ETSI TS 143 055 V18.0.0 (2024-05)

Digital cellular telecommunications system (Phase 2+) (GSM);
Dual Transfer Mode (DTM);
Stage 2
(3GPP TS 43.055 version 18.0.0 Release 18)

Reference
RTS/TSGR-0043055vi00

Keywords
GSM

ETSI

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Foreword

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Introduction

Motivation

The definition of GPRS class A mode of operation in Release 97 assumes a total independence between the CS and PS domains. Thus the direct implementation of the existent standards for class A would result in mobile stations that are required to operate in two different frequencies either in the same timeslot, in timeslots *n* and *n* + 3 or their adjacent ones. This complicates enormously the internal architecture of the ME, resulting in a very high development cost, which both operators and manufacturers would prefer to avoid.

Nevertheless, operators have expressed their need for this type of mobiles, since they want to offer services that demand the simultaneous existence of a CS connection and a PS session. This is particularly important during the coexistence of GSM/GPRS with UMTS, as these capabilities will exist in UMTS. However, UMTS coverage may not be available in some areas where there is GSM/GPRS coverage (e.g. deep inside buildings or when roaming to a 2G network). As coverage is a vital service, in order for an operator to be able to sell "UMTS class A services" it is necessary to be able to imitate class A services in areas of only GSM coverage. On the other hand, the provision of class A services with GERAN technology is also essential for operators without UMTS coverage.

Concept basis

A constant aim throughout this document is to reuse the existing functionality when possible, in order to minimise the impact on current implementations. In general, the changes proposed have little impact on the core network elements (i.e. MSC and SGSN) and 3G TS 24.008 [11].

The solution outlined in this document overcomes the restrictions mentioned above and makes possible to have simultaneous CS and PS active connections. This is achieved by sending PS data (signalling and user data)

- on the timeslot use by the CS connection
- on timeslot(s) not used by the CS connection

The possible timeslot configurations are based on two restrictions in Release 99:

- the number of timeslots allocated to the CS connection is limited to one;

- the timeslots allocated in each direction are contiguous.

More flexible proposals are left for further study. In addition, for the definition of DTM multislot classes, the restrictions in 3G TS 45.002 [6] for multislot capabilities shall apply.

Figure 1 shows an example of a multislot configuration (2 uplink, 3 downlink).

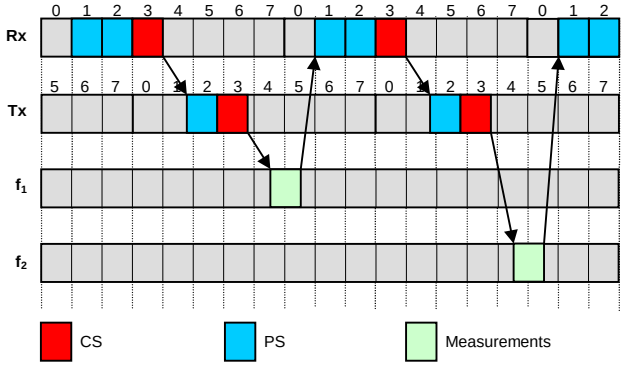

Figure 1: Example of multislot configuration of a GPRS *simple* class A mobile station in dual transfer mode.

In a similar manner to UMTS, the A interface is modified so that the BSC knows the IMSI associated with each SCCP connection to the MSC. This means that the BSC is able to ensure that 'packet paging' messages can be delivered to mobile stations which have a connection to the MSC. The same functionality can be reused to deliver MSC originated pages to mobiles in packet transfer mode while the network is in mode of operation II (i.e. no Gs interface).

Mobility management is basically the same as is specified in 3GPP TS 23.060 [9] for class A mobiles, but using the same techniques as UMTS for control of "in connection" cell, routeing area and location area updates (e.g. System Information 6 message is extended to contain the Routing Area Code).

If GPRS signalling needs to be sent during a standalone voice call, then it is proposed that these LLC frames can be sent on the main DCCH (FACCH or SDCCH) with layer 2 SAPI 0. This uses a new Protocol Discriminator in 3GPP TS 24.007 for LLC: GTTP (GPRS Transparent Transport Protocol). The use of the main DCCH for GPRS signalling is subject to certain restrictions to reduce the harm to the speech quality.

