conditions and user environment.

The interchange between user and network may be comprised of asymmetric data rates. The values of these rates may be part of the negotiation procedures.

Access Restrictions: In principle, it is assumed that a subscriber can access IMT-2000 services through diverse access networks. However, access limitations shall be possible according to subscription options and authorisation. Access restrictions may also be imposed by the Serving (Visited) network because of network conditions or other reasons.

4.6.2 Functions specific to routing of circuit-switched mobile calls

Request routing information: For mobile terminated calls, this function will request the *Routing information handling* function for relevant routing information.

Routing information handling: For mobile terminated calls, this function will provide the network with relevant routing information for the call to be established. Service capabilities can be stored as dynamic data in the network derived from end-to-end negotiation obtained at call set-up. Terminal capabilities could be obtained at service and user registration. Bandwidth and QoS modification on demand is an advanced technical requirement.

NOTE – The routing information may point to a final routing address or to an entity which will provide further routing information. In the latter case, this entity may trigger paging decision and control.

4.6.3 Functions related to routing and addressing of IMT-2000 packet data services

4.6.3.1 Functions related to routing of packet-data mobile communication service

This function supports routing of packet-data communication service. The communication service may be provided by one of the following methods, during a mobile service instance:

a) dial-up manner request and routing

This method allows the user to establish an on-demand communication path of choice. When the user requests the establishment of this on-demand communication path, the user supplies the packet handler "address" as destination address information. Then the network makes routing for the service according to the supplied destination address in an ordinary telephony manner (i.e. call set-up and establishment). The release of this communication path will be via an ordinary telephony service release request (i.e. call release).

b) service subscription based request and routing

This method allows the user to specify the packet handling function of choice at the time of service subscription with the home IMT-2000 family member. When the user initiates a mobile service instance with an IMT-2000 family member, the communication service (e.g. context association) between the mobile terminal and the specified packet handling function will be established. The release of this communication path occurs at the termination of the mobile service instance.

4.6.3.2 Functions related to types for connections and address management of mobile data packets

IMT-2000 supports point-to-point services (e.g. connectionless and connection-oriented) and point-to-multipoint services (e.g. group call and multicast services).

Functions shall include dynamic and static address management, support of Internet Control Message Protocol (ICMP) messaging, packet filtering and data privacy.

4.6.4 Functions related to handling of multimedia calls

The functions to support multimedia in IMT-2000 are the ability to provide bearers with flexible quality of service and the ability to provide parallel calls and point-to-multipoint calls. The flexible quality of service allows the user to modify the quality of service during an on-going call as required by the used applications. The flexible quality of service ensures that the requirements of all media types can be fulfilled. The parallel calls can be used to transfer different media components in different calls. Point-to-multipoint calls can be used, for example, for multimedia distribution services. Coordination and synchronization of different media components can be done by end system applications, which are outside the scope of this Recommendation.

4.6.5 Management of both circuit-switched and packet-switched communications

This function supports circuit-switched and packet-switched communication paths simultaneously.

4.7 Functions related to data coding & compression

Data coding: This function indicates voice coding or compression of image data. The coding depends on the content or meaning of the data.

Signalling compression function: The *Signalling compression* function will optimize the use of radio path capacity by transmitting as little of the signalling as possible while at the same time preserving the information contained within it.

Data compression: The data compression function will optimize the use of the radio path by transmitting as few information bits as necessary to accurately represent the network protocol packet contents, e.g. V.42 *bis* data compression.

4.8 Functions related to network intelligence and service control

4.8.1 Functions supporting UPT users

This function provides the ability to access telecommunication services at any terminal (not limited to IMT-2000 systems) on the basis of a personal identifier (e.g. the UPT number). This function involves the network capability to locate the terminal associated with the user for the purposes of addressing, routing, and charging of the UPT user for calls. Detailed functions and their allocation to each Functional Entity (FE) for IN-based UPT services are described in Recommendation Q.1541 [8].

4.8.2 Functions related to service portability

Service portability is the capability of the network to provide a particular set of services/features from any user access point within an IMT-2000 environment and according to the user's requests. From the subscriber's perspective, the service portability is the ability of users to have transparent access to a set of their subscribed services when roaming.

The service portability feature of the global roaming uses the "Virtual Home Environment" concepts or standardized supplementary services (see 7.2.2.5).

4.8.3 Functions supporting supplementary services

The optional supplementary services are associated with an IMT-2000 service subscriber upon specific subscription.

4.8.4 Functions related to support of the Virtual Home Environment

The Virtual Home Environment (VHE) capability is an integrated network capability that provides operator specific services that are accessible by the user even when this user is roaming outside the Home network.

The following functions are identified to support the provisioning of VHE supplementary services:

- **Provisioning of VHE specific service profiles**: This function is required to ensure that the Visited network receives the appropriate information to invoke the VHE supplementary services. The VHE service profiles are part of the IMT-2000 subscriber profiles. It contains the trigger information that has to be exchanged between the Home network and the Visited (Serving) network.
- **Dynamic arming of triggers within the switching network**: This function is required to activate the VHE triggers including the trigger profile (e.g. trigger conditions, information, etc.). The arming of these VHE triggers can be activated by a request from the Home network or service provider.
- **Downloading VHE trigger profiles to the Visited network**: This function is required to reduce the unnecessary signalling between the Home network and Visited network. The VHE trigger profile is downloaded towards the Visited network together with the IMT-2000 subscriber profile.
- **Service logic execution** (Home network capability): This function requires an agreement between the Home network and Visited network for the Home network to execute service logic from the Home network to control the Visited network resources. IN supported capabilities must be compatible between the two networks.
- **Service logic execution** (Visited network capability): This function requires an agreed upon application execution environment to execute distributed service logic from the Home network within the Visited network.
- **Service addressing** (Visited network capability): This function is required to allow the Visited network to address specific service control functions. This is used to request the initiation of a VHE context between the Visited network and the Home network.
- **Security and screening functions** (Visited network to Home network): These functions are required to enable the networks to verify each other's identity and bind the context between the networks for the execution of the VHE services.

4.8.5 Functions related to support of IN

One mechanism for providing services in IMT-2000 is use of Intelligent Network (IN) capabilities.

Mobile originated calls, mobile terminated calls, mobility registration and authentication activities and call unrelated activities can trigger IN procedures in the IMT-2000 network. Operator specific services can be implemented based on these generic service events.

The functions related to IN capabilities are associated with the provisioning of IN services.

The following functions are identified:

- **Service logic execution**: This function executes service logic instances that are requested by the network on behalf of the user.

- **Service/User data manipulation**: This function stores, retrieves or performs any other service data management activities.
- **Handling specialized resources**: This function interacts with the user by means of dedicated messages, such as text message, announcements, voice mail messages, etc. These kind of capabilities are supported by IN platforms.
- **Service logic triggering**: This function enables efficient interaction between the service logic and the call (un)related process that invoked that service.
- **Any time interrogation**: This function enables the service logic instance to retrieve the mobility management related information, such as location information and subscriber status information.

The details of these functions are described in the IN series of ITU-T Recommendations.

4.9 Additional functions related to global roaming

The functions in this subclause are used to support global roaming in addition to other functions described.

For IMT-2000 CS1, two alternatives for global roaming are envisaged:

1) Roaming of UIM and MT (terminal mobility): a UIM provided by the Home network is used with an MT available in the Home network and the Visited network.
2) Roaming of UIM (UIM portability): a UIM provided by the Home network is used with an MT available by the Visited network.

Figure 4-1 depicts the above two global roaming alternatives.

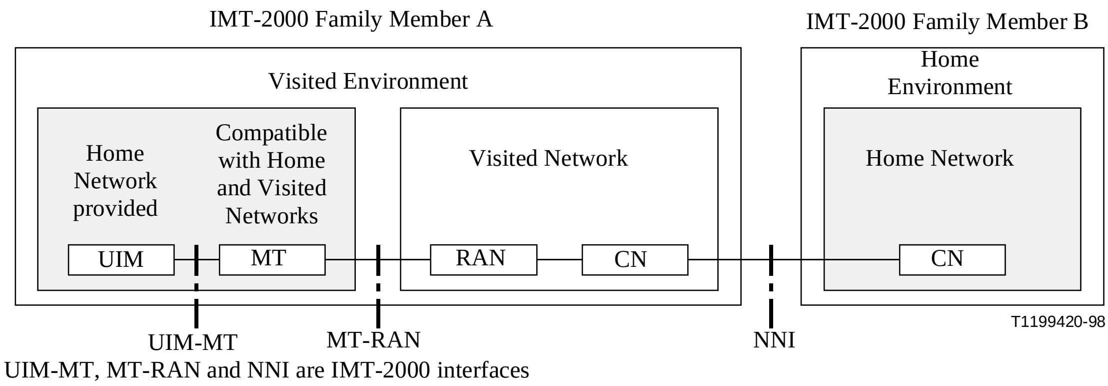


Figure 4-1a/Q.1711 – UIM and MT global roaming

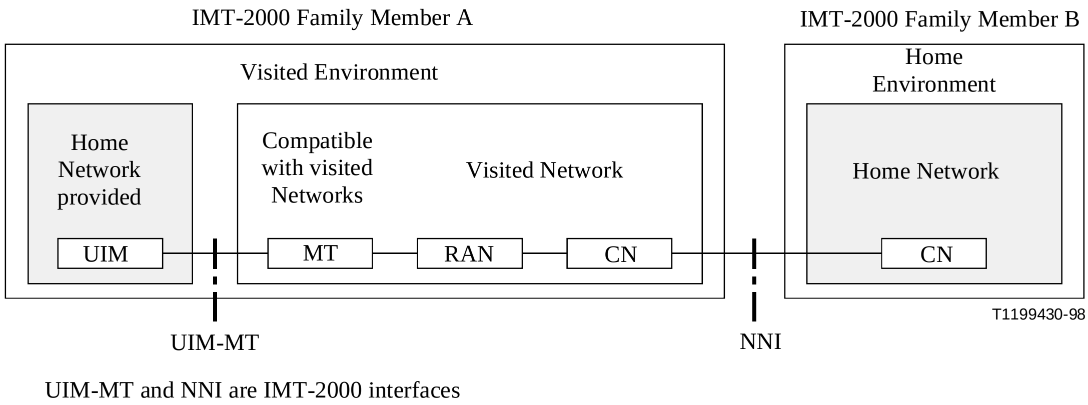


Figure 4-1b/Q.1711 – UIM global roaming

Selection of service providers allows mobile terminals to roam between networks supported by the same or different service providers/operators. This may include the use of mechanisms to preferentially select certain service providers/operators where multiple service providers/operators provide coverage in the same area.

Functions related to interworking includes the mechanisms to provide, for example, charging, fraud, and problem resolution. These mechanisms may be used in "real time" cases.

4.10 Functions related to user privacy & network security

4.10.1 Functions related to ciphering

Confidentiality control: This function provides the necessary information (keys or other parameters to calculate the keys) required for the physical radio channel ciphering and deciphering. Due to the fact that an operator may not wish to disclose the security algorithms used to other operators, the confidentiality control should be regarded as a centralised function. The confidentiality control is closely related to the authentication mechanisms.

Physical radio channel ciphering: This function is a pure computation function whereby the radio transmitted data can be protected against a non-authorised third-party. Ciphering may be based on the usage of a session-dependent key, derived through signalling and/or session dependent information.

Physical radio channel deciphering: This function is a pure computation function which is used to restore the original information from the ciphered information. The deciphering function is the complement function of the ciphering function, based on the same ciphering key.

Ciphering execution control: This function will deliver ciphering information and trigger ciphering and deciphering on the physical radio channel. Ciphering information will be obtained from the *Confidentiality control* function.

4.10.2 Functions related to authentication

Authentication data management: This function controls and manages the authentication data which include authentication parameters and authentication information required in the network.

User authentication processing: Based on parameters received from the *Authentication data management* function, this function will initiate and control the user authentication procedure and process the results. Mutual authentication supports functions for the verification between networks (including service providers) and users (including User Identity Modules). This includes the function for a network to verify the user, (i.e. the network determines if the user is indeed who the user claims to be) and the function for users to verify the network (i.e. the user determines if the network is indeed the network it states to be).

From the user authentication procedure it is possible to invoke IN services and the user authentication procedure can be modified according to the service logic of the invoked IN services. This capability does not include the generation of authentication parameters (e.g. triplets).

4.10.3 Functions related to network fraud/abuse control

Functions in the IMT-2000 Network have the capability to provide necessary information for fraud control, the monitored events being typically call addressing information, geographic position, subscriber identity, network element address information and supplementary service invocation events.

Determining whether fraud or abuse is taking place may involve a combination of real time call, mobility and service processing, and non-real time analysis of such processing across multiple instances of calls and service invocations.

Security mechanisms protect the IMT-2000 user, service provider, and network operator from fraudulent use of the system, and maximise their privacy.

4.10.4 Functions related to identity management

Identity management is a grouping of functions to prevent a permanent user identity from eavesdropping over radio interface to keep confidentiality of the identity. Temporary user identity is used to make network access instead of permanent user identity. This consists of functions to:

a) assign a temporary user identity to a mobile terminal in case of network access with a permanent user identity;

b) update a temporary user identity assigned to a mobile terminal in case of network access with a temporary user identity or validity time-out;

c) inquire a mobile terminal about its permanent user identity in the case where a received temporary user identity is unknown, both in a Visited network domain and another network domain which assigned the temporary user identity;

d) retrieve a permanent user identity from another network domain in the case where a received temporary user identity is unknown in a Visited network domain but is known in another network domain which assigned the temporary user identity.

4.11 Functions related to support of emergency services

Identification of emergency services calls: This function will handle the tasks of recognising calls to emergency services by end users (calls originated from emergency services personnel to the end users may be treated as normal call processing).

Emergency services calls handling: This function will enable the IMT-2000 network to provide priority access to identified emergency services calls, override the normal access and charging procedures and provide the emergency services providers with enhanced capabilities (e.g. call back) and information (e.g. location or geographic position) about the user of such services.

4.12 Functions related to charging

Circuit-switched information generation: At each relevant entity, this function will collect information relevant for charging at call setup, during the call and at call release. The information is sent to the *Charging processing* function. Relevant information for charging may include such parameters as: duration of call, time dependent charging rate, access charge rate, bandwidth used, invoked service instances, and registration charge rate.

