Leliwa Technical Bulletin

Dual Transfer Mode

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Introduction

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 MS, 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.

The DTM solution 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 used by the CS connection or other timeslot(s) that in both directions are contiguous with the timeslot used by the CS connection, see Fig. 12-1.

For paging, the behaviour of the MS is as in class B mode of operation.

The DTM applies the restriction that the MS is not required to operate in two different frequencies in the same moment in time. However, GSM CS and GSM GPRS services are still supported simultaneously. Thus, the DTM feature is a subset of the GPRS class A capabilities.

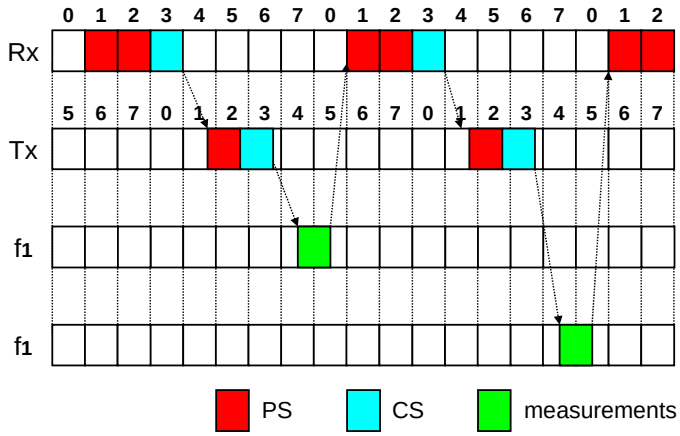

Figure 1 Multislot configuration of a simple class A MS in DTM

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 MSs 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).

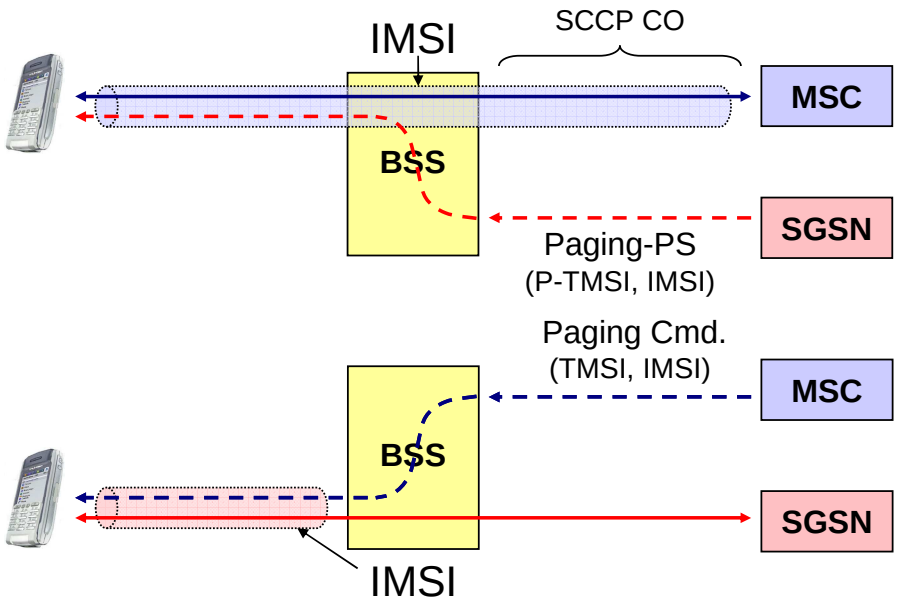

Figure 2 Paging coordination (no Gs interface)

Mobility management in DTM is basically the same as for class A mobiles (i.e. BSS decides about handover for CS and the PS has to follow the CS connection). In order to make the MS aware of RA changes during the DTM mode the System Information, type 6 is extended to contain the Routing Area Code.