Inter-BSC handover is planned to be controlled by A interface signalling. The *Old BSS to New BSS* information element is used to indicate to the target BSC that the mobile station is in DTM.

DTM Handover procedure is realized by utilizing in parallel the handover procedures that are defined in 3GPP TS43.129 [13] for the PS domain and in 3GPP TS 23.009 [14] for the CS domain.

Class A mode of operation

For paging, the behaviour of the mobile station is as in class B mode of operation: the PCH takes priority to PPCH, and both to CBCH.

The implementation described in this document also applies the restriction that the mobile station shall not be required to operate in two different frequencies in the same moment in time. However, GSM CS and GSM GPRS services will be still supported simultaneously. Thus, the feature here described is a subset of the GPRS class A capabilities.

The mentioned subset will be referred as DTM.

The specification of an *unrestricted* class A mode of operation that requires the mobile station to operate in different frequencies simultaneously shall not be forbidden.

1 Scope

The present document is a description of the practical implementation of GSM-GPRS class A mobiles and a basis for discussion on the changes and additions to the current specifications.

This work is part of the Release 99 Work Item "BSS co-ordination of Radio Resource allocation for class A GPRS services - GSM Radio Access (R99)" for which M Mouly of Nortel Networks is rapporteur. This work item was supported by Nortel, Motorola, Vodafone and Lucent.

In the following, GPRS refers to EGPRS, EGPRS2 and GPRS unless explicitly stated otherwise.

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. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: " Vocabulary for 3GPP Specifications ".

[2] 3GPP TS 22.060: "General Packet Radio Service (GPRS); Service description; Stage 1".

[3] 3GPP TS 44.013: "Performance requirements on the mobile radio interface".

[4] 3GPP TS 44.018: "Mobile radio interface layer 3 specification, Radio Resource Control Protocol".

[5] 3GPP TS 44.060: "General Packet Radio Service (GPRS); Mobile Station (MS) - Base Station System (BSS) interface; Radio Link Control/ Medium Access Control (RLC/MAC) protocol".

[6] 3GPP TS 45.002: "Multiplexing and multiple access on the radio path".

[7] 3GPP TS 45.008: "Radio subsystem link control".

[8] 3GPP TS 45.010: "Radio subsystem synchronization".

[9] 3GPP TS 23.060: "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS); Service description; Stage 2".

[10] 3GPP TS 23.121: "3rd Generation Partnership Project; Technical Specification Group Services and Systems Aspects; Architectural Requirements for Release 1999".

[11] 3GPP TS 24.007: "3rd Generation Partnership Project; Technical Specification Group Core Network; Mobile radio interface signalling layer 3; General aspects".

[12] 3GPP TS 24.008: "3rd Generation Partnership Project; Universal Mobile Telecommunications System; Mobile radio interface layer 3 specification, Core Network Protocols - Stage 3".

[13] 3GPP TS 43.129: "3rd Generation Partnership Project; Packet-switched handover for GERAN A/Gb mode; Stage 2".

[14] 3GPP TS 23.009: "3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Handover procedures; Stage 2".

[15] 3GPP TS 25.331: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC); Protocol Specification".

[16] 3GPP TS 25.413: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface RANAP signaling".

[17] 3GPP TS 48.008: "3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Mobile Switching Centre - Base Station System (MSC-BSS) interface; Layer 3 specification".

[18] 3GPP TS 48.018: "3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN); BSS GPRS Protocol (BSSGP)".

[19] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC);Stage 2"

[20] 3GPP TS 23.251: "Network Sharing; Architecture and functional description".

3 Definitions and abbreviations

3.1 Definitions

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

Dual transfer mode: It is only applicable for a mobile station that supports GPRS. A mobile station in dual transfer mode has resources for an RR connection and is simultaneously[1] allocated resources for one or more TBFs, provided that the BSS co-ordinates its allocation of radio resources. DTM is optional both for the mobile station and the network. A DTM mobile is a class A mobile. Hence all specifications/requirements for class A apply to this mobile unless specifically altered by the present document. The procedures specified for dedicated and packet transfer modes apply to a mobile station in dual transfer mode unless specifically altered by the present document.