Packet data information generation: At each relevant entity, this function will collect information relevant for charging at registration or attach, packet transfer, and at deregistration or detach. The information is sent to the *Charging processing* function. Relevant information may include such parameters as: number of packets exchanged, packet data rate or bandwidth used, average packet size, total bytes exchanged, access charge rate and registration charge rate.

Charging processing: This function will process the information received from the charging *information generation* function(s) and provide the billing and accounting functions with relevant parameters.

4.13 Functions supporting IMT-2000 users

UIM portability is an integral capability within the IMT-2000 networks that supports mobility of UIM devices among the IMT-2000 terminals. In this context, UIM portability requires a physical separated device from the terminal. Therefore, this capability is an optional capability since IMT-2000 supports a physical separated UIM as well as an integrated UIM within the terminal.

IMT-2000 personal mobility is a function which enables a user to transfer her/his identity between IMT-2000 mobile terminals. It is implicit in this definition that the IMT-2000 personal mobility is to access the telecommunication services delineated in the user's service profile, on any IMT-2000 mobile terminal. Every IMT-2000 user has a User Identity Module (UIM) which can interface and be associated with any IMT-2000 terminal.

4.14 Functions related to subscriber data management

4.14.1 Functions related to managing data in Serving networks

Managing subscriber data within Serving networks includes the capability to update or delete certain subscriber data within the Serving network. This could be requested on the following occasions:

- the operator has changed the subscription of one or more supplementary services, basic services or data of a subscriber;
- the operator has applied, changed or removed operator-determined call barring;
- the subscriber has changed data concerning one or more supplementary services by using a subscriber procedure;
- the operator has withdrawn the subscription of one or more supplementary services.

The following functions are required:

Insert subscriber data: This function updates certain subscriber data within the Serving network. It can change the subscriber data associated with the subscriber's bearer services (e.g. speech, data, etc.), tele-services (e.g. facsimile, speech, etc.), supplementary services, VHE services, regional subscription, etc.

Delete subscriber data: This function deletes certain subscriber data within the Serving network. The possible effects of this function are: deletion of basic services, deletion of supplementary services or deletion of VHE services.

4.14.2 Functions related to fault recovery of subscriber data

Fault recovery will enable the recovery from faulty situations, such as invalid subscriber data or missing location data within the Home or Serving network. Two functions are required:

Reset: This function is used to indicate to a list of Serving networks that a failure has occurred within the Home network.

Restore data: This function is used to indicate that the subscriber information associated with the provided IMUI is not available or not valid when the Home network requests routing information (i.e. roaming numbers). The indication is from the Serving network towards the Home network.

4.14.3 Functions related to subscriber control of supplementary services data

Supplementary service (SS) control enables the network operator, on behalf of the subscriber, or the subscriber directly, to control the supplementary service. The following functions are required:

SS data handling: This function updates, retrieves or erases the SS data. The subscriber can initiate the SS data update or erasure. The retrieval of the SS data can also be requested by the Serving network when it detects that the SS requested by the subscriber requires interrogation on its data.

SS activation: This function activates or deactivates the SS upon requests from the subscriber.

SS password protection: this function is required to protect the subscriber-controlled operations on the SS. This includes the registration of a (new) password upon request of the subscriber.

SS subscriber data: This function is required to exchange subscriber data between the subscriber and the network (Home or Serving). This could be initiated by the subscriber or by the network (i.e. Home or Serving).

SS invocation: This function invokes the subscriber-requested SS.

4.15 Functions related to messaging service management

Short Message Service (SMS) provides a means of sending messages of limited size to and from the mobile terminal. The provision of SMS makes use of a message centre which acts as a store and forward centre for short messages.

Application Data Delivery Service (ADDS) provides general purpose wireless data delivery. It delivers application/teleservice messages between service users and utilises the message centre to store and forward messages.

Message delivery: This function delivers the message towards the mobile terminal. This includes the retrieval of the routing information, forwarding the message from the message centre to the Serving network and finally delivering the message towards the mobile terminal.

Message handling: This function receives the message from the mobile terminal and forwards this message to the message centre for storage and subsequent delivery.

Message alerting: This function alerts the Home network that a message was stored at the message centre for a mobile terminal. A "message waiting indication" will be sent to the mobile terminal when it becomes reachable again.

4.16 Functions related to software configurable terminals

The software configurable terminals capability provides the mechanisms which allow applications to interact and operate with any MT. The applications and related data can permanently reside within the UIM, the MT, or an external device or can be downloaded by the Core Network.

Capability profile exchange: This function provides a mechanism for the MT, the UIM and the Core Network to exchange service capability information. For example, the following types of exchanges may occur:

- MT services capability may be provided to the UIM or Core Network;
- UIM services capability may be provided to the MT or Core Network;
- Core Network services capabilities may be provided to the UIM.

Application data transfer: This function provides a mechanism for the MT, the UIM and the Core Network to exchange applications and associated data. For example, the following types of exchanges may occur:

- MT data may be provided to the UIM or Core Network;
- UIM data and applications may be provided to the MT or Core Network;
- Core Network data and applications may be provided to the UIM or MT.

Proactive applications: This function gives a mechanism whereby applications can initiate actions to be taken by the MT. These applications may reside in the UIM, MT or an external device or may be downloaded from the Core Network. Examples of these actions include:

– display text from the UIM or Core Network to the MT;

– send a short message;

– set up a voice call to a number held by the UIM, MT or an external device;

– set up a data call to a number with bearer capabilities held by the UIM, MT or an external device;

– send a supplementary service control or service data;

– play tones in earpiece;

– initiate a dialogue with the user;

– provide local information from the MT to the UIM or to the Core Network;

– provide help information on each command involved in the dialogue with the user.

Screening service by UIM: This function allows that when this screening service is activated by the UIM, all dialled digit strings, supplementary service control service data are first passed to the UIM before the MT sets up the call, the supplementary service operation or the service data operation. The UIM has the ability to allow, bar or modify the call, the supplementary service operation or the service data operation. For example, a call request can be replaced by a supplementary service operation or a service data operation, and vice-versa.

Security: This function allows that applications, designed with the features in this capability, can be used to ensure data confidentiality, data integrity, and data sender validation, or any subset of these.

5 The IMT-2000 Functional Models

The functional model described here contains all functions necessary for supporting all capabilities specified by CS1 of Recommendation Q.1701. Family members have the option to selectively implement only those functions which are needed to support the services they choose to offer.

In the IMT-2000 functional model, the functions required for IMT-2000 service support have been grouped into Functional Entities (FEs) and the functional relationships between these FEs have been indicated. Since there are two possible approaches to the allocation of call control and connection control related functionality, two alternatives are identified: Alternative 1 with integrated call control and connection control FEs and Alternative 2 with separated call control and connection control FEs. This results in two slightly different functional models.

Besides the above-mentioned two alternatives, the model has been developed to be non-service specific as well as non-environment specific. It is mainly functional and does not imply any limitations regarding physical implementations or distribution of functions onto physical configurations. In addition, the model should allow modularised development to facilitate evolution to support further advanced end-to-end services.

5.1 Modelling principles

The same basic modelling principles, as used for IN DFP modelling, have been used. Subclause 5.3 describes FEs which are dependent on the transmission technology. They are specific to the radio access control. Subclause 5.4 describes FEs which are independent of the transmission technology. They specify communication and service control.

Furthermore, a mapping of the FEs to the subsystems UIM, MT, RAN and CN is also shown in the models to reflect the applicability of the IMT-2000 Family of Systems concept. In the functional models in the current Recommendation Q.1711, the allocation of FEs to the RAN and CN subsystems is preliminary. The final allocation of FEs to these subsystems will be addressed at a later stage. The interfaces between these four subsystems are shown as vertical lines. Thus the model supports the interfaces that are defined according to Recommendation Q.1701.

A separation has been made between the communications and service control and the radio access control.

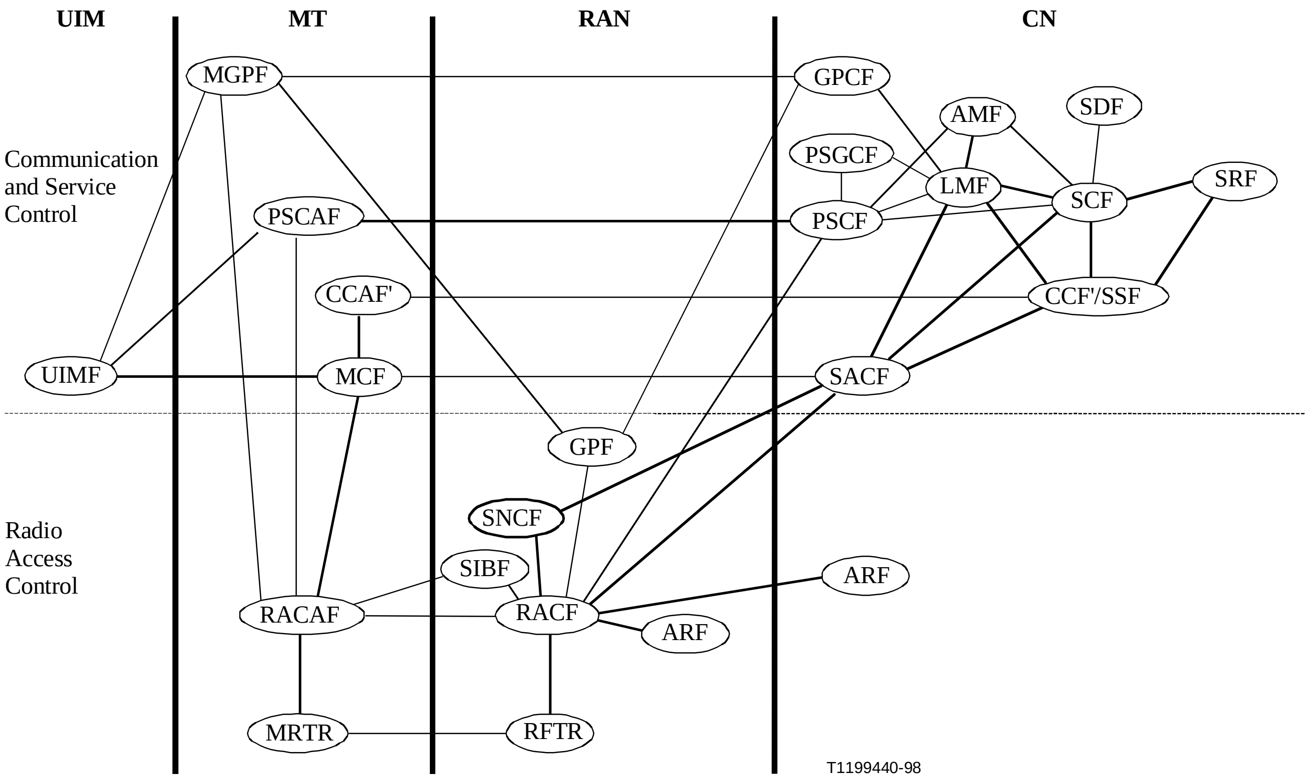
A distinction has been made between IMT-2000 basic capabilities (e.g. basic calls and basic mobility management) and IMT-2000 IN capabilities (IN capabilities triggered by e.g. basic call and mobility events).

5.2 The complete functional models

The complete functional models for IMT-2000, one for Alternative 1 (i.e. integrated call control and connection control FEs) and one for Alternative 2 (i.e. separated call control and connection control FEs), are shown in Figures 5-1a and 5-1b.

The distribution of functions to the Functional Entities is described in the following subclauses.

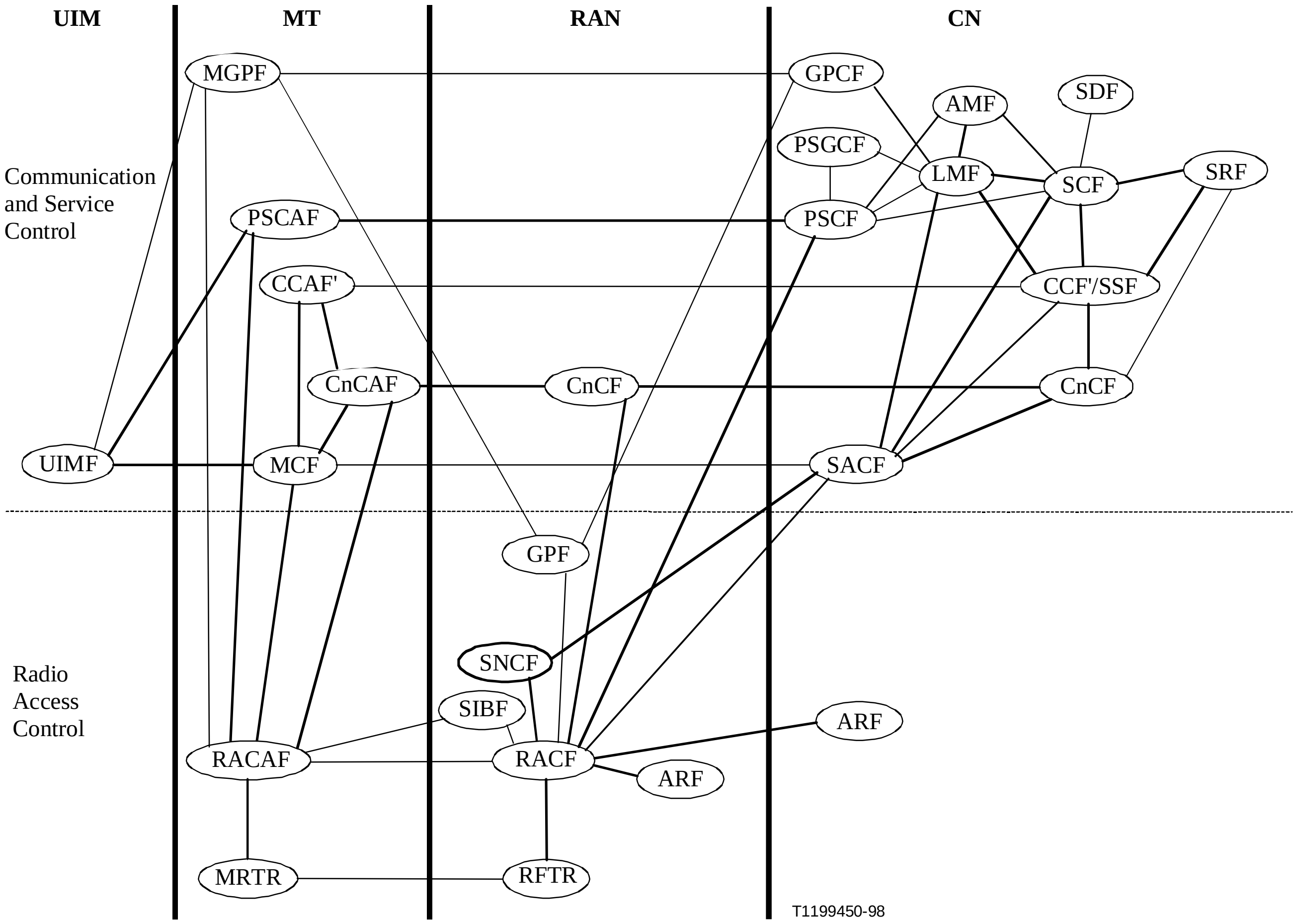
The radio access control related FEs and the communication and service control related FEs are described in different subclauses.



