3GPP TSG-T #7
Madrid, SPAIN
13-15 March 2000

TSGT#7(00)0027

Presentation of Specification/Report to TSG-T

Presentation to:	**TSG-T Meeting #7**
Document for presentation:	**TR 21.910, Version 2.0.0**
Presented for:	**Approval**

Abstract of document:

The present report deals with multi-mode UE related issues. This includes definitions of different types of multi-mode UE, scenarios for desired UE behaviour in specific situations and summary and evaluation of the work done on Multi-mode issues in other TSGs/working groups. Scenarios are described e.g. for start up, incoming connections, roaming and inter-system handover.

Changes since last presentation to TSG Meeting #6:

- Inclusion of text describing the ongoing work in other WGs, i.e. SA3-SA5, TSG CN and RAN3 and some evaluation of this work.
- The scenarios when different operators are running UMTS and GSM have been updated.
- Inclusion of a timestamp in the report to make the reader sure about that the content of the report is valid as of February 2000.
- Some identified further work.
- Editorial changes

Outstanding Issues:

None

Contentious Issues:

None

3G TR 21.910 V2.0.0 (2000-03)

Technical Report

3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) Terminals; Multi-mode UE issues

Reference
DTR/TSGT-0221910U

Keywords
Multi-mode UEs

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Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project, Technical Specification Group Terminals.

The contents of the present document may be subject to continuing work within the 3GPP and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released with an identifying change of release date and an increase in version number as follows:

Version m.x.y

where:

- m indicates [major version number]
- x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- y the third digit is incremented when editorial only changes have been incorporated into the specification.

Introduction

When UMTS is launched the coverage will be very limited in many areas while several second-generation systems will have a very wide coverage. To make UMTS useful for a wide range of users from the start, multi-mode UEs, combining e.g. second-generation radio access system with UMTS, are necessary. In the longer term, combinations with other radio access systems, such as HiperLAN or other cordless systems, could also be interesting and convenient. The present document describes all relevant issues concerning multi-mode UEs from a service and a terminal point of view.

1 Scope

The present 3GPP Technical Report identifies multi-mode User Equipments categories and describes the consequences on roaming capabilities and service availability (e.g. handover) of such multi-mode UEs while roaming in various regions implemented with various network configurations. The latter objective consists of case studies for each of the possible scenarios in reference to existing specifications. In these studies it has been important to make sure that no duplication of text has been made or that inconsistencies have been created between specifications.

The initial version of this TR is limited to UEs implementing release 99 of the various modes roaming in regions implementing specifications up to and including release 99 of the associated specifications (e.g. a rel 99 multi-mode UE in a release 97 GSM network should be covered).

In particular, the release 99 of this TR is focused on a type 2 UE, as defined in Ch. 4 in the present report. This type of UE can only camp on one cell and be in active communication in only one mode at the same time. When the UE is in active communication in one mode it should be able to listen to the other radio access technologies and make e.g. measurements reports on this radio access technology and send them to the network, but no simultaneous active communication should be possible.

The scope of this TR is the type of terminal implemented with at least the following modes:

- UTRA FDD and/or TDD mode
- GSM mode

The content of the scenarios could be used for other combinations of modes in a multi-mode UE. These are not considered in this version of this report.

Regarding the GSM mode, it encompasses the capabilities offered by the GSM technical specifications, i.e. MSC services, GPRS, EDGE. This means that the sub-categories as offered by GSM should be considered e.g. GPRS only terminals, circuit switched only terminal, dual capability terminals.

The present report is built on and references specifications/reports being produced in 3GPP or within other relevant foras e.g. ETSI SMG.

NOTE: The information collected in this document is reflecting the situation as of February 2000 and that is especially the case for Ch.7.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] 3G TS 22.135: "Multicall, Stage 1" v3.1.0

[2] 3G TS 25.303: "UE Functions and Interlayer Procedures in Connected Mode" v3.0.0

[3] 3G TR 23.920: "Evolution of the GSM platform towards UMTS" v3.1.0

[4] 3G TS 22.129: "Handover Requirements between UMTS and GSM or other Radio Systems" v3.2.0

[5] 3G TS 25.304: "UE Procedures in Idle Mode" v1.2.0

[6] 3G TS 23.121: "Architectural Requirements for Release 1999" v3.8.0

[7] 3G TR 21.905: "Vocabulary for 3GPP Specifications " v1.0.0

[8] 3G TS 22.101: “Service aspects; Service principles” v3.6.0

[9] 3G TS 22.100: “UMTS phase 1 Release 99” v3.3.0

[10] 3G TR 21.904: “Terminal Capability Requirements” v1.2.0

[11] 3G TS 21.111: “USIM and IC Card Requirements” v3.0.0

[12] 3G TR 25.942: “RF System Scenarios” v2.0.0

[13] 3G TS 25.103: “ RF Parameters in Support of Radio Resource Management” v2.0.0

[14] 3G T1 iWD-001: “Interim Working Document; Combined testing areas for RF and Signalling; Idle mode operations, handover and measurement reporting “ v0.2.0

[15] 3G TS 25.201: “ Physical layer - General description” v3.0.0

[16] 3G TS 25.215: “Physical layer – Measurements (FDD)” v3.0.0

[17] 3G TS 25.225: “Physical layer – Measurements (TDD)” v3.0.0

[18] 3G TS 23.009: “Handover procedures” v3.1.0

[19] 3G TS 23.022: “ Functions related to Mobile Station (MS) in idle mode and group receive mode” v3.1.0

[20] 3G TS 24.007: “ Mobile radio interface signalling layer 3; General aspects” v3.2.0

[21] 3G TS 24.008: “Mobile radio interface layer 3 specification, Core Network Protocols - Stage 3” v3.2.1

[22] 3G TS 23.060: “General Packet Radio Service (GPRS); Service description; Stage 2” v3.2.1

[23] 3G TS 27.060: “Packet Domain; Mobile Station (MS) supporting Packet Switched Services” v3.3.0

[24] 3G TS 27.001: “General on Terminal Adaptation Functions (TAF) for Mobile Stations (MS)” v3.3.0

[25] 3G TS 27.002: “Terminal Adaptation Functions (TAF) for services using asynchronous bearer capabilities” v3.2.0

[26] 3G TS 27.003: “Terminal Adaptation Functions (TAF) for services using synchronous bearer capabilities” v3.2.0

[27] 3G TS 33.102: “Security Architecture” v3.3.0

[28] 3G TS 32.102: “3G Telecom Management architecture” v3.0.0

[29] 3G TS 25.832: “Manifestations of Handover and SRNS Relocation” v3.0.0

[30] 3G TR 25.931: “ UTRAN Functions, Examples on Signalling Procedures” v1.2.2

[31] 3G TS 22.011: “ Service accessibility” v3.1.0

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions apply:

Active communication: a UE is in active communication when it has a CS connection established.. For PS active communication is defined by the existence of one or more Activated PDP contexts. Either one or both of the mentioned active communications may occur in the UE.

Camping on a cell: The UE is in idle mode and has completed the cell selection / reselection process and has chosen a cell. The UE monitors system information and (in most cases) paging information. Note that the services may be limited, and that the PLMN may not be aware of the existence of the UE within the chosen cell. [5]

Inter network handover: Handover between different radio networks, irrespective if within or between MSC or CN. [4]

Inter system handover: Handover between networks using different radio technologies, e.g. UMTS – GSM. [4]

Intra network handover: Handover within the same radio network. [4]

Multi-mode UE: UE that can obtain service from at least one mode of UMTS, and one or more different systems such as GSM bands or possibly other radio systems such IMT-2000 family members. [4]

Multicall: Multicall feature specifies functionality and interactions related to usage of several simultaneous bearers between a terminal and a network. Multicall features allows both circuit switched call(s) and packet session(s) to exist simultaneously.a function that makes it possible for a UE to have several CS and PS-connections/calls in active communication at the same time. For further description, please refer to [1].

Radio Access Mode: Mode of the cell, FDD or TDD [7]

Radio Access Technology: UMTS, GSM etc [7]

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CC	Call Control
CS	Circuit Switched
FFS	For Further Study
GMM	GPRS Mobility Management
HO	Handover
LA	Location Area
LU	Location Update
MM	Mobility Management
MMI	Man-Machine Interface
PS	Packet Switched
RA	Routing Area
RR	Radio Resource
RRC	Radio Resource Control
SM	Session Management
URA	UTRAN Registration Area

Additional definitions and abbreviations can be found in TR 21.905 [7].

4 General Aspects

A Multi-mode UE for UMTS and GSM/GPRS or other radio systems is considered to be a UE with at least one UMTS part (FDD and/or TDD) and with one part supporting some other radio system, e.g. GSM / GPRS. This is controlled by a common Interworking Unit which also controls one common MMI (keypad, display and menu functions). A reference configuration for Multi-mode UEs is shown in figure 1.

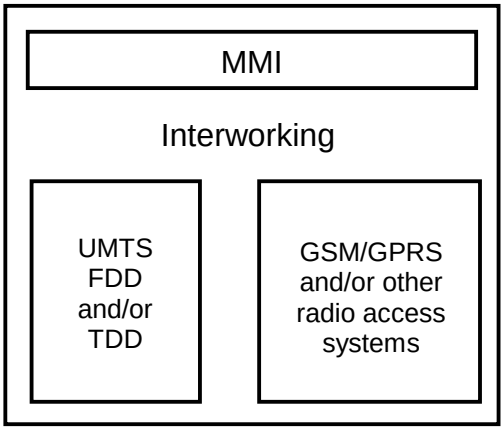


Figure 1: Reference configuration for Multi-mode UEs

Some parts in the UE, such as the microphone and the loudspeaker, could be reused by both the UMTS and the other radio access technologies parts or could be implemented separately. Integration of some RF parts is also foreseen.

The present document will mainly deal with the interworking between UMTS and 2nd generation access technologies, mostly GSM/GPRS, as much standardisation work considering the connection between these two radio access technologies is already done.