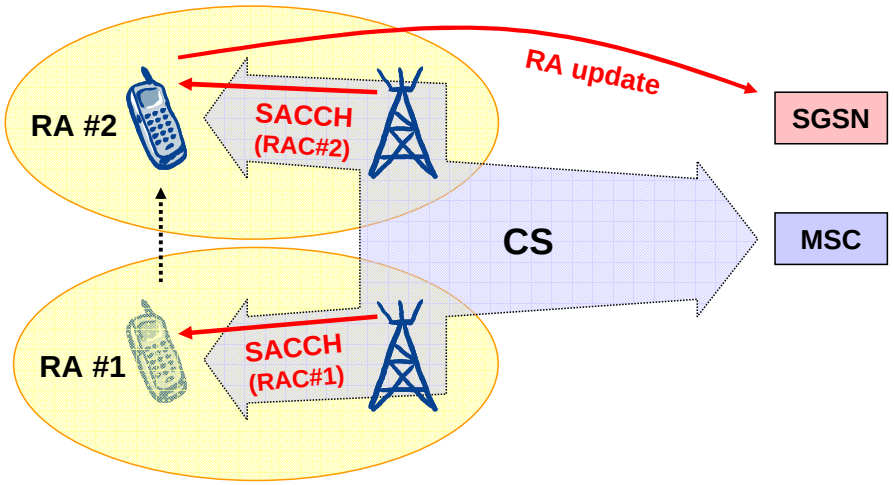

Figure 3 System Information, type 6 (RAC parameter)

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 MS is in DTM.

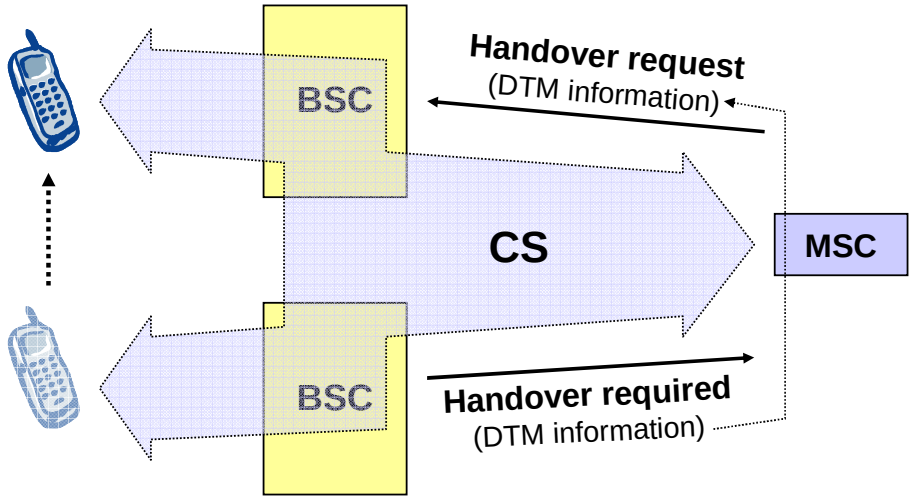

Figure 4 Inter BSC HO during DTM

DTM definition

An MS in Dual Transfer Mode (DTM) has resources for an RR connection and is simultaneously allocated resources for one or more TBFs, provided that the BSS co-ordinates its allocation of radio resources. DTM is optional both for the MS and the network. A DTM mobile is a class A mobile.

GPRS signalling over DCCH

If GPRS signalling needs to be sent during a voice call, then these LLC frames are sent on the main DCCH (FACCH or SDCCH) with Layer 2 SAPI 0. This uses a new Protocol Discriminator in Signalling Layer 3 message structure for LLC: GTTP (GPRS Transparent Transport Protocol).

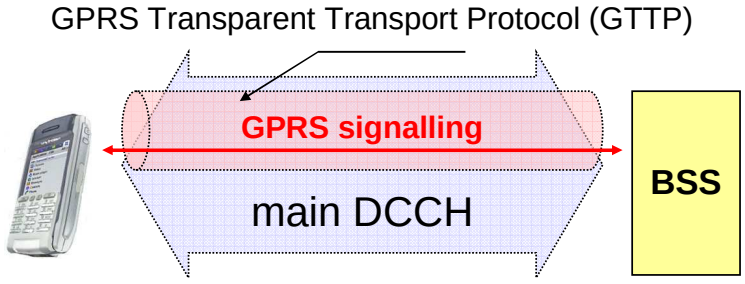

Figure 5 GTTP - GPRS Transparent Transport Protocol

The use of the main DCCH is only allowed when the MS is in dedicated mode. In DTM (i.e. the MS has resources allocated for an RR connection and for one or more TBFs), the main DCCH can not be used and the current GPRS resources are used for the transfer of GPRS signalling.