Class A/class B: In the present document "class A" and "class B" is used as a short form of "class A mode of operation" and "class B mode of operation", respectively.

DTM Handover: DTM handover is introduced in order to support the parallel handover of circuit-switched and packet-switched domains of a mobile station in dual transfer mode or RRC connected mode, from a source cell to a target cell. The procedures specified for circuit-switched handover (see 3GPP TS 23.009 [14]) and packet-switched handover (see 3GPP TS 43.129 [13]) apply to DTM handover unless specifically altered by the present document.

Network sharing: network sharing is an optional feature that allows different core network operators to connect to the same shared radio access network (see 3GPP TS 23.251 [20]). When network sharing is in use within a given cell, the network broadcasts within system information the PLMN identities of the PLMNs sharing the cell. A mobile station supporting network sharing uses this information for its PLMN (re)selection processes and indicates the selected PLMN to the BSS. When GERAN specifications have statements referring to network sharing support/non-support, this refers to whether or not the MS supports GERAN network sharing and (unless specified otherwise) are not related to support of network sharing on other RATs.

3.2 Abbreviations

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

CS	Circuit Switched
CN	Core Network
DTM	Dual Transfer Mode
PS	Packet Switched
RAT	Radio Access Technology

[1] The term "simultaneous" is used in the present document with the same meaning as in 22.060. Different services or connections may happen *simultaneously* and be multiplexed at lower layers so that they e.g. different TDMA time slots in the same carrier.

4 Class A capabilities

4.1 Main DCCH with SAPI=0

4.1.1 General

The main DCCH (with layer 2 SAPI=0) is used for GSM signalling. GPRS signalling shall be able to use this resource. User data shall not be sent on the main DCCH.

The use of the main DCCH is only allowed when the mobile station is in dedicated mode. In dual transfer mode (i.e. the mobile station has resources allocated for an RR connection and for one or more TBFs), the main DCCH shall not be used and the current procedures described in 3GPP TS 44.060 [5] apply.

When upper layers request to send a message uplink, the mobile station shall send the message on the main DCCH if:

- the mobile station is in dedicated mode;
- the information contained in the message is signalling; and
- the number of LAPDm frames is smaller than a certain value specified by the network. When the parameter defining the maximum number of LAPDm frames has not been received by the MS in the serving cell (e.g. immediately after a handover), the MS assumes the default value defined in 3GPP TS 44.018

Otherwise, the mobile station shall request an uplink TBF as specified in 3GPP TS 44.018 [4]. Even though the mobile station shall not send messages on the main DCCH in dual transfer mode, the network shall not reject the received messages.

NOTE: This is needed to prevent erroneous cases caused by race conditions (e.g. if an uplink message sent on the main DCCH is not completely acknowledged on layer 2 level by the network before the mobile station leaves the dedicated mode and enters the dual transfer mode, the network would reject the message).

On the other hand, the network should not use the main DCCH to send messages that exceed the maximum length specified for the uplink. The mobile station, however, shall not reject messages that exceed the maximum length. Similarly, the network should not use the main DCCH when the mobile station is in dual transfer mode, although the mobile station shall not reject the received messages.

NOTE: This is needed to prevent erroneous cases caused by race conditions (e.g. if the mobile station leaves the dedicated mode and enters the dual transfer mode at the same time as the network sends a downlink message on the main DCCH, the mobile station would reject the message).

4.1.2 MS-SGSN tunnelling

The GPRS information from upper layers (i.e. GMM or SM) is always sent inside an LLC frame. This LLC frame can now be passed down:

- to RLC and transmitted on a TBF; or
- to RR, if the MS is in dedicated mode, and transmitted on the main DCCH.

The procedures for the transmission of an LLC frame via RLC are defined in 3GPP TS 44.060 [5]. The procedures for the transmission of an LLC frame on the main DCCH are defined in 3GPP TS 44.018 [4]. The new tunnelling mechanism for the transmission of the LLC frame is shown graphically in figure 2.