4.1 Types of UEs

In different situations, it is feasible to study the services considering different types of terminals. From a user and operator/service provider perspective it is also important that different types of terminals exist so that customers can be offered a great variety of services through the terminals.

NOTE: Even though four different types of UEs are described in this report, the main focus for R99 is the type 2 UE. The other types of UEs are described for possible inclusion in future releases of the 3GPP standards. For this to be possible the types of UEs have to be approved by SA and the implications of them onto the other work in 3GPP has to be studied. Some of this work has already started in chapter 7.

The type of subscription the user is having may affect the usage of types of UEs. In the present document it was decided to take this aspect into account when describing the scenarios (see clause 4.2). Table 1 is also describing some aspects of this question by mapping the registration procedure for the different types of UE.

For all types of UEs both manual and automatic switching should apply. Definitions on the different switching modes can be found below.

Manual Switching Definition

This operation is initiated by the user or defined by a user setting to allow the UE to scan for all the available radio access technologies and/or networks at predefined occurrences, e.g. when entering a new roaming area. The UE should present a list of the available networks and/or radio access technologies to the user for their selection of the network and/or radio access technology service. Registration to the new network and/or radio access technology cannot be done without the user's consent.

Automatic Switching Definition

The automatic switching will identify when at the necessary points in time when the UE should scan for other networks and/or radio access technologies and should register onto the preferred option. This can occur without the user's knowledge and the UE does not have to request the user's permission to change, add or remove a connection to a network and/or radio access technology.

4.1.1 Type 1

This type of UE can be described as two or more single-mode UEs in the same shell. The MMI for the different modes are the same but no other functions are shared between the different modes of the UE The UE can only camp on one cell and be in active communication in only one mode at the same time. An example of a combination of modes that could benefit from this type is a PDC/UMTS UE where the different radio access techniques are connected to different core networks. The user will then carry both UEs around but in one shell and when one mode is registered and in active communication the other is totally blocked.

No simultaneous activity is supported with this type of UE. No simultaneous mode connections are supported with this type of UE.

4.1.2 Type 2

This type of UE can be described as two or more UEs in the same shell. The MMI for the different modes are the same but no other functions are shared between the different modes of the UE The UE can only camp on one cell and be in active communication in only one mode at the same time. When the UE is in active communication in one mode the UE should be able to listen to all kinds of signalling from the other radio access technologies and make e.g. measurements reports on this radio access technology and send them to the network, but no active communication is possible. This will allow the UE to send measurement reports about another radio access technology through the active mode.

No simultaneous active communication is supported via multiple radio access technologies with this type of UE. No simultaneous mode connections are supported with this type of UE.

4.1.3 Type 3

Type 3 UEs can camp on different cells in several modes at the same time but active communication is only possible in one mode at the same time. When the UE is in active communication in one mode it can listen and respond to paging in the other mode. The UE can also be registered in several modes at the same time (may be applied when the modes are belonging to different operators/service providers).

The above description implies that simultaneous registration and simultaneous monitoring is supported. No simultaneous traffic is supported but the UE can initiate/receive connections in different modes sequentially.

NOTE: The requirements for type 3 are not finalised for R99.

4.1.4 Type 4

UEs of type 4 can camp on cells in several modes at the same time and also be in active communication in several modes at the same time. No switching between modes is necessary.

This implies that simultaneous registration, simultaneous activation, simultaneous monitoring and simultaneous traffic is supported.

NOTE: The requirements for type 4 are not finalised for R99.

In Table 1 the types of UEs are collected and pictured with respect to registration, paging and measurements. The table is divided into requirements for the UE and the network. In respect to the network the requirements are divided according to whether the same operator (PLMN) or different operators run the networks.

In the table, in the column with registration, the expression "available mode" is used and that means that the network only has to register the UE in those modes that the UE is capable of utilising.

The column with measurements means, for the UE the ability to do the measurements in other available modes/radio access technologies at the location. For the network the column means the ability to evaluate the measurements sent from the UE from different modes/radio access technologies. The operator that only runs one of the modes does not have to be able to evaluate the measurements from other radio access technologies.

Table 1: Requirements for types of UEs and networks according to registration, paging and measurements

			Registration	Paging	Measurements to provide handover between modes
Type 1	UE require-ments		Only in one mode	Receive only in the registered mode	Measurements only in the registered mode
	Network requirements	Same PLMN	Only in one of the modes	Transmitted only in the registered mode	Evaluate measurements from only one mode. No HO applicable.
		Diff. PLMN	Only in one of the modes	Transmitted only in the registered mode	Evaluate measurements from only one mode. No HO applicable.
Type 2	UE require-ments		Only in one mode	Receive only in the camped mode	Ability to measure in several modes, even when in active communication.
	Network requirements	Same PLMN	One registration valid in all available modes	Paging co-ordination required	Evaluate measurements from several modes
		Diff. PLMN	Only in one mode	Paging in the registered mode	Evaluate measurements from only one mode
Type 3	UE require-ments		One or several modes as required	Receive and answer paging in all camped modes	Measurements in all camped modes.
	Network requirements	Same PLMN	One registration valid in all available modes	Paging co-ordination not required	Evaluate measurements from several modes
		Diff. PLMN	One registration for each mode	Paging in the registered modes	Evaluate measurements from only one mode
Type 4	UE require-ments		One or several modes as required	Receive and answer paging in all camped modes	Measurements in all camped modes.
	Network requirements	Same PLMN	One registration valid in all available modes	Paging co-ordination not required	Evaluate measurements from several modes
		Diff. PLMN	One registration for each mode	Paging in the registered modes	Evaluate measurements from only one mode

5 Scenarios

This clause provides some scenarios describing the usage and behaviour of multi-mode UEs in special situations from a technical and service point of view. These scenarios will then be the guideline when over-viewing the work and identifying additional work.

NOTE1: This clause is a collection of ideas on how to make the usage of a multi-mode UE and the interaction with the network more effective.

NOTE2: Eventhough the type 2 UE is of highest interest and priority for R99 and this report, the scenarios for the other types of UEs are still included in this clause. They are there to give more clarification about the differences of behaviour between the types of terminals.

5.1 UMTS complemented with 2nd generation or another radio access technology from the same operator

This scenario describes the case when an operator operates an UMTS-network as islands in a sea of this operator's own 2nd generation network and/or in combination with another radio access technology. The user can be reached through the same MSISDN irrespective of which mode/radio access technology the user is registered in.

5.1.1 Power on

The network selection procedure should be based on the requirements in [8] and [31].

The procedures for power on are described in [5] and the text below is taken from that document:

> "When a multi-mode UE is switched on, it attempts to make contact with a public land mobile network (PLMN) using a certain radio access system.
>
> The particular PLMN to be contacted may be selected either automatically or manually.
>
> The UE looks for a suitable cell of the chosen PLMN and chooses that cell to provide available services, and tunes to its control channel. This choosing is known as "camping on the cell". The UE will then register its presence in the registration area of the chosen cell if necessary, by means of a location registration procedure."

The above description is only dealing with the PLMN selection. For selection of radio access technology the following procedure is suggested.

The UE should first search for networks in the radio access technology last used. If the last radio access technology is not present or no network is available within this radio access technology, the UE should search for other radio access technologies for suitable networks. For the choice of radio access technologies a preferred technology list should reside within the UE. This list could be changed by the user or the operator.

The UE should register through the access network chosen. This registration should also apply for the other radio access technologies belonging to the operator. When a location and/or routing update is made for one radio access technology it may apply for the others as well.

It should be possible to transfer UE capability information in connected mode as well as in idle mode.

There are no differences between UE types at Power on.

5.1.2 Incoming connection

5.1.2.1 UE type 1

5.1.2.1.1 Idle mode

If the incoming connection is in the registered mode the connection can be set up.

If the incoming connection belongs to another mode than the registered the connection can not be set up.

5.1.2.1.2 Active communication mode

The UE can only be reached in the registered mode and the connection can not be set up.

5.1.2.2 UE type 2

5.1.2.2.1 Idle mode

If the UE is in the right mode for receiving the connection, the connection can be set up. If the UE is in another mode than the incoming connection (e.g. the UE is in the 2nd generation mode but the incoming connection is a videoconference) the network should page the UE through the active mode and the connection can be set up in a suitable radio access technology.

The calling party should be informed only if the set up attempt fails or a degradation in the requested QoS of the connection has taken place (e.g. a videoconference has been degraded to a speech call).

5.1.2.2.2 Active communication mode

As this type of UE is just able to receive pagings and be in active communication in one mode at the same time, it would sometimes be desirable to page the UE through the active mode about an incoming connection in another mode. This could for example be the case if the UE is in active communication in a PS-connection (e.g. web-surfing in UTRAN) and the incoming connection is a CS-connection in another mode (e.g. a speech call in GSM).

For other situations, e.g. the UE is in active communication in one mode in UTRAN and the incoming connection is incoming in this radio access technology, the normal procedure for this mode should apply. For UTRAN multicall may for example be applied. [1]

5.1.2.3 UE type 3

This type of UE is most interesting when having different operators for the modes included in the UE. As this is the case the description of these situations can be found in clause 4.2.2..

5.1.2.4 UE type 4

5.1.2.4.1 Idle mode

The incoming connection can be set up.

5.1.2.4.2 Active communication mode

In most cases the incoming connection can be set up at once, but there might be some exceptions. One of them is when the incoming connection is in the same system as the active connection and the active system not is able to deal with several active connections at the same time. The incoming connection may then be re-routed to another mode so that both connections can be active at the same time.