NOTE 1 – There are two alternate ways of supporting triggers for mobility management (i.e. location management or user authentication) related IN services. The triggers can be placed either in the LMF and AMF or in the SACF.

NOTE 2 – The ARF FE has to be mapped to both the RAN and the CN subsystems, since a branch of a BS approach link can be set up via the RAN or via the CN.

Figure 5-1a/Q.1711 – The IMT-2000 functional model
Alternative 1: Integrated call control and connection control FEs



NOTE 1 – There are two alternate ways of supporting triggers for mobility management (i.e. location management or user authentication) related IN services. The triggers can be placed either in the LMF and AMF or in the SACF.

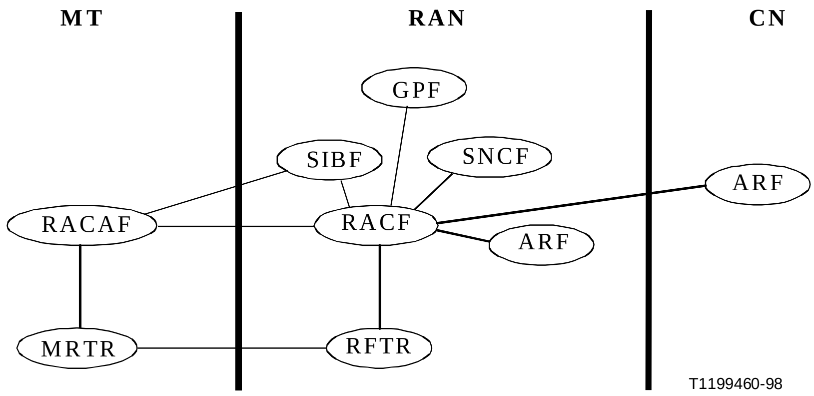
NOTE 2 – The ARF FE has to be mapped to both the RAN and the CN subsystems, since a branch of a BS approach link can be set up via the RAN or via the CN.

Figure 5-1b/Q.1711 – The IMT-2000 functional model
Alternative 2: Separated call control and connection control FEs

5.3 Radio access control related Functional Entities

The radio access control related FEs are in charge of controlling access links. This also includes the management and control of radio resources (e.g. selection and reservation of radio resources, radio channel and radio environment supervision, handover initiation, radio channel activation, handover execution, etc.). These FEs also handle some functions related to geographic position finding. These FEs represent the functionality performed by the radio access subsystem.

The radio access control related FEs and their functional relationships are shown in Figure 5-2.



NOTE – The ARF FE has to be mapped to both the RAN and the CN subsystems, since a branch of a BS approach link can be set up via the RAN or via the CN.

Figure 5-2/Q.1711 – The radio resource control Functional Entities

The functions are distributed as follows:

RACF – Radio Access Control Function: This FE handles the overall control of the association and access link(s) between a mobile terminal and the network. In general it includes functions to:

a) interact with the SACF to set up and release access links;

b) interact with the ARF and/or another RACF for the setup and release of a branch of BS approach link and access radio link;

c) interact with the RFTR to set up, maintain, modify, and release a branch of a BS approach link and associated access radio link;

d) interact with the RACAF for the allocation and reallocation of physical (radio) channel(s) for a branch of an access radio link;

e) interact with the RFTR and SACF for the establishment of a signalling connection;

f) perform handover decision (quality of service assessment based on radio channel quality estimations, including surrounding cells);

g) perform handover decision (initiated by the network side to reallocate the resources);

h) execute handover;

i) complete handover;

j) control the interconnection of branches of a BS approach link and the macro-diversity execution in handover when the macro-diversity point is located in the RACF;

k) execute terminal paging according to the request from the SACF or PSCF (for packet data);

l) determine and keep track of the position of a mobile terminal based on radio-environment-specific parameters (e.g. identification of the cell used by a terminal to access the network);

m) map radio-environment-specific location information (such as cell ID) onto radio-environment-independent location information;

n) provide terminal location information to the SACF and PSCF with the required accuracy;

o) select and reserve radio resources for the execution of handover, initiated by the RACF itself or on request from the SACF;

p) perform RF power control;

q) set service acceptability information (this function has to be included in either the RACF or the RFTR);

r) judge service acceptability (this function has to be included in either the RACF or the RFTR);

s) interact with the RFTR to coordinate the measurements necessary to determine the geographic position of a mobile terminal, or modify the transmitted RF signals to enable the mobile terminal to perform such measurements;

t) forward the result of the geographic position measurements to the GPF;

u) interact with the PSCF to initiate and control the dynamic allocation of radio resources for the transport of data packets across the radio interface;

v) interact with the SACF or PSCF for ciphering execution control when ciphering is performed by radio access control related FEs;

w) interact with the ARF to provide the capability to route to a BS approach link;

x) interact with the SNCF to dynamically control the configuration of radio network resources (for satellite networks);

y) schedule delivery of messages received from the SACF;

z) perform delivery of messages (this function may be in either the SIBF or the RACF);

aa) interact with the SACF for managing selection of global random challenge values when the global challenge scheme is used;

bb) interact with the SIBF to provide global random challenge values for broadcast when the global challenge scheme is used.

RACAF – Radio Access Control Agent Function: This FE handles the mobile side of the association and access link control between the mobile terminal and the network. In general it includes the following functions to:

a) interact with the RACF for the allocation and reallocation of physical radio channel(s) for a branch of an access radio link;

b) interact with the MRTR, MCF, and (for Alternative 2) the CnCAF to set up, maintain, modify, and release an access radio link;

c) perform handover decision (if mobile directed handover);

d) detect paging;

e) interact with the MCF or PSCAF (for packet data) for indication of paging;

f) perform system access information monitoring and analysis based on information broadcast by the SIBF;

g) trigger (or initiate) handover;

h) perform RF power control;

i) judge service acceptability;

j) interact with the MCF for ciphering execution control when ciphering is performed by radio access control related FEs;

k) control measurements of the quality of radio channels in neighbouring cells;

l) interact with the MRTR to perform the measurements necessary to determine the geographic position of a mobile terminal, or modify the transmitted RF signals to enable the network to perform such measurements;

m) forward the result of the geographic position measurements to the MGPF;

n) dynamically allocate radio resources for the transport of data packets across the radio interface;

o) Interact with the MRTR for cell selection in idle mode.

RFTR – Radio Frequency Transmission and Reception: This FE controls the interconnection and adaptation of the access radio link corresponding to the BS approach link. This includes radio channel error protection coding and decoding. It includes functions to:

a) interact with the RACF to set up, maintain, modify and release a branch of a BS approach link and associated branch of an access radio link;

b) maintain the state of an access radio link between the mobile terminal and the network;

c) cipher and decipher the radio channel when ciphering is performed by radio access control related FEs;

d) estimate the quality of radio channels;

e) set the RF power;

f) interact with the MRTR and RACF for the establishment of a signalling connection (i.e. random access detection and handling);

g) maintain the state of a signalling connection;

h) control the interconnection of branches of an access radio link and the macro-diversity in handover (when the macro-diversity point is located in the RFTR);

i) set service acceptability information (this function has to be included in either the RFTR or the RACF);

j) judge service acceptability (this function has to be included in either the RFTR or the RACF);

k) perform the measurements necessary to determine the geographic position of a mobile terminal, or modify the transmitted RF signals to enable the mobile terminal to perform such measurements;

l) forward the results of the measurements necessary to determine the geographic position of a mobile terminal to the RACF.

MRTR – Mobile Radio Transmission and Reception: This FE controls the interconnection and adaptation of the access radio link to the rest of the mobile terminal. This includes radio channel error protection coding and decoding. It includes functions to:

a) interact with the RACAF to set up, maintain, modify and release a branch of an access radio link;

b) maintain the state of an access radio link as perceived by this FE;

c) cipher and decipher the radio channel when ciphering is performed by radio access control related FEs;

d) estimate the quality of radio channels in the active cell and in neighbouring cells (if mobile directed or mobile assisted handover is used);

e) set the RF power;

f) interact with the RACAF for cell selection in idle mode;

g) interact with the RACAF for the reception of random access initiation request, and for the indication of the completion of the procedure;

h) interact with the RFTR for random access initiation;

i) maintain the state of a signalling connection;

j) perform the measurements necessary to determine the geographic position of a mobile terminal, or modify the transmitted RF signals to enable the network to perform such measurements;

k) forward the results of the measurements necessary to determine the geographic position of a mobile terminal to the RACAF.

ARF – Access link Relay Function: This FE handles the overall control for the transit of a branch of the BS approach link between two instances of the RACF. It includes functions to:

a) interact with the RACF or another ARF to set up and release a branch of a BS approach link;

b) control the transmission resources to provide the requested bearer capability;

c) interact with the RACF to obtain routing instructions for a branch of a BS approach link;

d) maintain the state of a branch of a BS approach link.

SIBF – System access Information Broadcast Function: This FE handles the overall control of system access information broadcasting. The information to be broadcast may be made available to the FE via an operation and maintenance function. It includes functions to:

a) perform system access information broadcasting;

b) perform service access permission information broadcasting;

c) perform delivery of messages (this function may be in either the SIBF or the RACF);

d) broadcast to the RACAF the information necessary to perform system access information monitoring and analysis;

e) interact with the RACF for broadcasting the global random challenge value when the global challenge scheme is used.

SNCF – Satellite Network Control Function: This FE dynamically controls the configuration of radio network resources, in response to demands for connections to and from mobile terminals. In particular, in satellite networks, optimal use of scarce communication resources requires this dynamic behaviour. In other kinds of networks this FE may not be required. The SNCF includes functions to:

a) interact with the RACF and SACF to establish and release associations between feeder links (to and from the Core Network) and radio channels;

b) interact with the RACF to manage the way in which the radio channels are targeted, for example to satellite spot beams;

c) establish and release associations between various bearer channels at the satellite, for example in support of direct terminal-terminal calls, which do not transit the Core Network.

GPF – Geographic Position Function: This FE handles the tasks associated with geographic positioning in the radio access side. It includes functions to:

a) receive requests from the GPCF or MGPF to perform the steps needed to determine the geographic position of mobile terminals;

b) interact with the RACF to perform the necessary RF measurements or to modify the transmitted RF signals to enable the mobile terminal to perform such measurements;

c) interact with the MGPF to synchronize with the mobile terminal to perform necessary RF measurements or modify transmitted RF signals to enable the GPF to perform such measurements;

d) receive relevant information (measurements, position data, timestamps, etc.) from the RACF or from the MGPF and perform some of the necessary computations to determine the geographic coordinates of the mobile terminal;

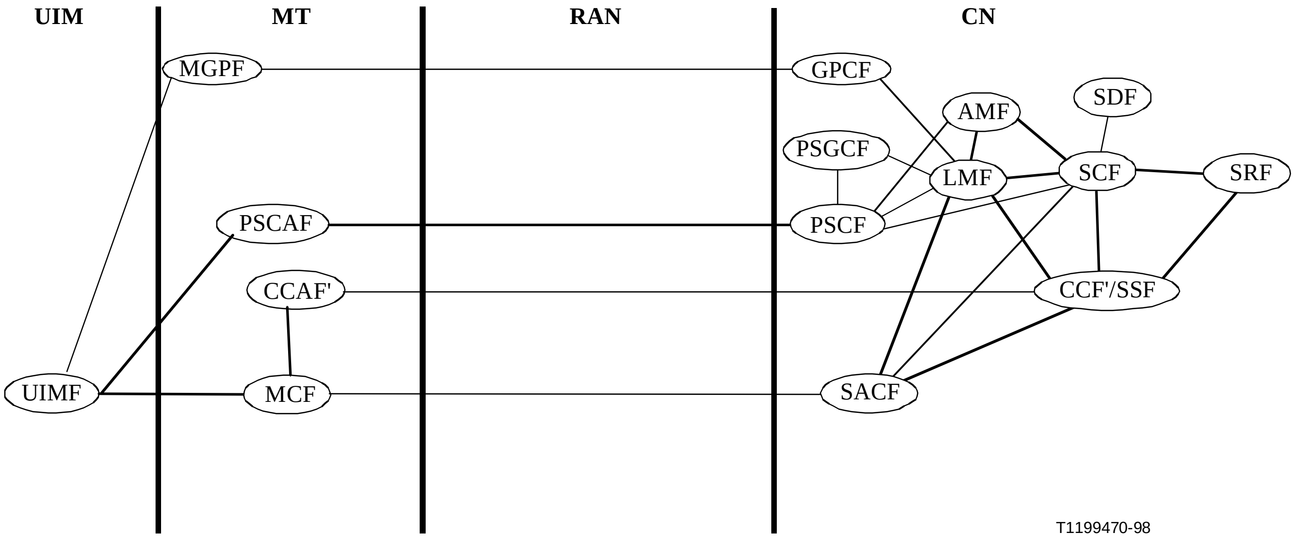
e) send the result to the requesting party (the GPCF or MGPF).

5.4 Communication and service control related Functional Entities

The communication and service control related functional entities are in charge of the overall access, service, call, and connection control. Two functional models are shown to reflect the option of having the call and connection controls integrated or separated. These FEs represent the functionality performed by the UIM, Mobile Terminal and Core Network subsystems.