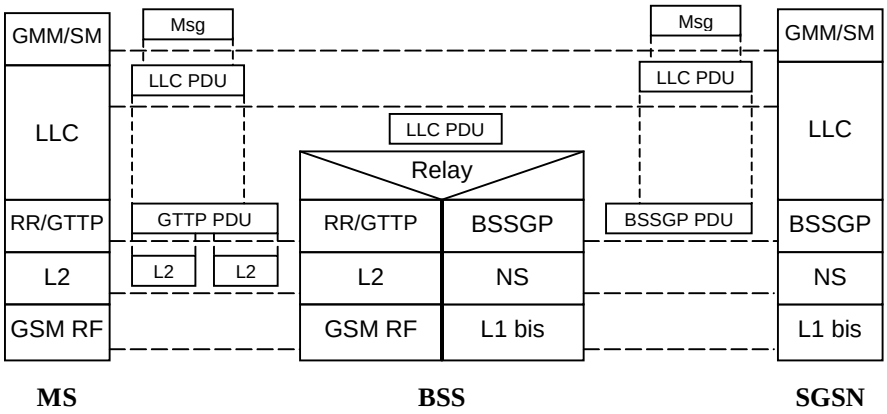

Figure 2: Transmission of an LLC PDU on the main DCCH

In the uplink, the LLC PDU is inserted in a new Layer 3 message[2]. This Layer 3 message is sent to the BSC on the main DCCH, with the existing Layer 2 mechanisms. The BTS re-assemblies the Layer 3 message and sends it to the BSC. The BSC extracts the TLLI and the LLC PDU, which are then put into a BSSGP UL-UNITDATA.

In the downlink, when the BSS receives a downlink BSSGP PDU, it can identify:

- if the PDU contains signalling information ("T bit" in the QoS profile IE);
- if the length of the LLC PDU meets the requirements; and
- if it has an RR connection to the addressed MS (with the IMSI);

in which case, it sends the LLC using the same procedure as described above. If any of the conditions above is not met, the BSC sends the information on a downlink TBF.

4.2 Single slot operation

4.2.1 General

A mobile station in dual transfer mode has one timeslot allocated for the CS services. It is possible to reuse the same timeslot for the transmission of GPRS signalling and user data.

It is desirable to be able to use the same timeslot as the CS connection for GPRS data, due to the impossibility for the network to allocate a TBF in some circumstances (e.g. congested cell, multislot capabilities not supported in the serving cell).

The proposed solution for single timeslot operation is the "TCH/H + PDCH/H" configuration (see 3GPP TS 45.002 [6]).

4.2.2 TCH/H + PDCH/H

A "TCH/H + PDCH/H" configuration implies the multiplexing of CS information and RLC/MAC blocks in the same timeslot of the TDMA frame. Which domain uses each half shall be flexible and indicated in the assignment command.

On the 'TCH/H' part, the support of AMR as the speech codec is mandatory. Support of other circuit switched half rate traffic channels are indicated in the bearer capability IE (see 3GPP TS 24.008).

The PDCH/H is a resource dedicated to the mobile station in both directions. For instance, if an uplink TBF is established, the network may send a control message in any of the downlink blocks. No downlink data, however, shall be sent without a previous downlink assignment.

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[2] This message is sent with a new Protocol Discriminator (GTTP) so that the BSC identifies the tunnelling mechanism without the need to analyse the Message Type. This helps reduce the processor load in the BSC.

The existent RLC/MAC block format is used. In the downlink, the mobile station shall only pass to upper layers those blocks with the TFI indicated in the assignment message. In the uplink, the mobile station may transmit in any of the blocks of the PDCH/H, irrespective of the USF in the previous blocks in the dynamic allocation case, if the USF was present in the (uplink) assignment message. The mobile station, however, stores the USF for possible multislot configurations where dynamic allocation is supported.

The PDCH/H can be used for both GPRS signalling and user data. A PDCH/H shall not be assigned to a DTM capable mobile station in packet transfer mode.