5.1.2.5 Clarifying tables

When a user is moving around with a UE, different areas can be entered. Either an area with just UMTS or GSM coverage can be entered or an area where both radio access technologies are available. This is depicted in Fig. 1 and the areas are denoted:

A UMTS area with just UMTS coverage

B Common area where both UMTS and GSM is available

C GSM area with just GSM coverage

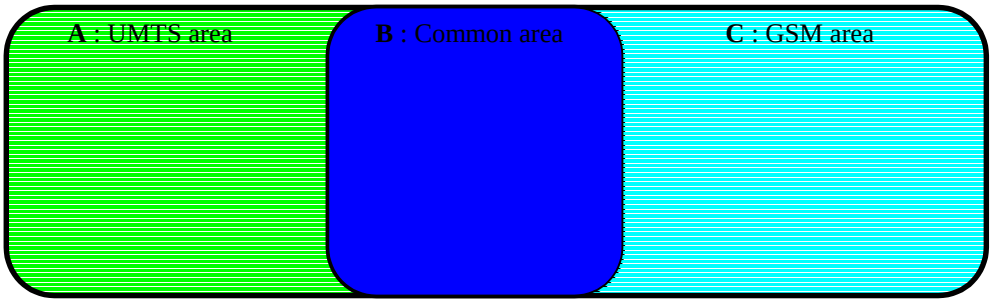


Figure 1: Service area

According to the UE types, described in section 4.1, the situation can be summarised as in Table 2. The table describes in which modes the UE can be registered and if it can be in active communication in just one, one at a time or both modes simultaneously.

Table 2 : UE situation

UE Type	Service area	Registered mode	Active communication modes
1	A	UMTS	UMTS
	B	UMTS or GSM	UMTS or GSM
	C	GSM	GSM
2	A	UMTS	UMTS
	B	UMTS or GSM	UMTS or GSM
	C	GSM	GSM
3	A	UMTS	UMTS
	B	UMTS and GSM	UMTS or GSM
	C	GSM	GSM
4	A	UMTS	UMTS
	B	UMTS and GSM	UMTS and GSM
	C	GSM	GSM

Table 3 describes the different situations when an incoming connection is received by a UE in active communication.

Table 3: The situation for a UE in active communication when receiving an incoming connection

UE mode		GSM								UMTS							
Connected mode		CS				PS				CS				PS			
Add connection from mode		GSM		UMTS		GSM		UMTS		GSM		UMTS		GSM		UMTS	
		C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P
Type	Service area																
1	A (UMTS)	-	-	-	-	-	-	-	-	X	X	O	O	X	X	O	O
	B (Common)	-	O	-	X	O	O	X	X	X	X	O	O	X	X	O	O
	C (GSM)	-	O	-	X	O	O	X	X	-	-	-	-	-	-	-	-
2	A (UMTS)	-	-	-	-	-	-	-	-	X	X	O	O	X	X	O	O
	B (Common)	X	O	S	S	O	O	S	S	S	S	O	O	S	S	O	O
	C (GSM)	-	O	X	X	O	O	X	X	-	-	-	-	-	-	-	-
3	A (UMTS)	-	-	-	-	-	-	-	-	X	X	O	O	X	X	O	O
	B (Common)	X	O	S	S	O	O	S	S	S	S	O	O	S	S	O	O
	C (GSM)	-	O	X	X	O	O	X	X	-	-	-	-	-	-	-	-
4	A (UMTS)	-	-	-	-	-	-	-	-	X	X	O	O	X	X	O	O
	B (Common)	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
	C (GSM)	-	O	X	X	O	O	X	X	-	-	-	-	-	-	-	-

C= circuit switched
P= packet switched
- = not possible
X= possible if direct re-direction of the connection in the CN. Applicable both for connections and signalling.
O= added connection OK if the UE can support it and the network allows it

S= the UE can be paged in the mode of active communication about the connection. For S to be possible the operators should have the different radio access technologies in their network. Changing of modes depends of the setting of the UE. (manually/automatically switched).

For idle mode the table becomes much simpler. Only two situations when the incoming connection can not be received are identified, and these are when a UE of type 1 and 2 is used and the incoming connection not is in the registered mode.

Table 4: The situation for a UE in idle mode when receiving an incoming connection

Registered mode Incoming connection	GSM		UMTS	
	GSM (CS or PS)	UMTS	GSM (CS or PS)	UMTS
Type of UE				
1	OK	X	X	OK
2	OK	X	X	OK
3	OK	OK	OK	OK
4	OK	OK	OK	OK

X= only possible if paged through the registered mode and re-routed to this radio access technology.

5.1.3 Outgoing connection

When initiating a connection, the chosen service may affect the choice of mode. The service may just be supported in one mode or the capabilities for the service may be better in a specific mode.

5.1.3.1 The UE in idle mode

If the appropriate mode for this connection is present, the connection can be set up. If a service is required by the user that the registered mode does not support or have limited support to, the network should hand over the UE to the radio access technology that supports the requested service. This means that the UE requests the call in the mode in which it is registered and the network hands it over to the mode that supports the service.

If the necessary mode is not present, the service may be connected with limited capabilities in the present radio access technology.

One exception from this may be with usage of UE of type 1. As the UE is not able to make measurements in other modes when registered in one mode, it is not possible for this type of UE to scan its surroundings. A handover is therefore in this case not applicable. Then it might be better to set up the connection with limited capabilities, as the latter suggestion above describes.

5.1.3.2 The UE in active communication mode

5.1.3.2.1 UE type 1

No more outgoing connections, belonging to different modes, can be set up.

5.1.3.2.2 UE type 2

No more outgoing connections, belonging to different modes, can be set up.

5.1.3.2.3 UE type 3

In some cases it might be desirable to put the active connection on hold to set up another connection for a while. An example of this is when the UE is busy with a data session in one mode and the user wants to make a speech call in another mode. The data connection can then be set on hold to make the user able to perform the speech call and after that resume the data session.

5.1.3.2.4 UE type 4

The connection can be set up.

5.1.4 Inter-system handover

This is the only handover that is interesting for the present document. Other transactions such as to/from idle mode and to/from multicall are not considered in the present document, see Annex A1

Handover may be initiated by:

- A service demanding a specific mode
- The UE losing coverage of the active mode
- The UE coming into coverage of a higher preferred mode, e.g. LSA concept
- The operator changing the mode of usage due to traffic reasons
- The preference list prioritising another than the present mode higher, e.g. GSM mode is prioritised higher than UMTS

The procedure of initiation for an handover either comes from the network or the UE. In [6], a handover between GSM and UMTS for a CS service is always network initiated whether the handover is from GSM to UMTS or not. On the other hand handover between GSM and UMTS for a PS service can be either network or UE initiated.

5.1.4.1 Inter-system handover versus service availability

The availability of services in case of a handover between UMTS and GSM depends on the capabilities of the UE. The tables below, Table 5 and Table 6, tries to summarise several different situations for handover and what the impact on different services, such as speech and data services, are.

In the tables only a type 2 multi-mode UE is considered. The other types of UEs are FFS.

The terminal configuration describes the support of services in the available modes in the UE, e.g. the GSM CS means that the GSM part of the UE does not support PS connections.

Table 5: UMTS to GSM handover

Multi-mode UE Type 2 configuration	Active communication in UMTS mode to be handed over		
	CS services	PS services	CS+PS services (simultaneously)
UMTS CS/PS + GSM CS	X	Dropped	CS - X PS - dropped
UMTS CS/PS + GPRS class C	X (If CS is supported in GSM mode)	X	One of the active communications (CS or PS) will be dropped, subject to user or network preferences.
UMTS CS/PS + GPRS class B	X	X	One of the active communications (CS or PS) will be dropped, subject to user or network preferences.
UMTS CS/PS + GPRS class A	X	X	X

X - The service and the active communication will be maintained through handover even though the change in e.g. service capabilities (e.g. speech codecs), data rate or QoS may be apparent to the user.

NA – not applicable

Table 6: GSM to UMTS handover

Multi-mode UE Type 2 configuration	Active communication in GSM mode to be handed over		
	CS services	PS services	CS+PS services (simultaneously)
GSM CS + UMTS CS/PS	X	NA	NA
GPRS class C + UMTS CS/PS	X (If CS is supported in GSM mode)	X	NA
GPRS class B + UMTS CS/PS	X	X	NA
GPRS class A + UMTS CS/PS	X	X	X

X - The service and the active communication will be maintained through handover even though the change in e.g. service capabilities, data rate or QoS may be apparent to the user.

NA – not applicable

5.1.5 For mobility management

While registered to a specific radio access technology, all MM procedures of that system should apply.

A LU from one radio access technology may be made valid for other radio access technologies as well.

Combining LU for different modes, e.g. the UE is registered in GSM and UTRA but still it is enough with one LU, is very desirable.

Combined LA/RA or signalling between entities that makes it possible to direct a connection or ask the UE/user to change mode is desirable.

5.1.6 Roaming

When roaming, mode should be chosen according to the preferred and forbidden network lists. The requirements for network selection can be found in [8] and [31].

For the procedure of radio access mode selection and reselection it is assumed that the UE frequently searches for available radio access technologies/PLMNs. The procedure may differ between types of UEs and operators.

After a registration in a desired mode (depending on the user settings for preferred mode/network), the UE should stay in this mode unless a mode selection/reselection is initiated either by the UE or the network, the network is lost or a certain service that requires a specific mode is chosen.

If the UE is set to automatic mode search and it is registered in a not preferred mode, i.e. at a low priority in the preferred mode list, the UE should switch to another mode, as soon as the more preferred mode is available.

5.1.7 Loss of coverage

When the UE is beginning to lose coverage it has to search for new networks to camp on.

To get the knowledge of other modes, two principles can be applied. Either the network tells the UE to make a scanning of the surroundings to search for another mode that is available or the UE continuously searches for other modes and tells the network when an interesting mode is becoming available.

For the first alternative, knowledge of the different modes and the locations of their cells have to reside within the network.

With the last alternative, the search may be restricted to be performed if the UE not is camping on and is registered in the highest prioritised network/mode.