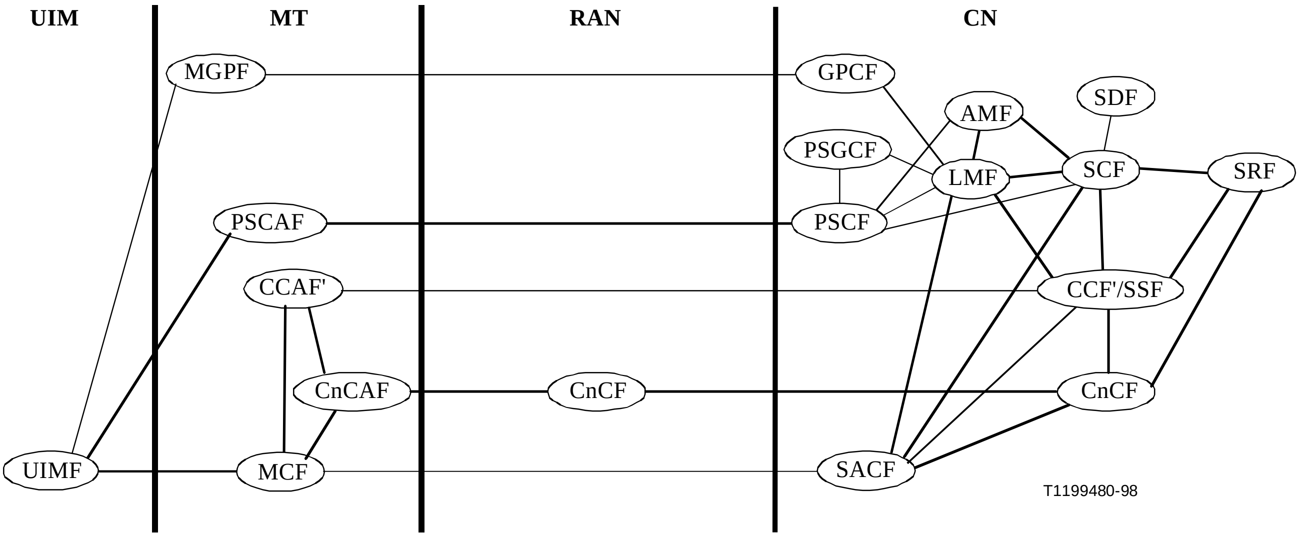
The Functional Entities and their functional interrelations are shown in Figures 5-3a and 5-3b.

The figures show the interconnections between the IMT-2000 specific FEs and the FEs that are defined for IN. Although not shown in the figure, it is assumed that Service Management functionality are included in the same way as for IN (SMF, SMAF, SCEF Functional Entities).



NOTE – There are two alternate ways of supporting triggers for mobility management (i.e. location management or user authentication) related IN services. The triggers can be placed either in the LMF and the AMF or in the SACF.

Figure 5-3a/Q.1711 – Communication and service control related Functional Entities Alternative 1: integrated call control and connection control FEs



NOTE – There are two alternate ways of supporting triggers for mobility management (i.e. location management or user authentication) related IN services. The triggers can be placed either in the LMF and AMF or in the SACF.

Figure 5-3b/Q.1711 – Communication and service control related Functional Entities Alternative 2: separated call control and connection control FEs

The distribution of functions onto functional entities is given in the following subclauses.

5.4.1 Functional Entities on the network side of the radio interface

This subclause describes the communication and service control related FEs in the Core Network subsystem.

SDF – Service Data Function: This FE is defined in Recommendation Q.1224 (IN CS-2) [7], however, it has been enhanced for mobile communications. It handles storage and access to service and network related data and provides consistency checks on data. It hides from the SCF the real data implementation and provides a logical data view to the SCF. It includes functions to:

a) store service data, (e.g. service profile, multimedia attributes);

b) check data consistency;

c) manage application data (e.g. create, administer, provision, etc.);

d) generate and manage user service related data;

e) interact with other SDFs to exchange service data.

SCF – Service Control Function: This FE contains the overall IN service control functionality in the IMT-2000. Service logic can be triggered by call processing, mobility management, or non-call associated events. The SCF interacts with other FEs to access additional logic or to obtain information (service, user or network data) required to process a service logic instance. It includes functions to:

a) interact with either the AMF and LMF or the SACF to provide mobility management (e.g. location management and user authentication) related IN services. This capability does not include the triggering of IN services from the authentication data (e.g. triplet) generation process;

b) interact with the SACF to provide call unrelated IN services;

c) interact with the CCF'/SSF to provide call related IN services;

d) interact with the SRF to provide specialized resources for IN services;

e) interact with the SDF to manage and update service data;

f) interact with other SCFs for secured data acquisition and manipulation, distributed service control and unsolicited service notifications, if necessary;

g) interact with the user for session control and access control for connection's services (including packet services), using call unrelated transparent user to service interactive operations;

h) interact with proactive applications within terminal- or user- agents;

i) process application data (e.g. initiates data download, SMS, ADDS);

j) interact with the LMF to obtain terminal and user information (e.g. location information, subscriber status information);

k) interact with the UIMF for service data/logic transfer and service profile modification, utilising the relationship with the SACF or PSCF.

SRF – Specialized Resource Function: This FE is defined in IN Capability Set documents. It provides the specialized resources required for the execution of IN provided services (e.g. digit receivers, announcements, conference bridges), mobile multimedia services, application data delivery services, and packet data transfer services. It includes functions to:

a) interact with the SCF, CCF'/SSF, and the CnCF (Alternative 2) to provide specialized resources for IN services;

b) provide the logic and processing capability to receive/send and convert information or application data received/sent from users;

c) provide functionality to terminate and manage bearer connections to the specialized resources.

SMF – Service Management Function: This FE is defined in Recommendation Q.1224 (IN CS-2) [7], however, it has been enhanced for mobile communications. It consists of a number of IN SMF functions. These functions can be grouped into the following five categories:

1) Service Deployment Functions;

2) Service Provisioning Functions;

3) Service Operation Control Functions;

4) Billing Functions;

5) Service Monitoring Functions.

(see Recommendation Q.1224 for further details).

SSF – Service Switching Function: This FE is defined in Recommendation Q.1224 (IN CS-2) [7], however, it has been enhanced for mobile communications. The SSF is associated with the CCF'. It provides the set of functions required for the interaction between the CCF' and SCF. It includes functions to:

a) interact with the CCF' and SCF to provide IN services;

b) manage the signalling between the CCF' and SCF;

c) modify functions in the CCF' as required to process requests for IN provided service usage under the control of the SCF.

The connection control function can be either contained in the call control Functional Entity or a separate Functional Entity. The CCF' functionality is mostly the same in either case, however, the differences are noted below the CCF' FE description.

CCF' – Call Control Function (enhanced): The definition of this FE is based on the Call Control Function defined in Recommendation Q.1224 (IN CS-2) [7], however, it has been enhanced for mobile communications. It provides call/connection processing control. It includes functions to:

a) interact with the CCAF' or other CCF's/CCFs to establish, maintain and release call instances;

b) establish and manage the relationship between the CCAF' Functional Entities involved in a call and/or connection instance (e.g. supervises the overall perspective of the call and/or connection instance);

c) provide trigger mechanisms for mobile originated calls and mobile terminated calls to access IN functionality (e.g. passes events to the SSF);

d) interact with the SACF for the setup and release of an access link;

e) interact with the SRF in support of IN services;

f) interact with the LMF to receive routing and profile information for mobile calls.

Alternative 1: Integrated Call Control and Connection Control Functions

When call and connection control are integrated, the CCF' includes the following additional function to:

g1) control the bearer connection elements in the network in order to provide the bearer capabilities requested, including the following functionality:

- establishment, maintenance and release of bearer connections in the network, including bearers to the SRF for IN services,
- cooperation with the peer CCF' in order to establish, maintain and release bearer control associations.

Alternative 2: Separated Call Control and Connection Control Functions

When call and connection control are separated, the CCF' includes the following additional function to:

g2) interact with the CnCF to establish, modify and release a connection of a call.

CnCF – Connection Control Function: This FE provides connection processing control. It includes functions to:

a) interact with the CCF', CnCAF, or other CnCFs to establish, maintain, modify and release connection instances;

b) establish and manage the relationship between the CnCAF Functional Entities involved in a connection (e.g. supervises the overall perspective of the connection instance);

c) controls the bearers in the network in order to provide the bearer capabilities requested, including the following functionality:

- establishment, maintenance and release of bearers in the network, including bearers to the SRF for IN services;
- cooperation with the peer CnCF in order to establish, maintain and release bearer control associations.

For simplification purposes, the LMF is shown containing data and mobility management functions and the AMF is shown containing data and authentication functions. However, the functions may be identified separately and different relationships may be used for interconnections purposes.

LMF – Location Management Function: This FE contains the basic terminal mobility logic. It supports location management, mobility management, activation status management, and identity management. The LMF interacts with other FEs to access additional logic or share information (e.g. user or network data). It also handles storage and access to subscriber mobility data. It includes functions to:

a) interact with the CCF'/SSF, SACF, and other LMF FEs to provide routing information for the establishment of calls;

b) interact with the CCF'/SSF to provide profile information including service capability (e.g. protocol, bearer) information;

c) interact with the AMF which provides user authentication processing;

d) interact with the SACF to send authentication related requests from the AMF;

e) interact with the SACF for basic mobility management (e.g. location and MT status management, identity management);

f) interact with the SCF to provide location management related IN services (this function can be provided by either the LMF or the SACF);

g) interact with the SACF to provide the paging strategy;

h) interact with the SCF to provide location and subscriber status information;

i) perform location and MT status management (e.g. attach, detach);

j) perform identity management;

k) manage, update, and transfer data (e.g. subscriber profile data, trigger profile data);

l) perform user verification (e.g. PIN verification for access to subscriber data);

m) identify radio-environment-independent terminal location information (e.g. in terms of a geographic area);

n) modify the location management procedures as required to process requests for IN provided usage under the control of the SCF (this function can be provided by either the LMF or the SACF);

o) store subscriber identity, subscriber profile, and mobility related data, e.g.
   - location information,
   - active/inactive status,
   - subscriber identity data,
   - supplementary service profile (e.g. call barring, call waiting),
   - trigger profile list;

p) manage temporary routing numbers for use by roamers (this function has to be in either the LMF or the SACF);

q) manage, update, and transfer relevant packet data services information (e.g. packet data service profile);

   NOTE – This is primarily associated with the Home LMF.

r) check data consistency;

s) interact with another LMF to manage the subscriber information;

t) interact with another LMF to ensure subscriber information integrity (e.g. fault restoration);

u) interact with another LMF or the SACF to control the supplementary services (SS) (e.g. activate/deactivate, update/retrieve/erase the SS information, register a subscriber provided password, handle the subscriber SS data);

v) interact with a message centre (e.g. the SCF[1]) to provide the messaging services (e.g. SMS, ADDS) based on MT availability;

w) interact with the SACF to deliver messages;

x) interact with the PSCF for accessing and updating subscriber-related data and updating packet service and routing information;

y) interact with the PSGCF for updates of packet service and routing information (this function can be provided by either the LMF or the PSCF);

z) interact with the GPCF to indicate the general area where RF control messages may be sent to mobile terminals.

AMF – Authentication Management Function: This FE handles storage and access to authentication data. It also provides the authentication function and confidentiality control. It includes functions to:

a) store authentication data (e.g. triplets, user authentication keys, security related parameters);

b) generate authentication information (e.g. generation of triplets, unique authentication challenge);

c) check the validity of received authentication data;

d) check data consistency;

e) perform user authentication;

f) perform confidentiality control;

g) manage, update, and share authentication parameters;

h) perform confidentiality control, user authentication, and parameter update for packet data services (this capability can be in either the LMF or the PSCF);

i) interact with the SCF to provide user authentication related IN services. This capability does not include the triggering of IN services from the authentication data (e.g. triplet) generation processes (this capability can be provided by either the AMF or the SACF);

j) modify the user authentication procedures (excluding the generation of authentication data e.g. triplets) as required to process requests for IN provided usage under the control of the SCF (this capability can be provided by either the AMF or the SACF);

k) interact with the UIMF for user authentication purposes (excluding the generation of authentication data e.g. triplets), utilising the relationship with the LMF.

SACF – Service Access Control Function: This FE provides both call-related and call-unrelated processing and control (e.g. in relation to mobility management). It includes functions to:

a) interact with the MCF for the establishment and release of both call-related and call-unrelated association between an IMT-2000 terminal/user and the network;

b) interact with the LMF to provide routing information for the establishment of calls and basic mobility management functionality (e.g. location and MT status management, identity management);

c) interact with the SCF to provide mobility management (e.g. location management and user authentication) related IN services. This capability does not include the triggering of IN services from the authentication data (e.g. triplet) generation processes (this capability can be provided by either the AMF and LMF or the SACF);

d) interact with the SCF to provide call-unrelated IN services;

[1] This message centre does not have to be mapped to an IN platform.

e) interact with the RACF to identify radio-environment-independent terminal location information across one or more RACFs;

f) interact with the CCF'/SSF and RACF for the setup and release of an access link (the SACF may simply transfer requests between the CCF'/SSF and RACF);

g) interact with the RACF for the setup and release of a branch of a BS approach link when the macro-diversity point is located in the SACF;

h) control the interconnection of branches of an access link and the macro-diversity execution in handover for cases when the macro-diversity point is located in the SACF;

i) interact with the MCF to detect and handle paging response;

j) interact with RACFs to request paging execution;

k) interact with the RACF for ciphering execution control (including ciphering information delivering and triggering);

l) interact with the LMF to provide the paging strategy;

m) interact with the RACF to support location-based services dependent on location information across RACFs;

n) manage temporary routing numbers for use by roamers (this function must be in either the LMF or the SACF);

o) interact with the LMF to control supplementary services (SS) (e.g. activate/deactivate, update/retrieve/erase the SS information, register a subscriber provided password, handle the subscriber SS data or to invoke the SS);

p) modify the location management procedures and user authentication procedures as required to process requests for IN-provided usage under the control of the SCF (this capability can be provided by either the AMF and LMF or the SACF);

q) interact with the RACF and LMF for delivery of messages;

r) interact with the RACF and LMF for managing the global random challenge activities when global challenge scheme is used;

s) interact with the MCF and LMF for managing unique authentication challenge activities when unique challenge scheme is used.

GPCF – Geographic Position Control Function: This FE provides the overall control for the geographic position finding function on the network side. It includes functionality to:

a) receive requests from the network or from its peer entity on the mobile side (i.e. the MGPF) to determine the geographic position of a mobile terminal;

b) establish, maintain and release a service instance for a geographic positioning request;

c) interact with the LMF to identify the general area where RF control messages may be sent to mobile terminals;

d) interact with the GPF to instruct it to perform the necessary RF measurements or to modify the transmitted RF signals to enable the mobile terminal to perform such measurements;

e) interact with the MGPF to request that the mobile terminal performs necessary RF measurements or that it modifies its transmitted RF signals to enable the GPF to perform such measurements;

f) receive relevant information (measurements, position data, timestamps, partial computations, etc.) from the GPF or from the MGPF on the mobile side and perform the necessary final computation to determine the geographic coordinates of the Mobile Terminal;

g) send the results to the requesting party.