GPRS user data can not be sent on the main DCCH.

Restrictions

The use of the main DCCH for GPRS signalling is subject to certain restrictions to reduce the harm to the speech quality.

The number of LAPDm frames has to be smaller than a certain value specified by the network (parameter MAX_LAPDm) in message DTM Information send on the main DCCH. 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 equal to 5 LAPDm frames.

If the message is longer that the specified limit, the MS requests an uplink TBF.

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 new tunnelling mechanism for the transmission of the LLC frame is shown graphically in Fig. 12-6.

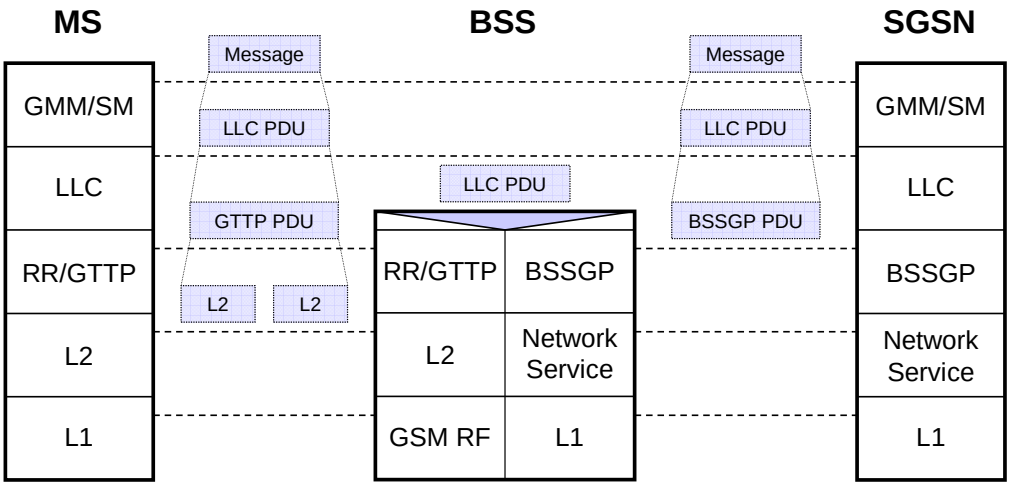

Figure 6 Transmission of an LL PDU on the main DCCH

In the uplink, the LLC PDU is inserted in a new Layer 3 message, with a new Protocol Discriminator (GTTP) so that the BSC identifies the tunnelling mechanism without the need to analyse the Message Type. 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);
- 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.

Single slot operation

If the MS in DTM has one TS allocated for the CS services, it is possible to reuse the same TS for the transmission of GPRS signalling and **user data.** In such case the CS information and RLC/MAC blocks are multiplexed in the same TS of the TDMA frame.

The configuration of logical channels used in that case is called 'TCH/H+ PDCH/H', which means that on one physical channel network configures one CS half rate connection and PS connection uses the remaining half of the physical channel.

This configuration is very useful when it is impossible for the network to allocate a TBF in some circumstances on separate TS (e.g. congested cell, multislot capabilities not supported in the serving cell).

On the 'TCH/H' part, the support of AMR as the speech codec is mandatory.

The PDCH/H is a resource **dedicated** (allocated exclusively) to the MS in both directions and can not be shared with other GPRS MS. 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, are sent without a previous downlink assignment.

In the uplink, the MS transmits in any of the blocks of the PDCH/H, irrespective of the USF in the previous blocks.

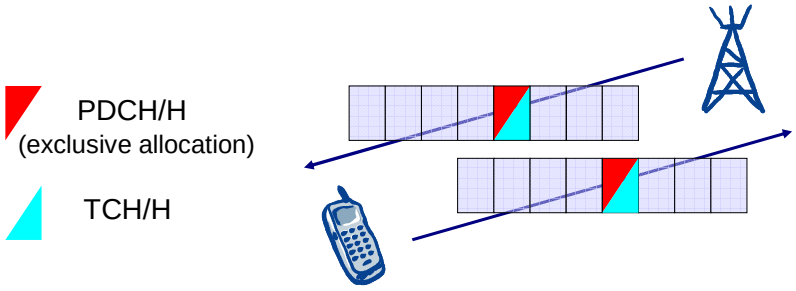

Figure 7 Single slot operation

Multislot operation

In multislot operation, the GPRS data is sent on a PDCH. The number of timeslots comprising the PDCH is decided by the network after taking into account the multislot capabilities supported by the MS.