If the network is lost, the UE should search for a suitable network within the same radio access technology first (presuming the user has set the UE to automatic switching with a preferred network list).

5.2 UMTS and 2nd generation or another radio access technology operated by different operators.

This scenario describes the case when the UMTS operator does not operate a 2nd generation system but has to rely on roaming agreements.

For this situation most of the things mentioned in the above chapters can be applied. The main differences often reside within the network and the behaviour of the UE is the same. Just the differences will be marked out in this chapter.

Even so, a type 3 UE might be the most appropriate type of UE to use when choosing different operators for the various modes and therefore this section is concentrated on this type of UE, if nothing else is stated. For behaviour for registration, paging and measurements, please refer to Table 1.

5.2.1 Power on

A type 3 UE may in this procedure be able to register in several modes if they are available at the location.

This may apply even for a type 4 UE.

5.2.2 Incoming call/connection

5.2.2.1 UE type 3

When this type of UE is in active communication, it can receive and answer pagings in the mode(s) that is not in active communication. This implies that an indication can be given to the user that an incoming connection exists in another mode and the user can then choose to set up this connection or resume to the connection already in active communication. During this procedure the active connection will be suspended. If the user chooses to accept the incoming connection, a hand over to the mode where the incoming connection resides should be made.

5.2.3 Outgoing connection

5.2.3.1 The UE in idle mode

For a type 3 UE there is no problem reside and the connection can be set up.

For a type 2 UE the mode(s) not utilised for a connection has to be de-registered before the connection can be set up. This procedure may not be able to fulfil the time requirements for set up of a connection, and therefore it might not be applicable to utilise this type of UE for the scenario of different operators.

5.2.3.2 The UE in active communication mode

No differences from the scenario with same operators have been found.

5.2.4 Roaming

When the UE comes into an area where no mode of the users own operator is present, a mode of another operator has to be chosen. The roaming agreements between operators should be the basis of the preferred network/PLMN lists.

5.2.5 Inter-system handover

The inter-system handover in this case requires roaming agreements between the different operators. If there are no roaming agreements, the handover can not be done.

5.2.6 For mobility management

The mobility management may here be duplicated if the various operators do not have roaming agreements that allows them to exchange this kind of information.

5.2.7 Loss of coverage

Just one of the procedures described in the previous chapter (5.1.7) is feasible in this case. The feasible procedure is that the UE continuously searches for available networks and tells the network about its results.

5.3 Evaluation

Most work associated with handover between UMTS and GSM/GPRS is already initiated in the standardisation. The work progresses but it is not sure that it will be finalised for R99.

Two independent search mechanisms are needed:

- Manual/automatic radio access technology search with a preferred radio access technology list
- Manual/automatic network search with a preferred network list / forbidden network list

A function residing within the network that gives the operator the opportunity to move the user/UE from one mode to another is desirable within the network.

An entity that keeps track of in which radio access technology the UE is camping or in active communication for the moment is also desirable.

6 Identities

For a multi-mode user it is desirable to be able to be reachable by the same MSISDN. How the treatment (e.g. in what entity the identities will be combined) and signalling of these multiple identities are interesting and important questions for a multi-mode UE usage. Even so they are not treated in this version of the report.

7 Ongoing work and identified additional work

This section tries to collect all relevant documents related to multi-mode UE issues and reviews the multi-mode UE aspects in them. In some cases additional work has been identified.

The list of document may not be complete but more relevant documents might reside within the group.

7.1 TSG SA

In SA there is one document that collects all requirements for R99 that are set by the different WG:s within SA, TS 3G 22.100 [9]. The requirements on Multi-mode UE:s can be found in ch 8 and reads as follows:

> "UMTS phase 1 shall support dual mode UMTS/GSM terminals. At least one Capability Class shall be standardised for mobile terminals supporting the GSM and UTRA modes. It shall support monitoring of cells belonging to the two types of access networks in idle mode (cell reselection procedure) and active mode (handover preparation procedure)."

This corresponds to a type 2 UE as defined in this report. The requirement does not exclude any other types of terminals as those defined in this report

7.1.1 SA1

7.1.1.1 Service requirements

The service requirements for release 99 is collected in TS 3G 22.101 [8]. The requirement related to Multi-mode UE:s can be found in ch. 17 (Handover requirements) and ch 18 (Network selection).

The handover requirements are very general and states that:

> "Any handover required to maintain an active service while a user is mobile within the coverage area of a given network, shall be seamless from the user's perspective. However handovers that occur between different radio environments may result in a change of the quality of service experienced by the user.
>
> It shall be possible for users to be handed over between different UMTS networks subject to appropriate roaming/commercial agreements.
>
> Handover between UMTS and GSM systems (in both directions) is required, even if this requires changes to GSM specifications. In addition, a generic solution may be implemented in UMTS which allows calls to be handed over between UMTS and other pre-UMTS systems in both directions."

The initial requirements for network selection that are relevant for Multi-mode UE:s are:

> "Three roles may be involved in UMTS network selection: the home environment, the serving network and the user. Services may be available to the user through a choice of several serving networks in a given location, possibly using different types of Radio Access Network. However it is expected that a user terminal will communicate with one network at a given instant (there may be exceptions such as when an inter-network handover occurs). "

Even more relevant for the UE and user is how the network selection shall be performed. For that three selection procedures are defined: a default automatic procedure, a manual procedure and a home environment specific procedure. The first two shall be implemented in all UMTS UE:s. As the multi-mode UE defined in this report shall include UMTS, these requirements is valid also for a multi-mode UE. This is also stated in this report for all types of UE:s and can be considered to be in line with the requirements.

A requirement that may affect the specified types of UE in this report is:

> "If simultaneous access to more than one home environment is required (through a card with multiple USIMs or through several cards in a multi-slot terminal), manual selection shall be invoked."

The type 3 UE should be able to camp on several cells from different radio access technologies that are belonging to different operators/PLMN:s at the same time and still an automatic switching between modes are defined for this types of terminal. This has to be considered in later releases of the report. Either the definition of this type of terminal has to be changed or the requirement has to change. The type 3 terminal is not of highest priority for R99 and therefore this is left FFS.

7.1.1.2 Handover requirements

TS 3G 22.129 [4] is a specification that only deals with handover requirements, both within UMTS and between UMTS and GSM. The requirement for handover from UMTS to GSM can be found in clause 6 and the requirements for handover from GSM to UMTS can be found in clause 7.

The requirements for handover from UMTS to GSM are divided into operational, performance and service requirements. The requirements most affecting the UE are those in the performance clause, which include Detection Time of Potential GSM Handover Candidates, Number of GSM handover candidates to detect, Probability of Connection Loss and Temporary degradation of service caused by handover. As a summary it can be said that the requirements that is set for intra-GSM handover shall be applied even when handover from UMTS to GSM. More stringent requirements than that are not set. These requirements mostly affects the radio part of the Multi-mode UE and some of the specifications for that can be found in clause 7.2 in this report.

In the clause with service requirements there are no specific requirements except for the speech, USSD and data bearer service. These services should be continued after a handover. An example of a service that may be interrupted after a handover is the facsimile service.

For the speech service it is said:

> "any call based on the default UMTS speech codec shall be mapped to the FR GSM speech codec. In the case the terminal and the GSM network support AMR and /or EFR and/or HR, it shall be the operators choice to define the appropriate mapping."

For USSD it is said:

> "The technical standards shall provide means to ensure that any handover that occurs during a USSD interaction need no more affect the service than intra-GSM handover."

For the data bearer service it is said:

> "Standards shall be defined to permit the possibility of handover of a UMTS connection oriented data bearer service to GSM which shall result in an appropriate GSM/GPRS bearer service. The mapping between UMTS data bearer services and appropriate GSM/GPRS data bearer services will depend upon many factors such as data rate, delay constraints, error rate etc. Means shall be provided for the application to indicate minimum acceptable QoS for service continuation after handover."

In the clause with requirements for handover from GSM to UMTS mostly just requirements for services are dealt with. The services that should continue after a handover are speech, USSD, a circuit switched data service mapped onto a

UMTS packet switched data service and a data switched packet service (if not the change of QoS is too big to be accepted by the user).

When using multiple bearer services in GSM/GPRS it is said that:

> "Consideration must be given to multimedia services which may involve the use of multiple bearer services. For example Class A GPRS terminals will be capable of simultaneously supporting more than one data bearer services. The mapping between GSM/GPRS data bearer services and UMTS bearer services will depend upon many factors such as data rate, delay constraints, error rate etc. Means shall be provided to allow handover of several data bearer services from GSM to UMTS. Means shall be provided for the application(s) to indicate minimum acceptable QoS for services continuation after handover."

These service requirements shall apply for all multi-mode UE:s that supports these kind of services.

7.1.2 SA2

7.1.2.1 Architectural requirements on UMTS for release 99

3G TS 23.121 [6] describes the architectural requirements on UMTS for release 99.

This specification divides connections into if they are in the CS or in the PS domain. The division between GSM and UMTS radio access technology is not so obvious for the core network. From an architectural point of view the division between the CS and PS domain are more important.

Data retrieval between UMTS and GPRS is dealt with in ch. 4.2.2.1. There is even a proposed solution how it shall be done.

The MM procedures for UMTS are described in section 4.3. In section 4.3.1.1 there is a requirement for the R99 UE to support both combined and separate update mechanisms between CS and PS services. The background is that in GSM/GPRS combined updates between RA and LA can be made via the Gs interface between MSC/VLR and SGSN. This possibility is facilitated to optimise the radio resources. As said before, in UMTS it is suggested to use both separate and combined updates for R99 UE:s.

In ch 4.3.14.3 there is a small comparison between MM for UMTS and GSM. The reason for the comparison is to see if the same signalling can be used and how the MM messages should be transferred when handover. If a combined update between GSM and UMTS can be done is in a way studied in [3] as described further down.