5.4.2 Functional Entities on the mobile side of the radio interface

This subclause describes the communication and service control related FEs in the UIM and Mobile Terminal subsystems.

MCF – Mobile Control Function: This FE provides the overall service access control logic and processing at the mobile side of the radio interface. Specifically, it interacts with the network for mobility management. It includes functions to:

a) interact with the SACF for the establishment and release of the association between a mobile terminal and the network;

b) interact with the SACF to initiate location and MT status management;

c) detect user's need to interact with call-unrelated service features for personal mobility features;

d) relay indications relating to service access to the user/terminal functional entities as required;

e) interact with the RACAF to setup, maintain, modify, and release a signalling connection;

f) interact with the CCAF' (Alternative 1) and the CnCAF (Alternative 2) to setup, maintain, modify, and release an access channel;

g) interact with the UIMF to retrieve user identification information, location management related information (e.g. location area identity), security and privacy related information (e.g. temporary mobile user identity);

h) interact with the UIMF to exchange application information with the applications that are allocated within the UIMF, MCF, or an external device;

i) interact with the SACF and RACAF to handle paging;

j) interact with the SCF (utilising the relationship with the SACF) for service control purposes, for example to download and store service logic and application data (this can also be done by the UIMF);

k) interact with the SACF for managing unique authentication challenge activities when unique challenge scheme is used;

l) interact with the RACAF for ciphering execution control when ciphering is performed by radio access control related FEs;

m) interact with the UIMF to perform serving system selection;

n) maintain service capability (e.g. protocol, bearer) information for the mobile terminal.

UIMF – User Identification Management Function: This FE provides the means to identify both the IMT-2000 user and the mobile terminal to the network and/or to the service provider, and contains processing capability for authentication and service handling in the UIM. It includes functions to:

a) store IMT-2000 user-related information such as IMT-2000 user identification information both to identify the IMT-2000 user and to address the mobile terminal, location management-related information and security and privacy related information;

b) interact with the MCF to provide IMT-2000 user identification information, location management-related information (e.g. location area identity), security and privacy related information (e.g. temporary mobile user identity);

c) interact with the MCF to exchange application information with the applications that are allocated within the MCF, UIMF, or an external device;

d) interact with the MCF to provide serving system selection information based on e.g. location area identity, service availability, and service preferences;

e) interact with the AMF (utilising the relationship with the MCF or PSCAF) for IMT-2000 user authentication and ciphering key generation (e.g. calculation of authentication response and generation of ciphering key);

f) perform and control authentication of the network to the user in case of mutual authentication, and update authentication parameters in the UIM in interaction with the AMF, utilising the relationship with the MCF or PSCAF;

g) interact with the SCF to exchange application information, utilising the relationship with the MCF or PSCAF, for example to support proactive applications;

h) store, process and/or work with the Man-Machine Interface (MMI) functionality in the MT to display application data or other types of data downloaded from the network or loaded into the UIMF by other means;

i) execute service logic required to handle service attempts in the UIM, both related to a call and not related to a call.

The connection control agent function may be either contained in the call control agent Functional Entity or a separate Functional Entity. The CCAF' functionality is mostly the same in either case, however, the differences are noted below the CCAF' FE description.

CCAF' – Call Control Agent Function (enhanced): The definition of this FE is based on the Call Control Agent Function defined in Recommendation Q.1224 (IN CS-2) [7], however, it has been enhanced for mobile communications. It provides service access for users and may also provide integrated call/connection control. It is the interface between user and network call control functions. It includes functions to:

a) interact with the CCF' and MCF to establish, maintain, or release a call or other service instance;

b) provide for user access, interacting with the user to establish, maintain, modify and release a call or other service instance;

c) relay information between the user and the CCF';

d) maintain call/service state information.

Alternative 1: Integrated Call Control and Connection Control Functions

When call and connection control agent functions are integrated, the CCAF' includes the following additional function:

e1) control bearer connection elements with the CCF' to provide the bearer capabilities requested, including the functionality for the establishment, maintenance and release of bearer connections and bearer control associations.

Alternative 2: Separated Call Control and Connection Control Functions

When call and connection control agent functions are separated, the CCAF' includes the following additional function:

e2) Interact with CnCAF to setup, maintain, modify, and release connections.

CnCAF – Connection Control Agent Function: This FE provides connection control functions for users. It is the interface between the Call Control Agent Function (CCAF') and the Radio Access Control Agent function (RACAF). It includes functions to:

a) interact with the CCAF', MCF, and CnCF to establish, maintain, modify and release connections;

b) relay information between the CnCF and CCAF';

c) maintain connection state information;

d) interact with the RACAF or MCF to setup, maintain, modify, or release a connection.

MGPF – Mobile Geographic Position Function: This FE provides the overall control for the geographic position finding function on the mobile terminal side. It includes functionality to:

a) provide for user access, interacting with the user to establish, maintain, modify and release a service instance;

b) access the service providing capabilities of the GPCF, using service requests for the establishment, maintenance and release of a service instance;

c) receive requests from the mobile terminal user or from its peer entity on the network side (i.e. the GPCF) to initiate an action for determining the geographic position of the mobile terminal;

d) if an independent way of assessing the mobile terminal's position is available (e.g. a GPS receiver), determine the position based on the provided input and make the result available to the requesting party;

e) interact with the RACAF to perform the necessary RF measurements or to modify the transmitted RF signals to enable the network side to perform such measurements;

f) interact with the GPF to request that the network side performs necessary RF measurements or that it modifies its transmitted RF signals to enable the mobile terminal to perform such measurements;

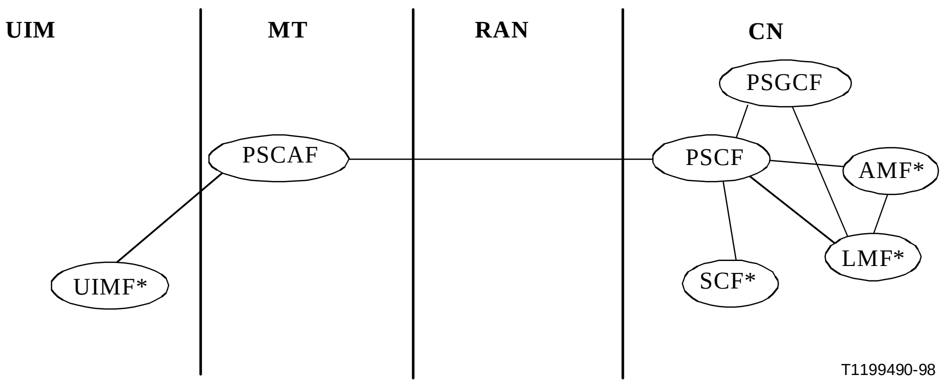
g) interact with the UIMF in support of user identification, authentication and privacy;

h) receive relevant information (measurements, position data, timestamps, etc.) from the radio receiver on the mobile side or from the GPF on the network side and, either forward the data to the GPCF, or, if possible, perform the necessary computations to determine the geographic coordinates of the mobile terminal;

i) present the results to the mobile terminal user or send them to the GPCF.

5.4.3 Packet data services control related Functional Entities

This subclause refers to the Functional Entities needed to support the context-based routing for packet data services. The functionality of the packet data services control is in charge of the overall context access and service control. The functions are grouped into Functional Entities (FE). The Functional Entities and their functional interrelations are shown in Figure 5-4.



* For a description of these FEs please see sections 5.4.1 and 5.4.2.

Figure 5-4/Q.1711 – The packet data service-related FEs

5.4.3.1 Functional Entities on the network side of the radio interface

PSCF – Packet Service Control Function: This FE provides the packet service control functionality in the IMT-2000 Core Network. It includes functionality to:

a) control a packet service by interacting with the PSCAF in establishing and maintaining:
   - a packet data service context associated with a mobile terminal to enable the support of a specific packet data protocol (e.g. Internet Protocol),
   - a packet data routing context associated with a mobile terminal to enable routing of packets to and from a mobile terminal and between mobile terminals;

b) interact with the PSGCF for:
   - provision of updates on the packet data service and routing context associated with a mobile terminal (this function can be provided by either the LMF or the PSCF),
   - user data transfer between external packet data networks and the mobile terminal;

c) interact with the AMF for authentication purposes;

d) perform confidentiality control, user authentication, and parameter update for packet data services (this capability can be in either the LMF or the PSCF);

e) interact with the LMF for:
   - accessing and updating subscriber-related data (e.g. subscriber service profiles),
   - updating packet service and routing information (e.g. packet data services information and location information);

f) interact with the SCF to support the transfer of information between the SCF and UIMF;

g) interact with the PSCAF as the mobile counter-part of the PSCF for control of user data transfer across the radio interface, including support for sleep mode and priority access;

h) interact with the RACF to initiate the dynamic allocation of radio resources for the transport of data packets across the radio interface;

i) interact with the RACF for ciphering execution control (including ciphering information delivering and triggering);

j) control packet-data bearers to transport data packets within the fixed network part and interact with the appropriate Functional Entities;

k) perform location management for the mobile terminal, including:
   - identification of radio-environment-independent terminal location information (in terms of a geographic area) provided by the RACF,
   - detection and handling of paging responses, if needed,
   - interaction with RACFs for the request of paging execution, if needed, and
   - to update the packet data routing context, if necessary;

l) route and relay packets to and from a mobile terminal according to the packet data service context and the associated quality of service classes.

PSGCF – Packet Service Gateway Control Function: This FE provides the packet service gateway control functionality in the IMT-2000 Core Network. It includes functionality to:

a) route and relay data packets transparently between other packet data networks and the PSCF according to the packet service and routing context associated with a mobile terminal;

b) interact with the PSCF for updates of packet service and routing contexts;

c) interact with other packet data networks, such as to provide routing address to external packet data networks (such as Internet Protocol or X.25) to allow them to address a mobile terminal (e.g. an Internet Protocol address for Internet Protocol-based networks) or to provide route optimisation messages to an external packet data network;

d) control packet-data bearers for the transport of data packets between the PSGCF and PSCF;

e) interact with the LMF for updates of packet service and routing information (e.g. packet data services information and location information).

5.4.3.2 Functional Entities on the mobile side of the radio interface

PSCAF – Packet Service Control Agent Function: This FE provides the packet service control agent functionality in the IMT-2000 mobile terminal. It includes functionality to:

a) interact with the PSCF to control the transport of data packets across the radio interface according to the chosen packet service including support for sleep mode and priority access;

b) provide location management information to the PSCF;

c) interact with the RACAF to initiate and control the dynamic allocation of radio resources for the transport of data packets across the radio interface;

d) interact with the UIMF and PSCF for support of authentication and service control handling;

e) relay indications relating to packet data service access to other user/terminal Functional Entities as required.

6 Network Reference Model

This subclause shows a possible grouping of Functional Entities into physical collections of functions and the physical relationships between those collections that may be realised for IMT-2000. This specific configuration alternative is not the only configuration possible. It is possible to construct other physical and network configuration scenarios for IMT-2000 deployments, including those noted in ITU-R Recommendations M.687-2 [1], M.816-1 [2], and Recommendation Q.1701 [9]:

- Satellite:
  - Passive mode;
  - Switching in the sky.
- Cellular.
- Cordless:
  - Public network – private users;
  - Public network – public access;
  - Private network – private users;
  - Private network – public access;
  - Residential.
- High bit rate access – line of sight:
  - Office – indoor;
  - Wireless local loop – outdoor.

6.1 A generic reference model

Figure 6-1 is a generic figure to illustrate possible groupings of Functional Entities into physical collections of functions and the physical interface relationships between those collections (i.e. reference points) that may be realised for IMT-2000. Note that the Network-to-Network Interface (NNI) is not shown as a single interface, since all the interfaces across Core Network boundaries together constitute the NNI.

The following is a list of physical groupings shown in Figure 6-1:

AC	Authentication Centre
BS	Base Station
DMSC	Drift MSC
GLR	Gateway Location Register
GMSC	Gateway MSC
HLR	Home Location Register
IP	Intelligent Peripheral
MSC	Mobile Switching Centre
MT	Mobile Terminal
PDGN	Packet Data Gateway Node
PDSN	Packet Data Serving Node
RNC	Radio Network Controller
SCP	Service Control Point
SDP	Service Data Point
Tx	Transit Exchange
UIM	User Identity Module
VLR	Visitor Location Register