The PDCH/F may be shared with other GPRS MS.

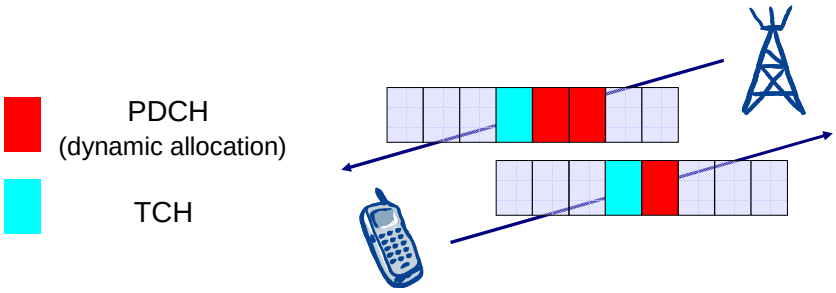

Figure 8 Multislot operation

DTM capabilities

MS DTM capabilities

The MS DTM class is indicated in the Classmark 3 and MS Radio Access Capabilities. The absence of this information indicates that the MS 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 information elements.

MS DTM classes

Different MSs supports 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 previously defined multislot capabilities (i.e. HSCSD multislot class, ECSD multislot class, GPRS multislot class, EGPRS Multi Slot Class)

When EGPRS is supported, DTM multislot capability for EGPRS operation is indicated independently from DTM multislot capability for GPRS operation.

Up to now DTM multislot classes 5, 6, 9, 10 and 11 are defined, other classes can be defined in the future if strictly required, see appendix A, Fig. A-5.

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 MSs indicating support for Extended GPRS DTM Multi Slot Class or Extended EGPRS DTM Multi Slot Class respectively. The half rate packet data channel is only allowed on the same time slot as the circuit switched channel.

Network DTM capabilities

The network indicates on the BCCH or PBCCH whether or not the cell supports DTM and if so whether or not it supports enhanced CS establishment and release (described later).

It also indicates it on the SACCH for DTM capable MSs in dedicated mode or dual transfer mode. It may also indicate it on the PACCH for DTM capable MSs in packet transfer mode. A cell level indication is needed because adjacent BTSs may be in the same RA and LA but may be parented by different BSCs (from different vendors or different releases). The indication in the SACCH is needed to enable/suppress the transmission of packet resource requests when the MS is in dedicated mode and cannot read the BCCH data.

Layer 1 modifications

Timing advance

A MS in DTM disables the timing advance features for the GPRS side (i.e.: the MS inhibits the transmission of timing advance access bursts and ignores

the reception of GPRS timing advance messages. The control of the TA value is done over the SACCH.

Measurement reporting

The MS continues to send measurement reports for the CS part, but GPRS measurement reports are not sent.

Signalling procedures

The existent establishment procedures for class A mode of operation rely on the capability of the MS to be able to operate in different frequencies in the same timeslot, e.g. to listen to the (P)BCCH while in dedicated mode. New procedures are added to the specifications to allow MSs without such capabilities to be able to enter the DTM.

PS establishment while in dedicated mode

A new message is defined to enable the MS to request to enter the DTM: the **DTM Request** message.

Two **DTM assignment** messages are defined:

- **DTM Assignment Command**: this message describes both the CS and packet resources when a reallocation of the CS resource is needed, e.g. when a multislot configuration cannot be accommodated or when an "TCH/H + PDCH/H" configuration is to be used.
- **Packet Assignment**: this message describes the allocated packet resources when no reallocation of the CS resource is necessary, e.g. on an adjacent TS.