Chapter 6 is totally devoted to the questions on interoperability between GSM and UMTS. In the beginning a recommendation of combined updates if a UE is supporting simultaneous ISDN/PSTN and packet services is made. Otherwise the chapter deals with the signalling procedures for handover between UMTS and GSM. The only thing that is affecting the terminal is where the decision of the handover is performed. For CS services the decision is taken in RNS for UTMS to GSM handover and in BSS for GSM to UMTS handover. For PS services the decision can be made in either the UE, the BSS or in the SRNS. This applies for both directions of handover. In this case the details for how the decision shall be made is FFS.

7.1.2.2 Additional architectural requirements

3G TR 23.920 [3] collects architectural requirements that are not yet accepted or stable enough to be included in the other architectural specification, 23.121.

A small section on the procedures for ciphering keys is included in ch. 5.5.2 and deals with the case of UMTS-GSM handover. The actual interoperation in the case of different ciphering keys for UMTS and GSM are for further study. This does not directly affect the UE but rather the USIM.

Dual-mode operation between UMTS and GSM when the GSM part of the UE is a MS of GPRS class A is handled in chapter 5.8. The section deals with questions of MM procedures and availability of PS services after a handover of a CS service from one of the radio access technologies to the other. The suggestions include letting the UMTS MM to do distinction between CS and PS services in the registration related procedure. The requirements on the MS/UE are that it must be capable of handling the GSM-UMTS dualism, i.e. to be a multi-mode UE.

The UMTS Mobility Management (UMM) for R99 shall use packet anchoring at the GGSN. This implies that some changes have to be introduced in GPRS. In section 5.9.5.4 the affects the requirements of QoS when using the anchor

concept and the UE/MS described above (a dual-mode UE with a UMTS part that supports simultaneous CS and PS services combined with a GPRS class A MS) is described. There are no specific requirements on the multi-mode UE and all suggested changes reside in the network.

A definition on simultaneous mode has been made in chapter 5.17. It is defined as:

> "Simultaneous mode is defined as the support of active parallel CS and PS communications.
>
> The UE has simultaneous PS MM Connected and CS MM Connected states when in UE simultaneous mode."

In this section it is also stated that it is important that from day one of UMTS launch supply terminals that supports simultaneous active communication with both the CS and the PS domain. This requirement only applies for and within UMTS but puts special requirements on the UE in respect to terminal capabilities.

Chapter 5.18 deals with the question on GSM and UMTS cells in the same registration area. This could save a lot of signalling when changing between UMTS and GSM, as also described and asked for in the scenarios (chapter 5.1.5). One reason for introducing this is, as stated in [3], that:

> "Third generation needs to offer higher quality (eg higher MT call success rate) than second generation. Hence the capability to have GSM and UMTS cells in the same Registration Area is needed for at least CS traffic."

Some open issues still reside for implementing GSM and UMTS in the same registration area and these are questions on security, network service capabilities, terminal capabilities, idle mode control and the capacity of paging channels, as described in [3].

7.1.3 SA3

In SA3 there has been discussion on the issue of fraud in the event of intersystem HO/intersystem change 3G-2G and vice versa. The possibility of the end-user to affect the change of system, to log the HO and to choose whether HO overall is possible. These issues are still under discussion.

7.1.3.1 TS 33.102; Security Architecture V3.3.0

TS 33.102 [27] describes the security features and the security mechanisms for 3G. The section interesting to multi-mode UE issues is section **6.8 Interoperation and handover between UMTS and GSM**, intersystem handover for CS services from UTRAN to GSM BSS and vice versa is described as is also intersystem change for PS services.

Section 6.8.3 Intersystem handover for CS Services-from UTRAN to GSM BSS

There are two handover cases distinguished: 1) Handover to a GSM BSS controlled by the same MSC/VLR and 2) handover to a GSM BSS controlled by another MSC/VLR. For these two handover cases it is explained how the UE derives and applies the GSM cipher key Kc for UMTS and GSM security contexts respectively.

Section 6.8.4 Intersystem handover for CS Services-from GSM BSS to UTRAN

Here there are also two handover cases distinguished: 1) Handover to a UTRAN controlled by the same MSC/VLR and 2) handover to a UTRAN controlled by another MSC/VLR. For UMTS security context the UE applies the stored UMTS cipher/integrity keys CK and IK and for the GSM security context the UE derives the UMTS cipher/integrity keys CK and IK and applies them.

Section 6.8.5 Intersystem change for PS Services-from UTRAN to GSM BSS

For UMTS security context there are three cases distinguished: 1) Handover to a GSM BSS controlled by the same SGSN, 2) handover to a GSM BSS controlled by another R99+ SGSN and 3) handover to a GSM BSS controlled by a R98- SGSN. At the user side in cases 1) or 2) the UE derives the GSM cipher key Kc from the stored UMTS cipher/integrity keys CK and IK and applies it. In case 3) the handover makes that the UMTS security context between the user and the serving network domain is lost. **The UE needs to be aware of that.** The UE then deletes the UMTS cipher/integrity keys CK and IK and stores the derived GSM cipher key Kc.

NOTE Case 3) makes a special demand on the UE, when the UMTS security context is lost. There has to be taken steps to make sure that the UE is implemented to work right in this case SWG5 should clarify if SA3 or T2 is responsible for the right implementation.

For GSM security context two cases are distinguished: 1) handover to a GSM BSS controlled by the same SGSN 2) handover to a GSM BSS controlled by another SGSN. In both cases the UE applies the GSM cipher key Kc that is stored.

Section 6.8.6 Intersystem change for PS services-from GSM BSS to UTRAN

For UMTS security context two cases are distinguished: 1) handover to a UTRAN controlled by the same SGSN 2) handover to a UTRAN controlled by another SGSN. In both cases the UE applies the stored UMTS cipher/integrity keys CK and IK.

For GSM security context two cases are distinguished: 1) handover to a UTRAN controlled by the same SGSN 2) handover to a UTRAN controlled by another SGSN. In both cases the UE derives the UMTS cipher/integrity keys CK and IK from the stored GSM cipher key Kc and applies them.

7.1.4 SA4

SA4 is working on codecs and nothing specific for multi-mode UE issues was found in the documents of SA4.

7.1.5 SA5

7.1.5.1 TS 32.102; 3G Telecom Management architecture V 3.0.0

TS 32.102 [28] deals with the physical architecture for management of UMTS. In section 7.3.1 in figure 2 an overview of the UMTS network element management domains and interfaces is shown. Itf-T is the interface between a terminal and a NE Manager. This interface will in some extent manage the 3G terminal and the USIM of the subscriber. Requirements of this interface are for further study.

7.2 TSG RAN

7.2.1 RAN1

7.2.1.1 Physical layer – general description

The specification 25.201 [15] is the general description of the physical layer in UTRAN.

In chapter 4.2.5, Physical layer measurements, it is stated that the UE shall be able to perform:

"2) The measurement procedures for preparation for handover to GSM900/GSM1800;"

It also gives an overview of all the other documents produced within RAN1. The documents described below are the most relevant from a multi-mode UE perspective.

7.2.1.2 Physical layer – Measurements (FDD)

TS 25.215 [16] describes the measurements on the physical layer for the FDD mode.

The scope is to establish the characteristics of the physical layer measurements in the FDD mode, and to specify:

- the measurements that Layer 1 is to perform;
- reporting of measurements to higher layers and network;
- handover measurements, idle-mode measurements etc.

Chapter 5.1 describes the measurement abilities for the UE. Among them we have the GSM carrier RSSI which is defined as:

"Received Signal Strength Indicator, the wide-band received power within the relevant channel bandwidth. Measurement shall be performed on a GSM BCCH carrier. The reference point for the RSSI is the antenna connector at the UE"

UTRAN carrier RSSI is also described in a similar way to the GSM carrier RSSI, as the specification is made for the UTRAN.

The compressed mode, making it possible for the UE camping or in active communication in UMTS, to make measurements in other radio access modes/technologies is described in chapter 6.

These measurements are in line with the, in the present report, definition of a type 2 UE.

7.2.1.3 TS 25.225: Physical layer – Measurements (TDD)

TS 25.225 [17] describes the measurements on the physical layer for the TDD mode.

The scope is to establish the characteristics of the physical layer measurements in the TDD mode, and to specify:

- the measurements that Layer 1 is to perform;
- reporting of measurements to higher layers and network;
- handover measurements, idle-mode measurements etc.

The general measurements concept can be found in chapter 4.1. Chapter 4.2 is describing the measurements for cell selection/re-selection and chapter 4.3 is describing the measurements for handover.

The UE measurement ability is described also in chapter 5.1, including the GSM carrier RSSI. In this chapter an Observed time difference to GSM cell is also defined as:

"Time difference between the Primary CCPCH of the current cell and the timing of the GSM cell"

These measurements are in line with the, in the present report, definition of a type 2 UE.

7.2.2 RAN2

7.2.2.1 UE functions and Interlayer procedures in Connected Mode

In 3G TS 25.303 [2] the functions and Interlayer procedures for a UE in connected mode are described. It starts with defining the UE states and states transitions. The states and states transitions are divided according to if a the UE is utilising the CS GSM domain (PSTN/ISDN only) or the GSM/GPRS domain (IP only).

Section 5.6 shortly describes the inter-system handover between UMTS and GSM when simultaneous services in the IP and the PSTN/ISDN domain are used. This procedure requires a terminal with GPRS class A capabilities and no other inter-system procedures for terminals not capable of simultaneous services are described. A GPRS class A MS is not thought to be produced in the nearer future and therefore procedures for other GPRS classes are also needed. Possibly these procedures can be used even if the UE is not connected to both domains at the same time.

The RRC mobility procedures are described not just for FDD and TDD but also for inter-system handover between UMTS and GSM. These procedures are just described for the PSTN/ISDN domain and the procedures for the IP domain are lacking.

7.2.2.2 UE Procedures in Idle mode

In RAN2 another specification dealing with procedures for a UE, 3G TS 25.304 "UE Procedures in Idle Mode" [5], is produced.