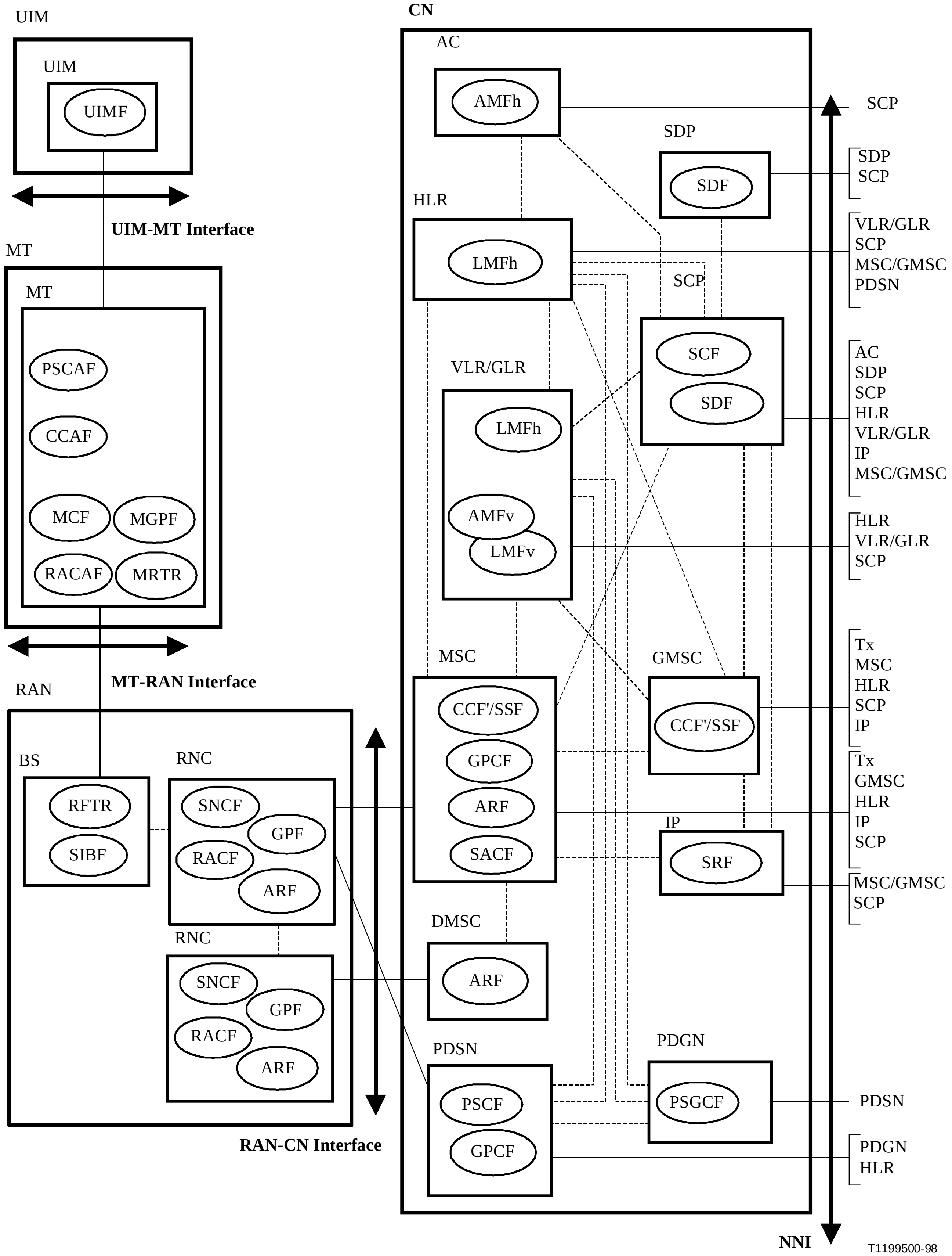


Figure 6-1a/Q.1711 – Generic reference model for IMT-2000
Alternative 1: Integrated call control and connection control FEs

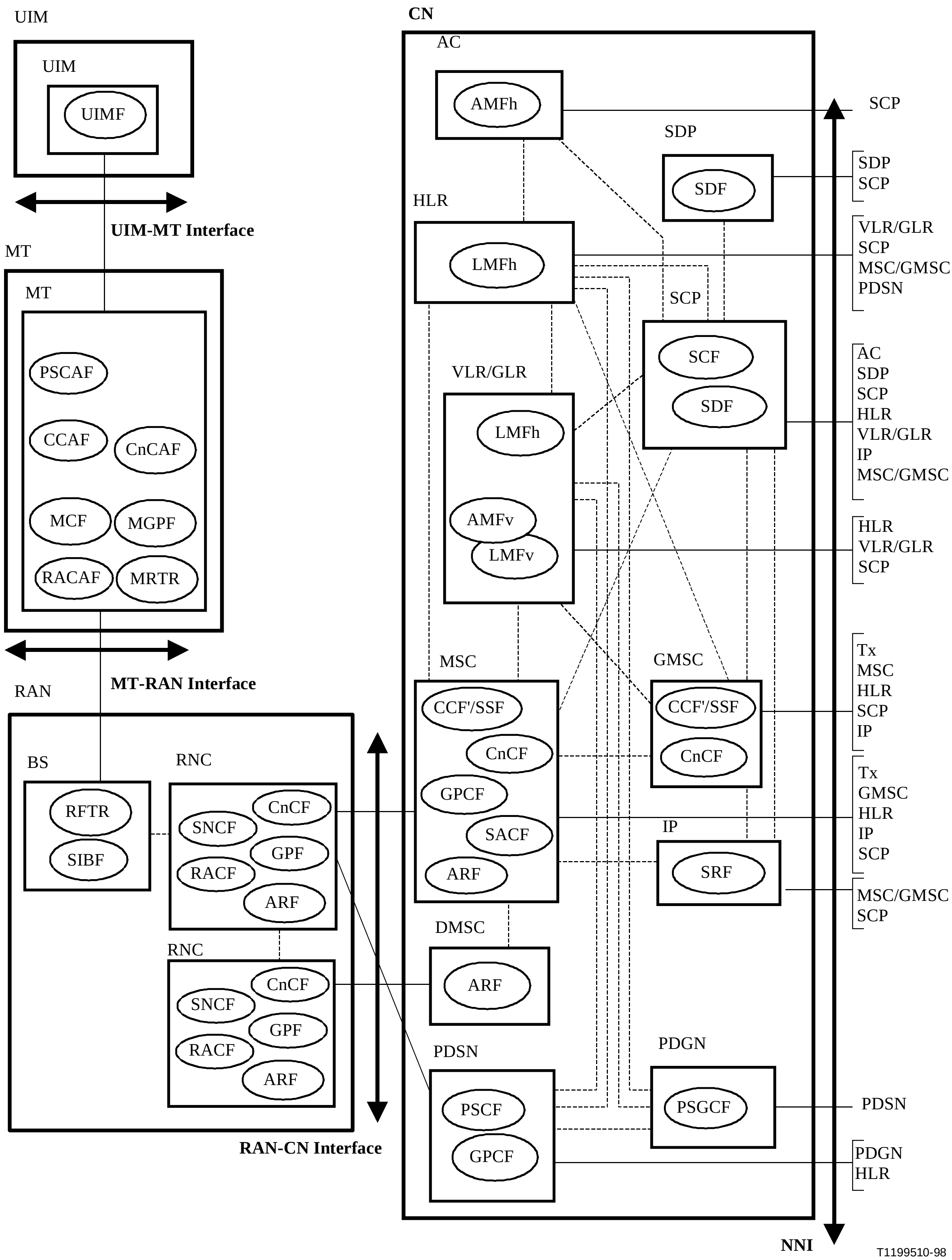


Figure 6-1b/Q.1711 – Generic reference model for IMT-2000
Alternative 2: Separated call control and connection control FEs

NOTE 1 – The GLR is an optional node between the VLR and the HLR, which may be used to optimize the handling of subscriber location data across network boundaries. In the case a subscriber is roaming outside the Home IMT-2000 network the GLR plays the role of an HLR towards the VLR and the role of a VLR towards the HLR. The GLR handles any location change between different VLR service areas in the Visited network without involving the HLR. The GLR is not involved when the subscriber is roaming within its Home IMT-2000 network.

NOTE 2 – The GMSC can be placed in any network. In the case where a GLR is not used, the GMSC contacts the HLR for routing information. The call is then routed to the visited MSC. In the case where a GLR is used, two possible alternatives can be used: 1) the GMSC in the Interrogating network contacts the HLR for routing information to the Visited network's GMSC. After connecting the call to the Visited network, the GMSC in the Visited network contacts the GLR for routing information to the visited MSC. The call is then routed to visited MSC. 2) the GMSC contacts the HLR for routing information. The call is then routed directly to the visited MSC.

6.2 Network reference points

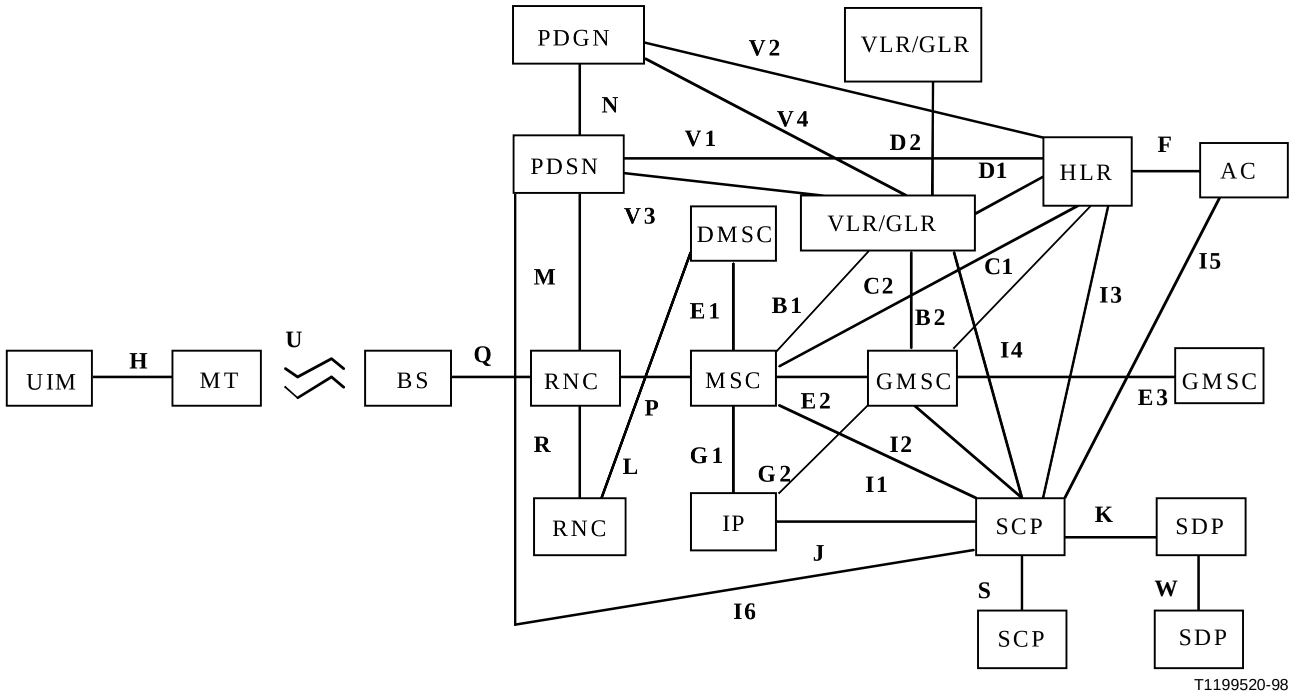


Figure 6-2/Q.1711 – Reference points in IMT-2000 reference model

Table 6-1/Q.1711 – Names of Reference Points

Reference Point	Interface
B1	MSC – VLR/GLR
B2	GMSC – VLR/GLR
C1	GMSC – HLR
C2	MSC – HLR
D1	VLR/GLR – HLR
D2	VLR/GLR – VLR/GLR
E1	MSC – DMSC
E2	MSC – GMSC
E3	GMSC – GMSC
F	HLR – AC
G1	MSC – IP
G2	GMSC – IP
H	MT – UIM
I1	MSC – SCP
I2	GMSC – SCP
I3	SCP-HLR
I4	SCP-VLR/GLR
I5	SCP-AC
I6	SCP-PDSN
J	SCP – IP
K	SCP – SDP
L	RNC-DMSC
M	PDSN-RNC
N	PDSN-PDGN
P	MSC – RNC
Q	RNC – BS
R	RNC – RNC
S	SCP – SCP
U	BS – MT
V1	PDSN – HLR
V2	PDGN – HLR
V3	PDSN – VLR/GLR
V4	PDGN – VLR/GLR
W	SDP – SDP

7 Global Roaming and Interworking Scenarios

7.1 Introduction

An essential service requirement of IMT-2000 is that IMT-2000 users should be able to use their equipment and subscriptions in different family member networks, and to establish calls and connections between networks of different operators. To support this service requirement, interconnection between different IMT-2000 family member networks is required.

Network interworking is required whenever an IMT-2000 network and any other network are involved in the execution of a service request. An IMT-2000 network should therefore be able to interwork with a wide range of existing and future partner networks and services such as other mobile networks, the Internet, ISDN, B-ISDN, PSTN, UPT, PDN, GII, etc.

7.2 Global roaming

7.2.1 General

The types of networks that are required to support NNI interconnections are as follows:

a) **Home network** is the IMT-2000 network which is related by subscription to the IMT-2000 user. It permanently holds location and service profile information related to the IMT-2000 user.

b) **Supporting network** is the network which provides support for a variety of services including, but not limited to, service logic programs and service-related data for IN supplementary services provided to IMT-2000 users.

c) **Visited (Serving) network** is the IMT-2000 network where an active IMT-2000 user is being served.

d) **Interrogating network** is the network from which a routing data retrieval request is sent to the Home network of the called IMT-2000 user.

e) **Destination network** is the network to which an outgoing call from an IMT-2000 user is destined.

f) **Previously Visited network** is the network where an IMT-2000 user was served before entering the Visited (Serving) network.

All the above mentioned networks are logical networks. Some or all of them can, for a specific traffic case, be the same physical network.

7.2.2 Interconnections

Interconnection between different IMT-2000 family member networks is required for the following purposes:

a) Establishment of calls and connections between different IMT-2000 family member networks (this includes calls by and to roaming users).

b) Transfer/retrieval of user and location data of roaming users (e.g. for location management procedures: location update, location registration, location cancellation).

c) Transfer of call detail records/charging related information of roaming users.

d) Support for a Virtual Home Environment.

e) Security monitoring to protect the internal network signalling, including policing of procedures, protocol stack termination, and interworking with internationally recognised signalling systems. This may be coupled with mutual authentication.

f) Transparent exchange of packet data between different IMT-2000 family member networks (this includes packets originated by and destined to roaming users).

g) Network interconnections to support the interaction between the UIM and *home* SCF.

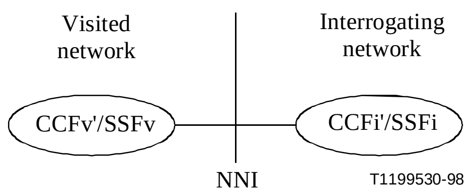
The network interconnection requirements for each of these purposes are treated in the following subclauses.

7.2.2.1 Establishment of calls and connections between IMT-2000 networks

For the establishment of calls and connections, interconnection between the call/connection control functions in different IMT-2000 networks is required. In addition, interconnection between IMT-2000 networks and networks for fixed communication is required.

Due to the mobility of the user, retrieval of location/routing data may be required prior to or during call set-up. The network interconnection required for this is treated separately in the next subclause.

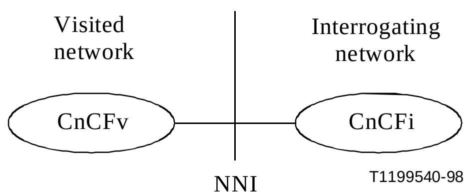
Figure 7-1 shows the network interconnection on a call control level. In the mobile originating case, the calls are established from the Visited network to any Destination network. In the mobile terminating case, the calls are established from the Interrogating network to the Visited network, however, one or more intermediate networks may be present, for instance if the Interrogating and Visited networks are not adjacent.