Apart from the different mapping onto physical resources, the PDCH/H has the same characteristics as a PDCH/F. A PDCH/H is always used in exclusive allocation.

If a mobile station and the network support multiple TBF procedures (see 3GPP TS 44.060) and the mobile station is DTM capable, the network may establish multiple downlink TBFs using the PDCH/H. Only one uplink TBF may be established on a PDCH/H since exclusive allocation is used.

4.3 Multislot operation

4.3.1 General

In multislot operation, the packet data is sent on one or more PDCHs. The number of timeslots (i.e. PDCHs) used to carry packet data is decided by the network after taking into account the DTM multislot capabilities supported by the mobile station.

4.3.2 Shared PDCH

The PDCH/F may be shared with other GPRS mobile stations. The existent procedures in 3GPP TS 44.060 [5] apply. In the case of GPRS, EGPRS and EGPRS2 MSs multiplexed on the same PDCH, the same restrictions as described in 3GPP TS 44.060 [5] shall apply.

If a mobile station and the network support multiple TBF procedures (see 3GPP TS 44.060) and the mobile station is DTM capable, the network may establish multiple downlink TBFs for that mobile station using one or more shared PDCHs. In this case the mobile station may request the establishment of multiple uplink TBFs and the network may allocate uplink TBF resources on one or more shared PDCHs.

4.3.3 Exclusive use of PDCH/H

The PDCH/H shall not be shared with other GPRS mobile stations. An uplink PDCH/H shall be assigned in exclusive mode, where the correspondent mobile station is always granted the right to transmit. The existent RLC/MAC block structure shall be kept. The procedures specified in 3GPP TS 44.060 [5] shall apply.

Despite the dedicated characteristics of the uplink PDCH/H, the network shall allocate and use a valid USF, in order to satisfy the signalling requirements defined in 3GPP TS 44.060 [5].

4.3.4 TCH/H + PDCH/F

For this configuration, on the 'TCH/H' part the support of AMR as the speech codec is mandatory. Support of other circuit switched half rate traffic channels is indicated in the Bearer Capability IE (see 3GPP TS 24.008).

4.3.5 Dual Carrier in the Downlink

DTM configurations which use two radio frequency channels in the downlink shall obey the following restrictions:

- Uplink PDCHs shall be assigned on the same radio frequency channel as the uplink CS timeslot.
- Only EGPRS or EGPRS2 TBFs shall be assigned to the packet resources.

4.4 Bearer capability

The decision of which of the class A capabilities shall be used shall be always made by the network after considering:

- the supported capabilities (by both the network and the mobile station);
- the type of data to be sent;
- the length of the data; and
- the requested QoS parameters;

shows the GPRS data supported by the different class A capabilities.

Table 1: Support of GPRS data by the different class A capabilities

Bearer / GPRS data		Main DCCH with SAPI 0	Single slot operation	Multislot operation
GPRS signalling	Short frames	Yes	Yes	Yes
	Long frames	No		
User data		No		

NOTE: The use of the main DCCH with SAPI 0 has the following properties:

- it delays RR commands;
- it harms speech quality;
- it places load onto the A-bis LAPD signalling links;
- it has a maximum length of 251 bytes.

4.5 Indication of the DTM capabilities supported by the MS

4.5.1 Definition of MS DTM classes

4.5.1.1 MS DTM classes

Different mobile stations may support different DTM capabilities and thus they need to be communicated to the network so that they can be taken into account for the allocation of radio resources. The DTM multislot capabilities are independent from the currently defined 3GPP TS 45.002 multislot capabilities. When EGPRS is supported, DTM multislot capability for EGPRS operation (applicable also to EGPRS2 operation if supported) is indicated independently from DTM multislot capability for GPRS operation.

DTM multislot classes 5, 6, 9, 10, 11, 31 to 33, 36 to 38 and 41 to 44 are defined in this release (see 3GPP TS 45.002 [6]). Classes 31 to 33, 36 to 38 and 41 to 44 are supported only by mobile stations supporting DTM High Multislot Class capability.