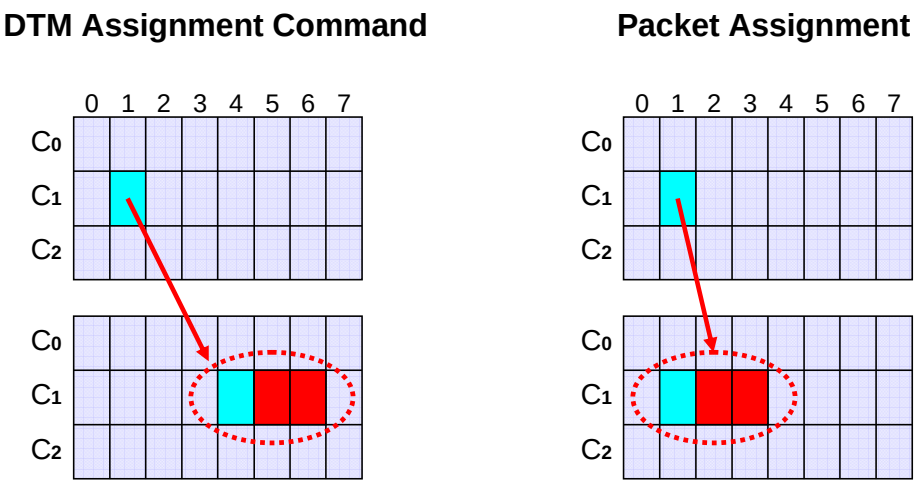

Figure 9 DTM assignment messages

When there is reallocation of the CS timeslot:

- if the MS successfully establishes the new CS connection, it sends an ***Assignment Complete*** message on the new main DCCH.
- if the MS fails to establish the new CS connection, it goes back to the old timeslot, send an ***Assignment Failure*** message on the old main DCCH and continue the CS operation. The MS assumes that the old PS resources were released and attempt its re-establishment.

If the network wants to move the MS to another cell, it sends a ***Handover Command*** message on the main DCCH. After the handover procedure is completed and if the MS was in DTM in the old cell, the network sends the ***DTM Information*** message on the main DCCH to speed up resumption of the DTM operation by the MS.

MO session

If the serving cell of the CS connection indicates that supports DTM, the MS requests the establishment of a PS session by sending a ***DTM Request*** message on the main DCCH.

The network answers the request with one of the two defined DTM assignment messages, sent on the main DCCH. If the network cannot allocate the packet resources, it shall answer with a ***DTM Reject*** message on the main DCCH. The DTM Reject message indicates if the mobile is allowed to reattempt the packet establishment in the same cell (possibly after a waiting time).

Fig. 12-10 shows the successful case of the allocation of an uplink TBF when the reallocation of the CS timeslot is needed. The MS informs the network about the correct seizure of the new CS resource by sending an Assignment Complete message on the main DCCH of the new resource.

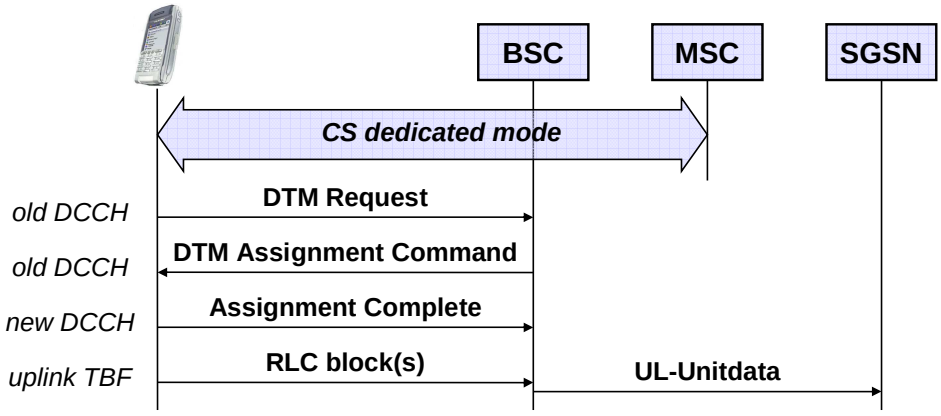

Figure 10 MO PS session establishment while in dedicated mode with reallocation of the CS resource

In Fig. 12-11, the packet resource is mapped onto adjacent timeslot(s) and thus the Packet Assignment message is used. There is no release and re-establishment of the main signalling link.