The specification shall, according to the scope, include examples of inter-layer procedures related to the idle mode processes and describes idle mode functionality of a dual-mode UMTS/GSM UE. Even so there is no description on how radio access technology shall be chosen. The specification only talks about PLMN selection and reselection. In the section with PLMN selection and reselection (5.1) it is stated:

"Selection of the radio access system may be part of the PLMN selection and reselection process or it may be a separate process inside NAS *[FFS]*.

[Note: Details of the possible NAS process of the radio access system selection are out of the scope of TSG-RAN WG2.]"

The Non Access Stratum (NAS) and the Access Stratum (AS) is a functional division to serve as a basis for the work division between SMG2 UMTS L23 and other groups.

The present report recommends that a specific procedure for choice of radio access technology should be implemented. Some suggestions on how this procedure could be outlined can be found in section 5.1.1.

7.2.3 RAN3

RAN3 is standardising the Iu, Iur, and Iub interfaces. For this report only the Multi-network relevant issues have to be considered (e.g. connection between CN and BSS and/ or RAN).

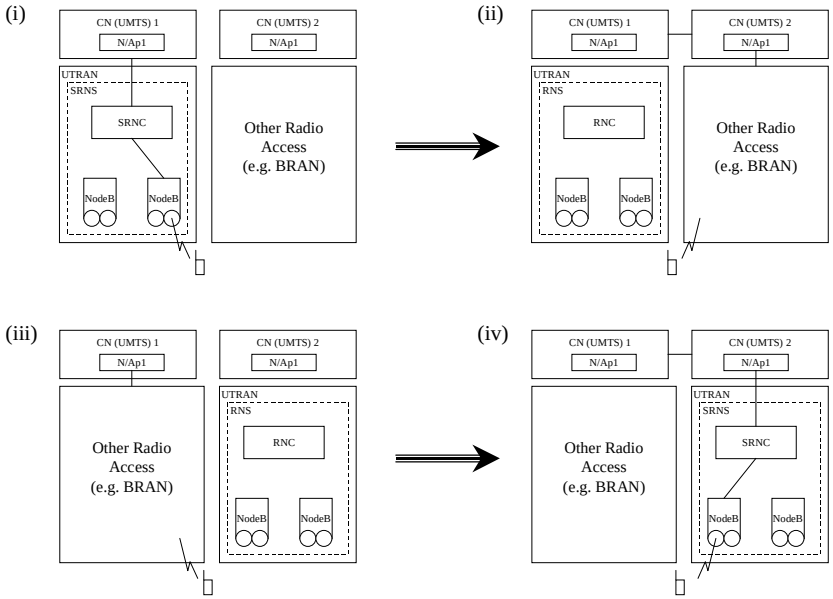
Specific Multi-mode interfaces are not mentioned in the RAN3 documents, nevertheless the HO scenarios are explicitly shown in TS 25.832 [29] and examples of the HO signalling are given in TR 25.931 [30].

7.2.3.1 TS 25.832; Manifestations of Handover and SRNS Relocation

In [29] TS 25.832 chapter 5.5 *Inter CN (different URAN types)* possible HO scenarios between UTRAN and an other 3G access network (e.g. BRAN) are given:

"This scenario is a combination of the previous two, with the handover between a UTRAN (connected to one UMTS CN) and another radio access (connected to a different UMTS CN; the interface is out of scope of this document). This scenario will note be supported in Release '99. Steps (i) & (ii) show handover from UTRAN. Steps (iii) & (iv) show handover to UTRAN."

Note Instead of the sentence "This scenario will note be supported in Release '99" it should be "This scenario will note be supported in Release '99". This is probably a typing error in 25.832. V3.0.0



Inter CN
Different URAN Types

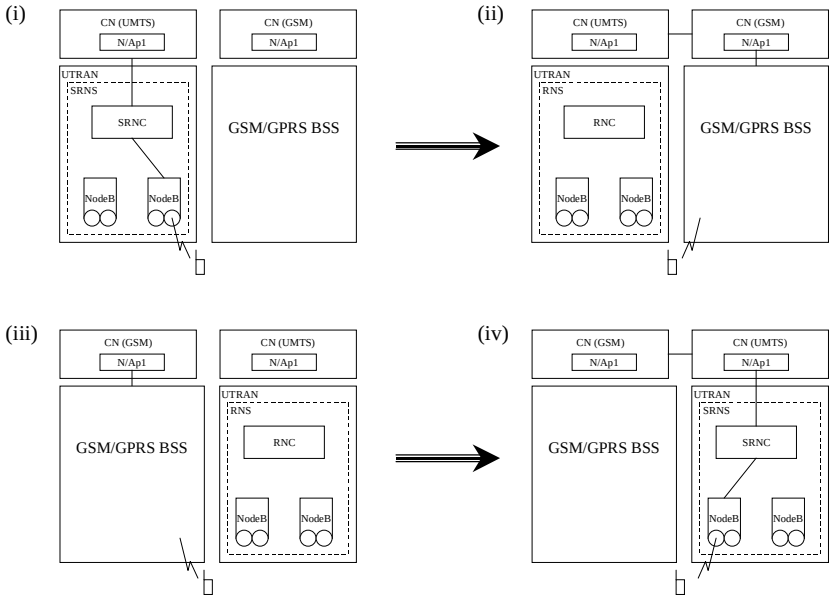
The type of HO (hard/soft) is not mentioned in this chapter, but it can be assumed that only a hard HO is possible.

For this it is necessary to have at least a type 2 Multi-mode UE to fulfil the requirements for this scenarios. A type 1 UE will not be able to send measurement reports to indicate a handover situation to the network or to initiate a handover. This apply to all HO scenarios mentioned in this chapter 7.2.3.

In 25.832 chapter 5.6 *Inter CN (different CN/URAN types)* and chapter 5.7 *Intra CN (UTRAN-GSM/GPRS)* the HO scenarios between UTRAN and a GSM/BSS are shown. Chapter 5.6 gives an example of two different CN connected to each other, while chapter 5.7 assumes a common CN. A scenario in which a GSM network and a UMTS network is run by the same operator is more likely for a situation described in Chapter 5.7.

"5.6 Inter CN (different CN/URAN types

This scenario shows the case of UMTS-GSM handover. More generally this scenario is for inter core network handover with different URAN types. It will be supported by UTRAN as a hard handover only. It is assumed that there will be no direct UTRAN-BSS interface. Steps (i) & (ii) show handover from UTRAN. Steps (iii) & (iv) show handover to UTRAN."

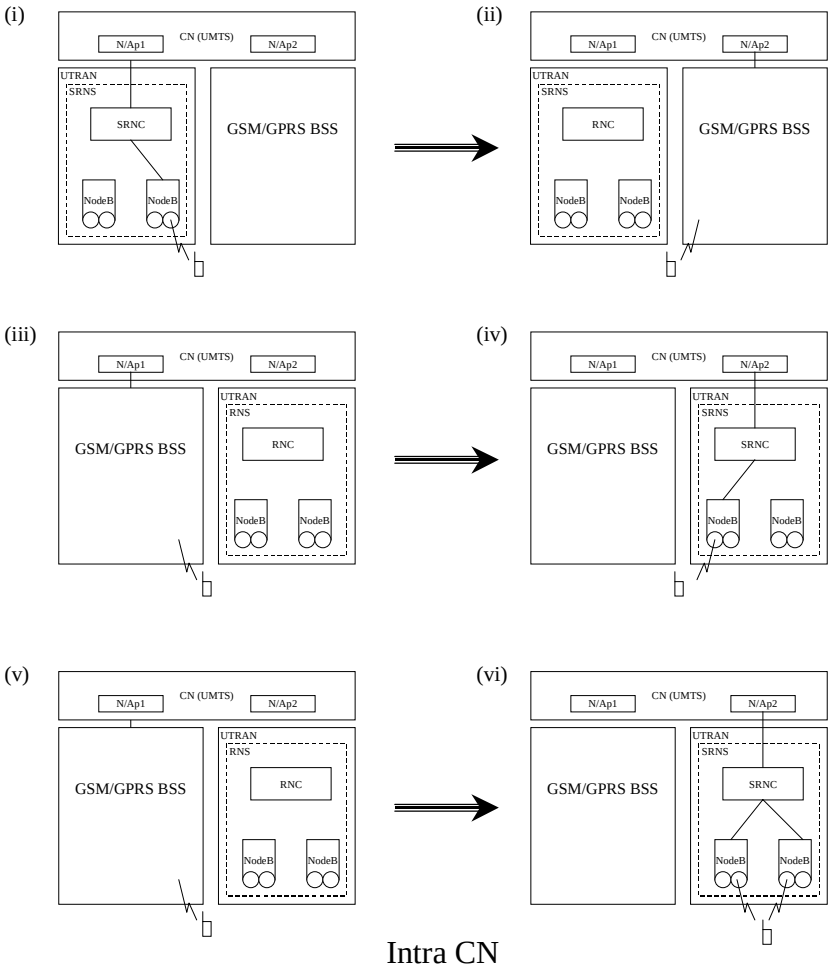


Inter CN
Different CN/URAN Types

"

"5.7 Intra CN (UTRAN-GSM/GPRS)

This scenario shows handover between UTRAN and a GSM BSS. This will be supported by the UTRAN as hard handover only. It is assumed that there will be no direct UTRAN-BSS interface, so handover between GSM BSS and UTRAN is supported by switching in the core network. Steps (i) & (ii) show handover from UTRAN. Steps (iii) & (iv) show handover to UTRAN. Steps (v) & (vi) show an example of the special case of hard handover from GSM to a macrodiversity situation in UTRAN. The ability of the GSM system to support this scenario is for further study, and is out of scope for this report."