4.5.1.2 Use of full and half rate

The mix of full and half rate packet data channels is not allowed in the uplink. This mix is only defined for the downlink direction and only supported by mobile stations indicating support for Extended GPRS DTM Multi Slot Class or Extended EGPRS DTM Multi Slot Class respectively (See 3GPP TS 24.008). The half rate packet data channel is only allowed on the same time slot as the circuit switched channel. Due to the different rate of the full and half rate channels used for GPRS during DTM, the network shall take care that the RLC/MAC blocks are sent in such an order that the reception is in sequence when using RLC unacknowledged mode.

4.5.1.3 Incremental support

In order to reduce the number of possibilities and the length of the coding, incremental support shall be used; that is, a mobile station that supports a certain level of capabilities shall support the capabilities of the less restrictive DTM classes. Annex B defines the incremental support for mobile stations supporting Extended DTM GPRS Multi Slot Class or Extended DTM EGPRS Multi Slot Class. For other mobile stations supporting DTM, the implicit support of the less restrictive DTM classes shall be as indicated in Figure 2a; for these mobile stations the single slot DTM operation is optional and supported if indicated by Single Slot DTM capability bit in the MS Classmark 3 and MS Radio Access Capability IEs.

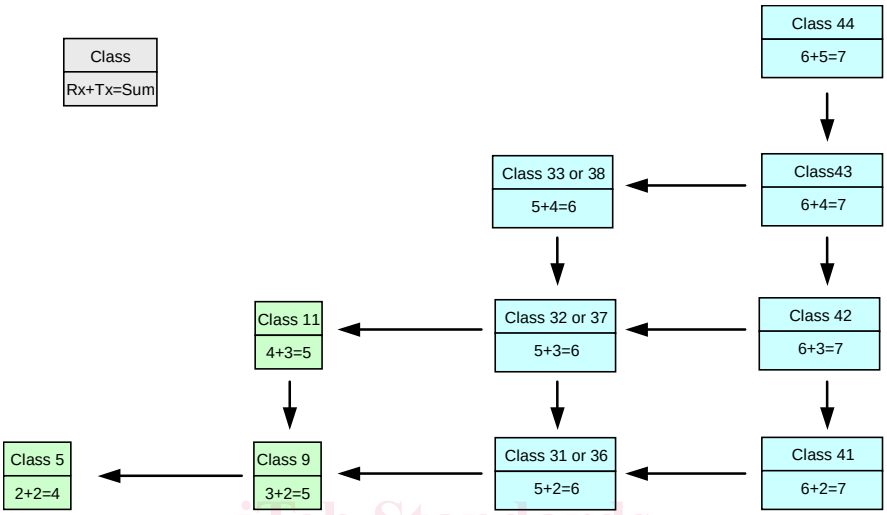

Figure 2a – Incremental support of DTM multislot classes

4.5.2 Options

The support of the following four capabilities has to be indicated independently from the DTM class:

- **Single Slot DTM**: single slot DTM operation supported or not;
- **E-GPRS**: supported or not;
- **Enhanced CS establishment and release**: supported or not;
- **DTM Handover:** supported or not.

The mobile station also indicates support of the following capabilities which, if supported, require the indication of an additional DTM class:

- **Extended DTM**: supported or not. If supported, the Extended DTM multislot class shall also be indicated; a separate indication is provided for GPRS and EGPRS;
- **DTM High Multislot Class**: supported or not. If supported, the DTM high multislot class shall also be indicated; a separate indication is provided for GPRS and EGPRS.

In addition the following rules apply:

- exclusive allocation in the PDCH/H shall always be used; a mobile station supporting E-GPRS shall support GPRS.

4.6 Indication of the capabilities

The mobile station DTM class is indicated in the MS Classmark 3 IE and MS Radio Access Capability IE. The absence of this information shall indicate that the mobile station does not support simple class A (i.e. either it supports *unrestricted* class A or it cannot operate in mode of operation A at all). The support of enhanced CS establishment and release is indicated in the MS Classmark 3 and MS Radio Access Capability IEs. For mobile stations supporting DTM