NOTE – In some cases, the Interrogating network could be the Home network.

Figure 7-1/Q.1711 – Network interconnection at call control level

For Alternative 2 of subclause 5.4 (Separated Call Control and Connection Control), a functional relationship between CnCFs is also needed. Similar to the call control level, different instances of the Connection Control Function are possible: the function resides in the *interrogating* CnCF (CnCFi) or in the *visited* CnCF (CnCFv). Figure 7-2 shows this interconnection.



NOTE – In some cases, the Interrogating network could be the Home network.

Figure 7-2/Q.1711 – Network interconnection at connection control level

7.2.2.2 Transfer and retrieval of user and location data

Between IMT-2000 networks, user profile data and location (routing) data are separated from normal call control. This supports the mobility aspect: user data can be transferred to and location data retrieved from a Serving network, enabling quicker call set-up, and user and location data can be retrieved independently of call control.

A) LMFv (Visited network) – LMFh (Home network) – Relationship

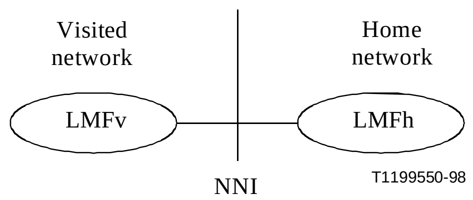


Figure 7-3/Q.1711 – Network interconnection for transfer of user data

Figure 7-3 shows an interconnection between a *home* LMF (suffix 'h') and a *visited* LMF (suffix 'v'). This type of interconnection is used in the following procedures:

Location registration/updating

The transfer and retrieval of location data is performed between the LMF in the Home network (LMFh) and the LMF in the Visited network (LMFv).

Transfer or retrieval of trigger/service profile data

The transfer and retrieval of trigger/service profile data is performed between the LMFh and the LMFv at location registration, when changes are made, or at the request of the home or visited system.

Retrieval of location and user data

The relationship between the home and visited LMFs may also be used for retrieval of previous location and user data (e.g. authentication data) in case an IMT-2000 user leaves the area controlled by the previously visited LMF.

Updating of user data

The updating of user data is performed between the LMFh and LMFv when profile changes are made, or at the request of the visited system, e.g.:

a) User identity data (e.g. IMUI);

b) VHE-related data;

c) Standardized service data.

B) LMFvn (New Visited network) – LMFvp (Previously Visited network) – Relationship

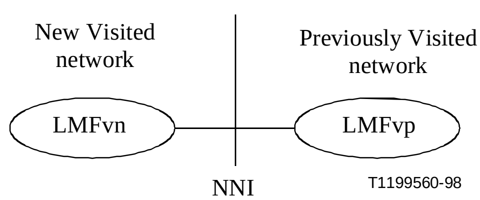


Figure 7-4/Q.1711 – Network interconnection for retrieval of user data

Figure 7-4 shows a network interconnection between the *previously visited* LMF (suffix 'vp') and the *new visited* LMF (suffix 'vn').This type of interconnection may be used for the following procedure:

Location updating

The transfer and retrieval of user information (e.g. IMUI and authentication data) from the LMFvp is performed when the user has roamed into an area controlled by the LMFvn.

NOTE – By retrieving user information from the LMFvp using the temporary identity, user integrity can be maintained. The alternative is also supported, meaning that the mobile terminal is requested to provide the full identity in clear text after which user information can be retrieved from the Home network using the relationship illustrated in Figure 7-3.

C) LMFvp (Previously Visited network) – LMFh (Home network) – Relationship

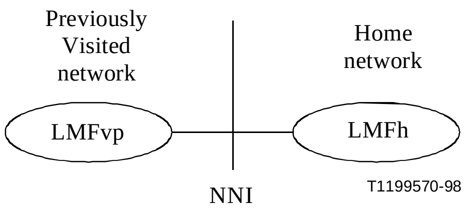


Figure 7-5/Q.1711 – Network interconnection for location cancellation

Figure 7-5 shows an interconnection between a *previously visited* LMF (suffix 'vp') and a *home* LMF (suffix 'h'). This type of interconnection is used in the following procedures:

Location and user data cancellation

The purpose of this process is to delete a subscriber's record (location and user data) from a previous LMF after he has registered with a new LMF. The procedure may also be used if the subscriber's record is to be deleted for other operator determined purposes, e.g. withdrawal of subscription, imposition of roaming restrictions or modifications to the subscription which result in roaming restrictions. Location cancellation can be used to enforce location updating including updating of subscriber data in the LMF at the next subscriber access.

7.2.2.3 Retrieval of user data for routing of calls

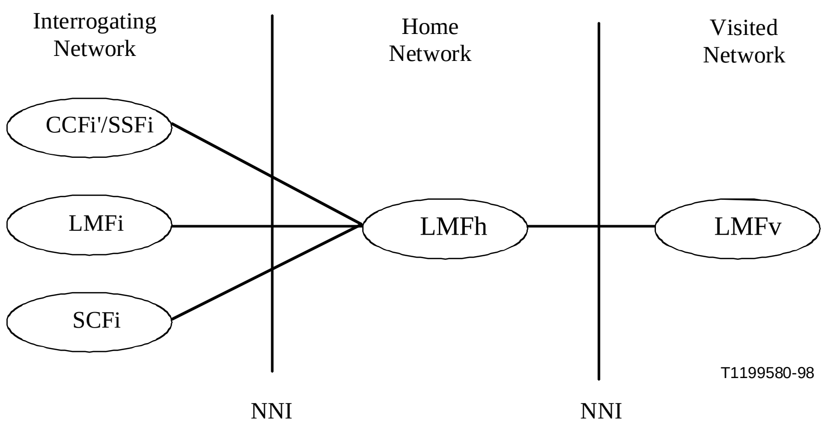


Figure 7-6/Q.1711 – Network interconnection for retrieval of data for routing calls

Figure 7-6 shows network interconnections between the *interrogating* LMF, CCF'/SSF, and SCF (suffix 'i'), the *home* LMF (suffix 'h'), and the *visited* LMF (suffix 'v') that are required for retrieval of routing and user data. Retrieval of routing and user data is necessary in the case of establishment of incoming calls to IMT-2000 users. This type of interconnection is used for the following:

1) The LMFi, CCFi'/SSFi, or SCFi may retrieve routing data from the LMFh. The LMFh may also provide trigger information to arm terminating triggers for the called party within the Interrogating network.

2) The LMFh retrieves more detailed routing information from the LMFv to be passed to the LMFi, CCFi'/SSFi, or SCFi.

7.2.2.4 Transfer of call detail records

Transfer of call detail records of users that roam outside their Home IMT-2000 network is required for:

a) Charging users for calls made in Visited networks;

b) Reimbursement of visited operators by the home operator for calls made by the home operator's customers in the visited operators' networks.

Transfer of call detail records is done at a TMN level. It is not discussed in detail here.

7.2.2.5 Virtual Home Environment

The VHE is a capability whereby a user is offered the same service experience in a Visited network as in one’s home system. The establishment of this concept realises that service provision and network operation may be separated, allowing services to the offered by networks other than those providing the home or visited call processing capabilities.

NOTE – The degree to which the VHE matches the actual home environment may be subject to, for example, the degree of cooperation between the Visited network and Home or Supporting networks, their relative technical capabilities and the compatibility of the user terminal.

7.2.2.5.1 Virtual Home Environment capabilities

The Virtual Home Environment supports:

- **Service transparency** between different IMT-2000 networks.
- **Transparent execution** of the "*Virtual Home Environment*" service features: the VHE service features are used by the mobile operators to provide more functionality to the mobile users than basic mobility. The services may be executed without necessary sharing of service and subscriber information to the visited mobile operator (except roaming agreements).
- **Customised services**: the means for network operators, service providers and users to define their own specific features/services.
- **A personalised service set** with user personalisation of features/services.
- **Service level**: It is desirable that the roaming mobile users will experience the same service level as within their Home networks (the Virtual Home Environment concept). Therefore, it is desirable that the services are provided transparently by the Visited networks.
- **Provisioning of subscriber specific services**: The mobile users may have custom demands for functionality from their home service providers. The Virtual Home Environment intends to make management access to customised services available to the mobile users when roaming.
- **Limited network load**: The current mobile networks already contain a considerable signalling load to handle a mobile call. This signalling is required to maintain the mobility information of the mobile subscriber up to date. Therefore, the signalling load of new

features must be limited as much as possible to ensure that the mobile network will not overload its signalling capacity.

- **Activation of mobile-related call events**
- **Performing charging activities**: The VHE may be able to exchange charging parameters between the home service provider and Serving (Visited) network. This exchange is required to have service capabilities such as advice of charge.
- **Performing in-band user interaction**: The VHE shall provide the capabilities to order the playing of announcements and tones towards calling/called subscribers during the call-setup, call disconnection, unsuccessful call establishment, and incoming call procedures.
- **Allowing subscriber interaction**: The subscriber should have control capabilities to activate/register/invoke supplementary services. The VHE should be able to add functionality to these supplementary service control mechanisms.
- **Interaction with the supplementary services**: The mobile network's ability to provide interaction with a number of supplementary services needs to be considered.

7.2.2.5.2 Virtual Home Environment scenarios

In this Recommendation two VHE scenarios are identified and described from their inter-networking implications perspectives and the location of the service control functionality. The Direct Home Command scenario, shown in Figure 7-7 and the Relay Service Control scenario shown in Figure 7-8, illustrate how the Virtual Home Environment concept can be supported. The Direct Home Command scenario may utilise the same IN procedures as in the transparent Relay Service Control.

Direct Home Command: This scenario calls for invocation of service logic to query for instruction/information to the SCFsn. In this scenario the pre-arrangement between the Supporting and the Home networks or between the Supporting and the Visited networks may need screening capabilities of triggering invocation.

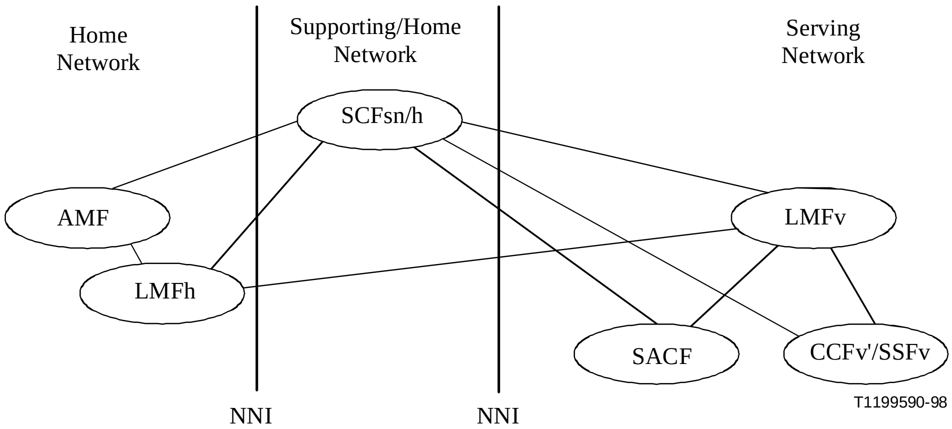


Figure 7-7/Q.1711 – VHE scenario: Direct Home Command

Relay Service Control: This scenario calls for the invocation of the service logic via the SCFh or SCFv to query for instruction/information from the SCFsn. In this scenario the pre-arrangement between the Supporting and the Home networks or between the Supporting and the Visited networks ranges from relaying, to security/screening capabilities, to shared service logic.

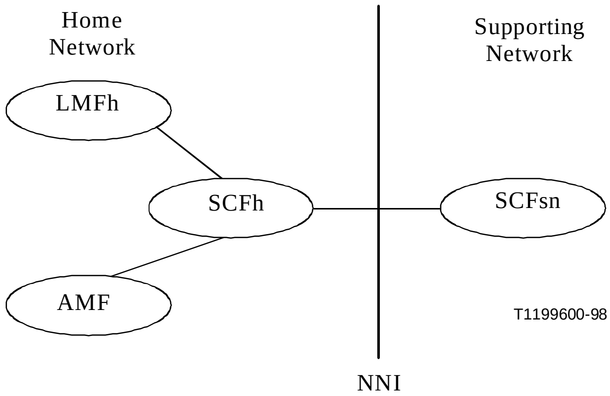


**Figure 7-8a/Q.1711 – VHE scenario: Relay Service Control
Mobility management triggers from Home network**

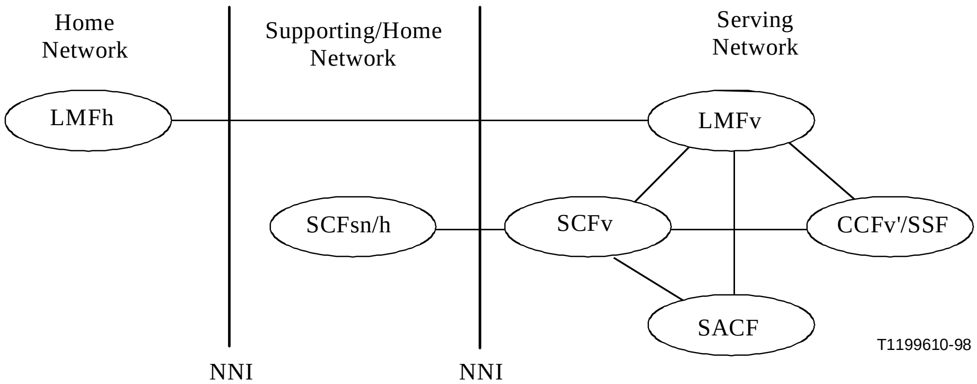


**Figure 7-8b/Q.1711 – VHE scenario: Relay Service Control
Call-related, call-unrelated, and mobility management triggers from Visited network**

7.2.2.6 Obtaining and transferring fraud/abuse control related data

Fraud/Abuse Control may be executed by a Service Logic Program (SLP) at an SCF. Events of interest may be reported to the SCF from the CCF'/SSF, LMF, AMF, or SACF. Figures 7-7 and 7-8 show the interconnections across the NNI which can be used for this event reporting. The triggers in the invoking FEs may be armed by the subscriber's profile or by the provisioning process for the FE.

When events of interest occur, they would be reported to the SLP interested in them. This SLP may be constructed to deal with certain real time events only, or monitor events across multiple calls to look for patterns, or both.