Intra CN
UTRAN/GSM

In 25.832 chapter 6 *Applicability of the Scenarios* it is said that the HO between TDD and FDD mode is included in the scenarios already mentioned:

> "Handover between TDD and FDD mode (and vice versa) is a special case of the inter-cell, intra UTRAN or inter UTRAN hard handover scenarios shown above whenever the cells involved are of different modes (FDD or TDD). So, these mixed mode scenarios are already included in the relevant scenarios above."

7.2.3.2 TR 25.931; UTRAN Functions, Examples on Signalling Procedures

TR 25.931 [30] chapter 9.15 *HO between UTRAN and GSM/BSS* is dealing with signalling examples for a UMTS and 2G network HO.

As the scope of TR 25.931 defines itself as:

> "This document describes the UTRAN functions by means of signalling procedure examples (Message Sequence Charts). The signalling procedure examples show the interaction between the UE, the different UTRAN nodes and the CN to perform system functions. This gives an overall understanding of how the UTRAN works in example scenarios."

they should only be regarded as signalling examples. This is also stated in chapter 9 *UTRAN Signalling Procedures*:

> "The signalling procedures shown in the following sections do not represent the complete set of possibilities, nor do they mandate this kind of operation. The standard will specify a set of elementary procedures for each interface, which may be combined in different ways in an implementation. Therefore these sequences are merely examples of a typical implementation."

Chapter 9.15.1 gives the overview of the UTRAN -> GSM/BSS HO, 9.15.2 the overview for the vice versa scenario (GSM/BSS -> UTRAN) and chapter 9.15.3 the overview for the GPRS-> UTRAN HO scenario.

Examples for the UTRAN->GPRS UE initiated HO are given in chapter 9.15.4 and examples for the Network initiated HO are shown in chapter 9.15.5.

7.2.4 RAN4

7.2.4.1 RF System Scenarios

The RAN4 report, 25.942 [12], describes the RF System Scenarios. It is/has been used when defining UTRAN and the scope states:

> "During the UTRA standards development, the physical layer parameters will be decided using system scenarios, together with implementation issues, reflecting the environments that UTRA will be designed to operate in."

No scenarios describing the effects of combined UTRAN and GSM environment is present in the report.

7.2.4.2 RF Parameters in Support of Radio Resource Management

Another document produced by RAN4 is 25.103 [13]. This specification describes the RF parameters in support of radio resource management (RRM). Section 6.1.4 in this specification treats the RRC Mobility connection for Handover from 3G to 2G. The section describes the UE requirements for performing handover from UMTS to GSM, e.g how many carriers the UE shall be able to monitor and syncronise. The opposite direction is not treated and for that direction references to GSM specifications are made.

7.3 TSG CN

7.3.1 CN1

The work in CN1 is concentrated around signalling aspects such as MM/CC/SM and signalling over the Iu-interface.

Work done during the CN1-meeting (ad hoc meeting on GSM/UMTS interworking) end of November 1999 were a list with tasks that needed to be completed for R99. The most important of them affecting the UE is how MS/UE classmarks shall be changed and the interworking of the classmarks in the network e.g. at handover, for a multi-mode UE. The discussion has been long and has resulted in the conclusion that the easiest way of implementing the functionality that a multi-mode UE informs the network about its capabilities, is that the classmarks for both GSM and UMTS are sent and stored in the network. This means that no new classmark especially designed for multi-mode UEs will be defined, but the UE and the network will have to store two classmarks instead.

Other interesting subjects on the list were:

- changes to modify GSM-MM+GMM to UMTS-MM+GMM+PMM,
- service continuity between GSM and UMTS, e.g. QoS mapping, handover,
- handling of identities as USIM may contain 3G-IMUI as well as a 2G-IMSI.

The work in CN1 does not affect the terminal itself but produces procedures defining behaviour in the core network that indirectly are related to the UE. One example of that are the handover procedures.

7.3.1.1 Handover procedures

In TS 23.009[18], the functionality for the core network for handover procedures is described. IN Ch. 5 the handover initiation conditions are described.

> "Handover may be initiated by the network based on RF criteria as measured by the MS or the Network (signal level, Connection quality, power level propagation delay) as well as traffic criteria (e.g. current traffic loading per cell, interference levels, maintenance requests, etc.).
>
> In order to determine if a handover is required, due to RF criteria, it is typically the MS that shall take radio measurements from neighbouring cells. These measurements are reported to the serving cell on an event driven or

regular basis. When a network determines a need for executing a handover the procedures given in GSM 08.08 [5] TS 25.303 [13], TS 25.331 [14] are followed."

This section does not consider the case where the UE makes the decision about handover. This is a requirement from SA2 and is requested for certain PS services, see section 6.1.2.1.

7.3.1.2 Functions related to Mobile Station (MS) in idle mode and group receive mode

TS 23.022 [19] are defining functions related to the MS in idle and group receive mode. In this specification only the GSM and GPRS MS are described. It does not say anything about a UMTS UE or if the modes are combined in one terminal. A quote from the scope states that:

"This TS gives an overview of the tasks undertaken by a GSM Mobile Station (MS) when in idle mode, that is, switched on but not having a dedicated channel allocated, e.g. not making or receiving a call, or when in group receive mode, that is, receiving a group call or broadcast call but not having a dedicated connection. It also describes the corresponding network functions. The idle mode functions are also performed by a GPRS MS as long as no dedicated channel is allocated to the MS. The idle mode functions are also performed by a CTS MS as long as the CTS MS is in manual mode GSM only or in automatic mode under PLMN coverage.

NOTE: The term GSM MS is used for any type of MS supporting one, or combinations, of the frequency bands specified in GSM 05.05."

This means that the functions for the GSM/GPRS part of an UE is specified for idle mode the network layer but the UMTS part has still to come.

7.3.1.3 Mobile radio interface signalling layer 3; General aspects

In TS 24.007 [20] the general aspects for layer 3 mobile radio interface signalling are defined. The beginning of the scope reads as follows:

"This Technical Specification (TS) defines the principal architecture of layer 3 and its sublayers on the GSM Um interface, i.e. the interface between Mobile Station (MS) and network; for the CM sublayer, the description is restricted to paradigmatic examples, call control, supplementary services, and short message services for non-GPRS services. It also defines the basic message format and error handling applied by the layer 3 protocols."

The general aspects are described from the perspective of different types of MS/UE. The list of MSs considered is:

1. Non-GPRS
2. GPRS functionality of class A and B
3. GPRS functionality of class C

These division can be applied even for UMTS and it is not just the PS domain that is described, but the CS also, as it is the terminal categorisation from GPRS that is used.

Further on, the signalling procedures are described for different services in the PS domain. The four service cases described are:

1. for non-GPRS services:
2. for CTS services (in addition to non-GPRS services)
3. for GPRS services supporting Class C MSs :
4. for non-GPRS and GPRS services supporting Class A and Class B MSs :

7.3.1.4 Mobile radio interface layer 3 specification, Core Network Protocols - Stage 3

TS 24.008 [21] are the stage 3 description of the core network protocols for mobile radio interface layer 3 procedures. The procedures currently described in this TS are for the

- call control of circuit-switched connections,
- session management for GPRS services,
- mobility management and radio resource management for circuit-switched and GPRS services.

Even if no specific UMTS terminology is used, the functionality for GPRS is used for the UMTS case too. The whole document is considered for the combination of GSM MSs and UMTS UEs if nothing else is stated (e.g. GSM only). When talking about the PS-domain it is referred to as for GPRS. When using PS-services in GSM only, a GPRS MS may operate in one of the following MS operation modes, see 03.60 [22]:

- MS operation mode A;
- MS operation mode B; or
- MS operation mode C.

As for packet services in UMTS only case, an UE attached to packet switched domain may operate in one of the following MS operation modes, see 23.060 [74]:

- PS/CS mode of operation; or
- PS mode of operation.

In the PS-domain only the network modes I and II are considered as network operation mode III is not applicable for UMTS, see 23.060 [22].

7.3.2 CN2

This group is working with specifications for CAMEL/MAP. The assumptions for their work are that the work should not influence the behaviour of the terminal. Therefore no relevant documents for this work has been found.

7.3.3 CN3

This group is working with specifications for Interworking with external networks. The group itself are divided into two groups, one working with the circuit switched domain and the other working with the packet switched domain. For these domains, the implementation of services are studied and how interworking for the services can be done with other networks. Most work recently have been concentrated around the circuit switched services, e.g. the fax service.

7.3.3.1 Packet Domain; Mobile Station (MS) supporting Packet Switched Services

TS 27.060 [23] is the most important specification from this group that are dealing with the UE.

The scope of this specification reads as follows:

> "The UMTS/GSM PLMN supports a wide range of voice and non-voice services in the same network. In order to enable non-voice traffic in the PLMN there is a need to connect various kinds of terminal equipments to the Mobile Station (MS). The present document defines the requirements for TE-MT interworking over the R-reference point for the Packet Domain, including the protocols and signalling needed to support Packet Switched services, as defined in 3G TS 22.060 and 3G TS 23.060."

A quote from the introduction reads as follows:

> "This document defines the requirements for TE-MT interworking over the R-reference point for the Packet Domain, within the GSM and 3GPP systems. It is up to the manufacturer how to implement the various functions but this specification and existing 3G TS 27.001, 27.002, and 27.003 shall be followed where applicable.
>
> It is the intention that the present document shall remain as the specification to develop a MS for support of Packet Switched services and its text includes references to UMTS/GSM standards."

There are some common functions defined that are needed for all UEs supporting packet switched services. They are divided into Mobile Station Modes of Operation, Physical Interface and Terminal context procedures. The modes of operation defined are as described above in 7.3.1.4. A CS-mode of operation for a UMTS UE is out of scope for the document.

The specification is then divided according to functions that are needed to support specific services. The services described are:

1. X.25 based services
2. IP based services
3. PPP based services

A specific service, IHOSS (Internet Hosted octet Stream Service) is also described and in addition to that all AT-commands that are existing and needed for packet related services.