When a subscriber roams, the reporting of information for the events of interest would be handled by collecting the information in the Visited network and transferring it to the Home network as it is being obtained.

7.2.2.7 Network Interconnection for Packet Data Services

Figure 7-9 shows network interconnections between the PSGCF of IMT-2000 family network A and the PSCF of IMT-2000 family network B.

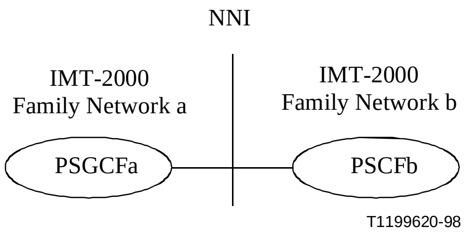


Figure 7-9/Q.1711 – Network interconnection for packet data services

The PSCF interacts with the PSGCF for:

- the provision of updates of the packet data service and routing context associated with a mobile terminal, and
- user data transfer between external packet data networks and the mobile terminal.

The PSGCF:

- routes and relays data packets transparently between other packet data networks and the PSCF according to the packet service and routing context associated with a mobile terminal;
- interacts with the Packet Service Control Function (PSCF) for updates of packet service and routing contexts;
- interacts with other packet data networks to provide a routing address to external packet data networks (such as Internet Protocol or X.25) to allow them to address a mobile terminal (e.g. an Internet Protocol address for Internet Protocol-based networks) or to provide route optimisation messages to an external packet data network controlling packet-data bearers to transport data packets between the PSGCF and PSCF.

7.2.2.8 Network interconnections to support the interaction between UIM and Home SCF

The interaction between the UIMF and *home* SCF for service control purposes will be supported across network boundaries. In this case the SACF or PSCF of the Serving network as well as the MCF or PSCAF support the transparent exchange of information between the SCFh and UIMF, for example to download and store service programs and/or application data.

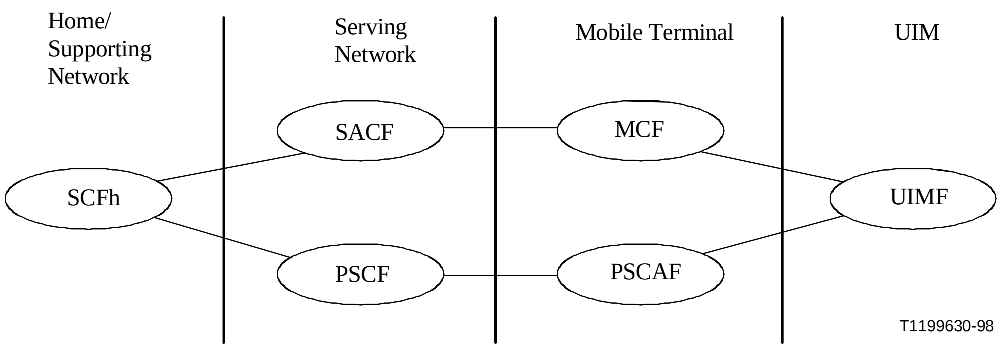


Figure 7-10/Q.1711 – Network interconnections: UIMF-SCFh relationships

7.3 Internet (Internet Protocol) interworking

Seamless packet data services and Internet access for IMT-2000 users require network interconnection and interworking of IMT-2000 family members.

The following requirements should be supported by IMT-2000 systems for Internet access:

- IMT-2000 packet data services should support mobile nodes regardless of whether their Internet Protocol addresses are assigned statically or dynamically.
- In particular, peer-to-peer communication of packet data users and mobile servers should be supported in either case.

Two scenarios illustrate access to the Internet from IMT-2000 networks. First, suppose a user starts a data session in a Visited network with a static (or dynamic) Internet Protocol address assigned by the Home network, as shown in Figure 7-11a. Registration is done by the LMFv and LMFh or by the PSCFv and LMFh (i.e. the VLR and HLR or the PDSN and HLR). Authentication is done by the AMF or PSCFv (i.e. the AC or PDSN). The LMF, AMF and PSCF may contain additional subscriber information such as service profiles. Internet Protocol packets destined to the user's Internet Protocol address are forwarded by the PSGCFh to the PSCFv, according to a routing context associated with the mobile terminal maintained in the PSGCFh. The routing context is established during the data user registration, and updated between the PSCFv and PSGCFh. In the reverse direction, the PSCFv may similarly transfer Internet Protocol packets to the PSGCFh, based on the routing context maintained by the PSCFv; the PSGCFh in turn passes on the packets to the final destination on the Internet. In this case, the extra step of transfer from the PSCFv to the PSGCFh may be required for reasons such as compatibility with *ingress* filtering operations (filtering based on packet's source Internet Protocol address) of firewalls or routers. In cases where such considerations are not a concern, the PSCFv may transfer packets to the Internet directly through the PSGCFv.

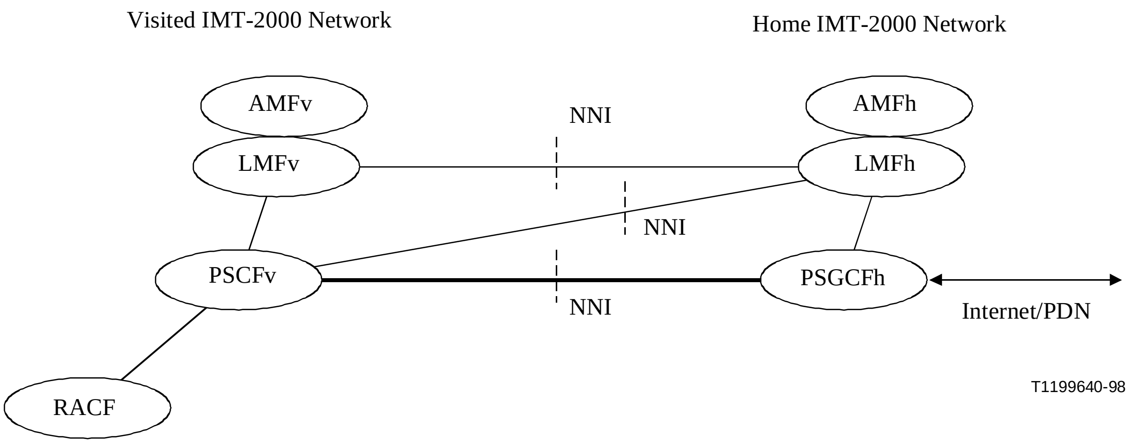


Figure 7-11a/Q.1711 – Network interconnection scenario I for IMT-2000 packet data services: Using Internet Protocol addresses (either static or dynamic) assigned by the Home network

If the user drifts to a new Visited network (i.e. moves from one Core Network to another), the routing context maintained in the PSGCFh is updated and Internet Protocol packets are forwarded by the PSGCFh directly to the PSCFvn (new Visited network), as shown in Figure 7-11b. In the reverse direction, the PSCFvn may transfer Internet Protocol packets to the PSGCFh as discussed in the previous paragraph.

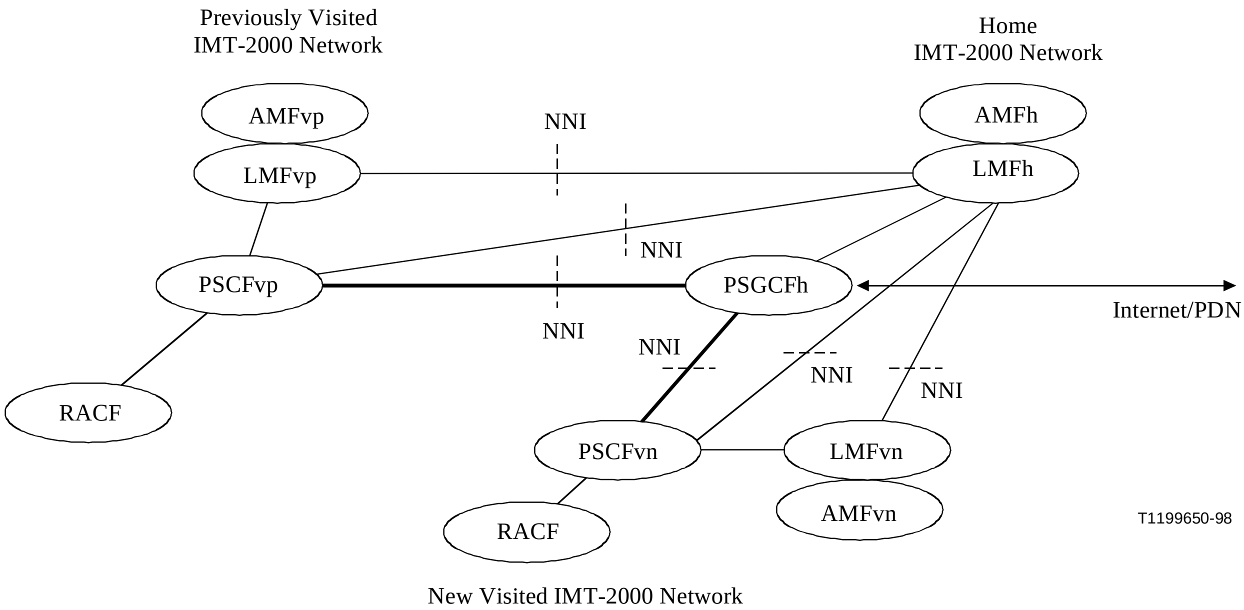


Figure 7-11b/Q.1711 – Scenario I continuation

For the second scenario, suppose a user starts a data session in a Visited network with a local Internet Protocol address assigned dynamically by the Visited network on a per-session basis, as shown in Figure 7-12a. The use of a dynamic Internet Protocol address local to the Visited network allows efficient local processing and routing, and conserves Internet Protocol addresses. Registration and authentication are as in the previous scenario. Access to and from the Internet is directly through the Visited network using the PSGCFv, without an extra step of Internet Protocol forwarding across the CN boundary as required in the previous scenario.

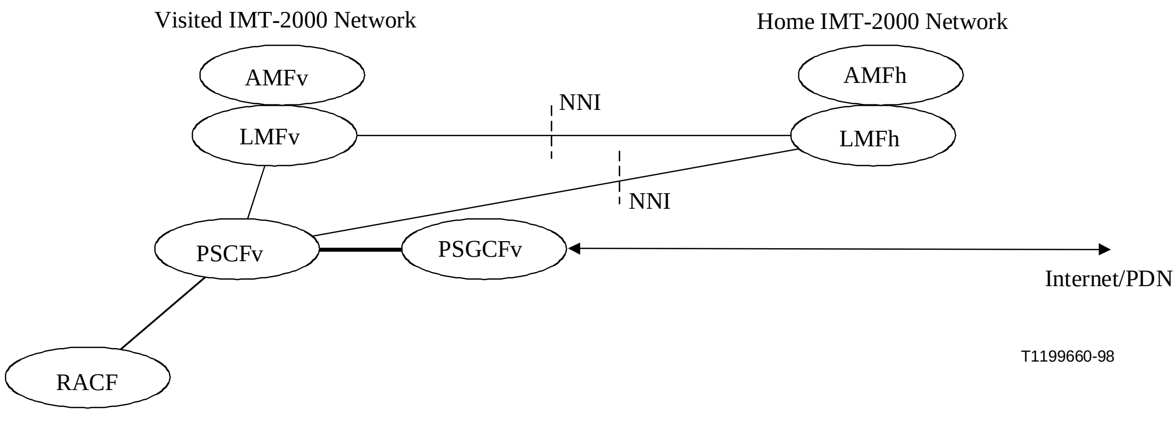


Figure 7-12a/Q.1711 – Network interconnection scenario II for IMT-2000 packet data services: Using temporary Internet Protocol addresses assigned dynamically by the Visited network

As the user drifts to a new Visited network (i.e. moves from one Core Network to another), Internet Protocol forwarding across the CN boundary between the PSGCFvp (previous Visited network) and the PSCFvn (new Visited network) may occur; this is shown in Figure 7-12b. Note that the LMFvn may retrieve user information directly from the LMFvp rather than from the LMFh, as discussed in Figure 7-4.

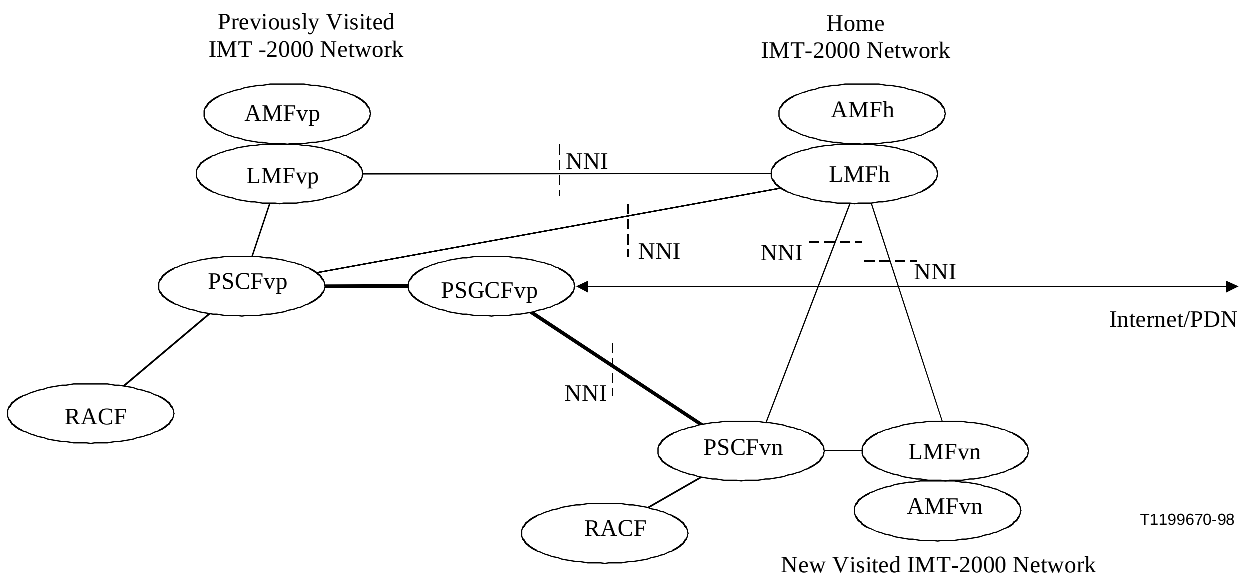


Figure 7-12b/Q.1711 – Scenario II continuation

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