As a whole, the specification deals with packet based services and the interface to both UMTS and GPRS is considered.

7.3.3.2 Terminal Adaptation Functions (TAF) for Mobile Stations (MS)

TS 27.001 [24], TS 27.002 [25] and TS 27.003 are defining the Terminal Adaptation Functions (TAF) for MSs.

The TAF is used to adapt the MT to TE needed to use even packet switched services in a PLMN. The TAF functionality is thought to be totally included in the MT.

27.001 describes the general aspects for TAF as defined in ITU-T I-series and considers both the UMTS and the GSM domain. This can be viewed in the following text extracted from the specification.

> "This TS is valid for a 2nd generation PLMN (GSM) as well as for a 3rd generation PLMN (UMTS). If text applies only for one of these systems it is explicitly mentioned by using the terms "GSM" and "UMTS". If text applies to both of the systems, but a distinction between the ISDN/PSTN and the PLMN is necessary, the term "PLMN" is used."

27.002 is describing the functionality for TAF for services using asynchronous bearer capabilities. One section (Ch. 5) is totally devoted to the mapping of terminal interfacing to GSM 04.08. Even so, only those elements/messages that are of particular relevance are considered in this section. E.g. mapping of other call establishment or clearing messages to the S interface (e.g. call proceeding) have not been included.

27.003 defines the TAFs for services using synchronous bearer capabilities.

7.4 TSG T

7.4.1 T1

T1 has at present stage an Interim Working Document called "Combined testing areas for RF and Signalling; Idle mode operations, handover and measurement reporting" [14]. The scope of the document states:

> "The purpose of the present document is to be used as a permanent-working document within T1 to elaborate the combined testing areas of RF and signalling. Those areas are:
>
> - PLMN selection/reselection
> - Cell selection and reselection
> - Handover, hard/soft, FDD/TDD, 2G/3G
> - Location Area (LA) and Routing Area (RA) updating (MS idle mode)
> - Cell and UTRAN Registration Area (URA) updating (MS connected mode)
> - Measurement reporting
>
> The present document describes the status of core requirements for conformance testing of Mobile Station idle mode operations. The present document primarily focuses on the MS idle mode operations in a pure 3G environment. However, the scope will be expanded covering also test cases for idle mode operations in the GSM/3G case as soon as possible. "

Chapter 5.1.3, MS idle mode – Inter Radio Access System selection and cell reselection, containes a table with system scenarios (e.g. Inter Radio Access System cell reselection from GSM to UTRAN; Sucessful cell reselection) and the appropriate core specifications for these system scenarios. The scenarios are describing both the cell re-selection from GSM to UMTS and from UMTS to other radio access technologies.

Chapter 5.2.6, MS connected mode – Inter Radio Access System Handover scenarios; describes the system scenarios for connected mode and directs to the appropriate core specifications for these system scenarios. The system scenarios are

here e.g. “Reception of message XXXX by the UE”, “Reception of message INTER SYSTEM HANDOVER COMMAND by the UE” and “Abnormal case: UE fails to complete requested handover”.

This document can be considered as rather important as a reference document as it collects all relevant specifications for different procedures.

7.4.2 T2

In the report 3G TR 21.904 [10], the choice of radio access technology is introduced in a diagram in chapter 4 where the baseline definitions for a UE are described. The diagram makes the choice of radio access technology after searching for networks to register on. After a network is found the UE will decide what radio access technology/mode to camp on.

This procedure is the in line with what is proposed by this report.

7.4.3 T3

The requirement document for T3, 21.111 [11], collects all relevant requirements for the USIM and the IC Card. One section, section 11, is concerned with 3GPP/GSM interworking. The requirements deal with GSM subscribers in a 3GPP network and 3GPP subscribers in a GSM network.

8 Conclusions

8.1 General

A lot of work has been put down to clarify the types of multi-mode UEs. When combining the different modes there will be a lot of other combinations of UEs as the GSM mode encompasses circuit switched GSM and the different types of GPRS terminals. On the other hand the UMTS mode of the terminal can encompass FDD and/or TDD and in that mode just be capable of CS or PS services or have capabilities or both.

8.2 Identified requirements

A network entity that knows the users preferences concerning choice of radio access technology. This functionality is necessary to be able to direct the user to a preferred mode and if just network originated handover is possible.

8.3 Identified further work

For the transition of the same service to another mode, the identified transitions that need to be studied are:

State 1	State 2
UMTS PS	UMTS CS
UMTS PS	GSM PS
UMTS CS	GSM CS
UMTS PS	GSM CS
UMTS CS	GSM PS
UMTS PS	other access technology PS
UMTS CS	other access technology CS
UMTS PS	other access technology CS
UMTS CS	other access technology PS

These transitions can be done in either direction.

Annex A:
Procedures in connected mode

A.1 General description

A UE is considered to be in connected mode when at least one signalling/RRC connection is active in one or several of the modes. [2]

In the connecting state of a multi-mode UE it is important to have connections between the different states in which the UE can be active.

To enable a UE to move from the idle mode to a connected state it is important for the different modes to be connected:

- to avoid connection failures
- to allow correct call set up according to UE type
- for allocation of the correct mode for the service requested

This clause identifies the actions that affect the connected mode of a user, e.g. when they enter new radio access technology areas. The addition or modification of bearers to a call will impact the connected mode of the UE and will become more complex when handovers between modes are designed., particularly if the nature of the bearer is altered e.g. PS to CS. The figure below identifies the possible changes to the connected mode that should be discussed, they split into 3 main areas:

- Call set up and termination
- Addition, modification or lose of a bearer
- Handover to another radio access technology

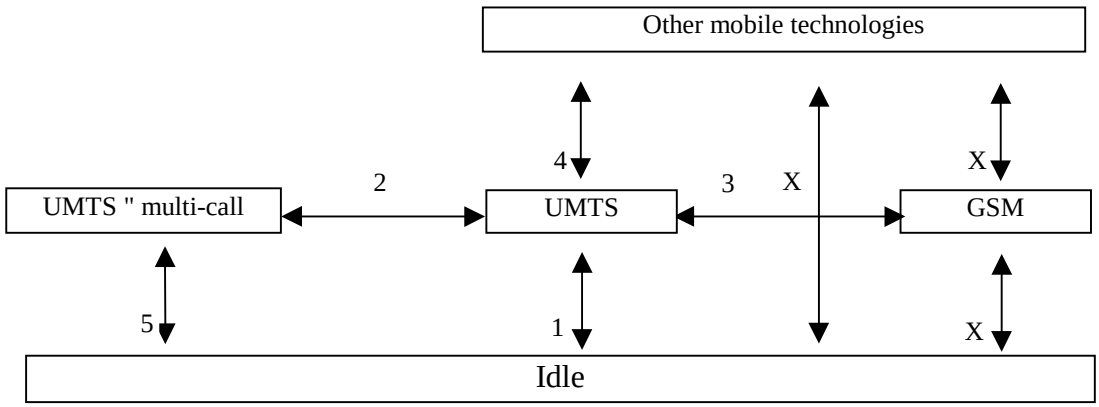


Figure A.1: Transition route between radio access technologies (the numbering system is discussed below)

Idle mode in the figure A.1 describes the idle mode for any of the radio access technologies. All other boxes identify an active call on the specified radio access technology. The UMTS Multicall box indicates that the UE may use more than one bearer, whether these bearers are related or not.

A.1.1 In Scope

A number of connecting states have been identified in the diagram above. The following connecting states shall be considered as in scope for this clause of the document:

A.1.2 Transition 3 UMTS - GSM

This interface considers the:

- Complete handover of a call to GSM from UMTS or vv
- Addition of a connected state in GSM e.g. a speech call or vv

A.1.3 Transition 4 UMTS to Other Access Technologies

This transition is important but will be left FFS.

This interface considers the:

- Complete handover of a call to other access technologies from UMTS or vv
- Addition of a connected state to other access technologies or vv

A.1.4 Out of Scope

A number of scenarios have been identified as out of scope for this clause these include:

- Idle mode to GSM or vv
- Idle mode to UMTS or vv
- Idle mode to UMTS Multicall or vv
- UMTS to Multicall or vv
- Complete or partial call handover from GSM to other access technologies or vv
- Call set up or termination from idle mode to other access technologies

A.1.5 For Further Study

The transition of the same service to another mode, the identified transitions are:

State 1	State 2
UMTS PS	UMTS CS
UMTS PS	GSM PS
UMTS CS	GSM CS
UMTS PS	GSM CS
UMTS CS	GSM PS
UMTS PS	other access technology PS
UMTS CS	other access technology CS
UMTS PS	other access technology CS
UMTS CS	other access technology PS

These transitions can be done in either direction.

A.3 Inter system handover

A.3.1 General Issues identified to be considered for Inter-system handover

Complexity issues - signalling in the network, complexity of the UE.

Delay requirements - at handover between UMTS and GSM systems and call types i.e. more delay can be tolerated when web surfing than a speech call.

Roaming - handover becomes more complex, and these issues need to be considered.

A.3.2 UMTS to other radio access technologies

TS 23.121 [6], 7.7 – Alternate Access technologies to UTRAN (BRAN/HiperLAN)

This type of handover will mainly be used for corporate and home environments. There are 2 possible network architectures to take into account:

- both modes are managed by the same operator;
- both modes are managed by different operators.

In the first case the handover may be simple as all the mobility management and signalling is managed by a single core network, this will allow a fast handover of the call. The network will make the handover more reliable as it will be able to force the UE back to the original connection if the handover fails.

In the second scenario the handover will be slower as location information, signalling and routing of the call has to be transferred completely to another network. If the handover has failed and the first network has passed the call to the other operator there is no chance to re-establish the call.

The complexity of the call handover will vary depending on the other access technology used, e.g. DECT, BRAN, HiperLAN.

History

Document history		
V 2.0.0	March 2000	Presented for approval to TSG-T#7