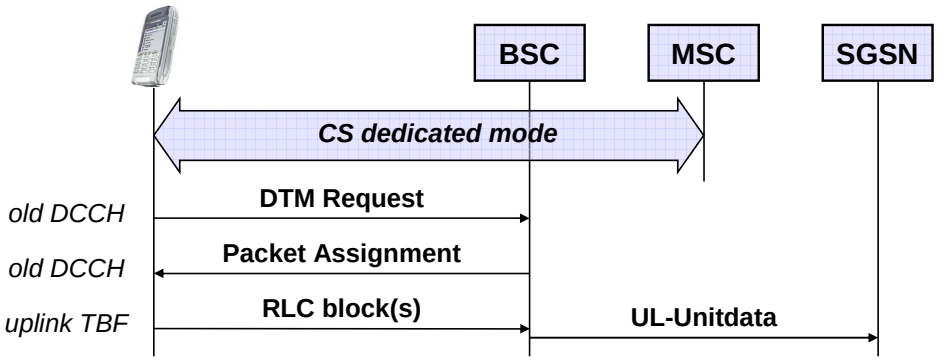

Figure 11 MO PS session establishment in multislot configuration while in dedicated mode

MT session

Ready state

If the MS is in the Ready state, the SGSN sends an LLC frame to the BSS parenting the MS's serving cell. The downlink LLC PDU includes the IMSI if it is known. As the IMSI of the MS was previously stored, the BSS is able to identify that the MS to which the data is sent is in dedicated mode. The **BSS uses the main signalling link** to send the downlink assignment command instead of the (P)CCCH, because a MS in dedicated mode does not listen to the (P)CCCH unless it is 'unrestricted class A' capable.

The assignment is done with one of the DTM assignment messages, sent on the main DCCH.

Fig. 12-12 shows the successful case, when a downlink TBF is assigned without reallocation of the CS resource.

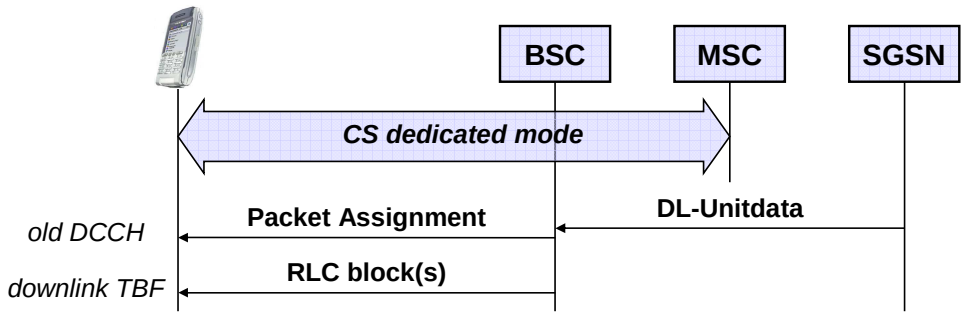

Figure 12 MT PS session establishment while in dedicated mode, packet idle mode and Ready state

Standby state: packet notification

If the MS is in the Stand-by state and the SGSN has something to send, it sends a page to the BSS(s) parenting the RA where the MS is, in order to find out the actual serving cell/BVCI. As the MS has an established signalling connection with the BSS, the BSS does not page the MS. Instead, the BSS informs the MS that it is being paged for packet services. This is done by sending the ***Packet Notification*** message on the main DCCH. The MS answers the notification with a Cell Update procedure: sending an LLC frame to act as a 'Packet Paging Response'.

For that purpose, the GMM layer requests the establishment of uplink resources. If the LLC frame is *dummy* (i.e. does not convey user data information) and it is short enough, the MS sends it on the main DCCH. Otherwise, an uplink TBF is needed and its establishment is done.

Once the LLC frame is sent, the MS moves to the GMM Ready state. The SGSN understands the LLC frame as a valid page response and starts sending the downlink information. In order to forward this information to the MS, the BSS send a second assignment message as soon as it receives the data from the SGSN.

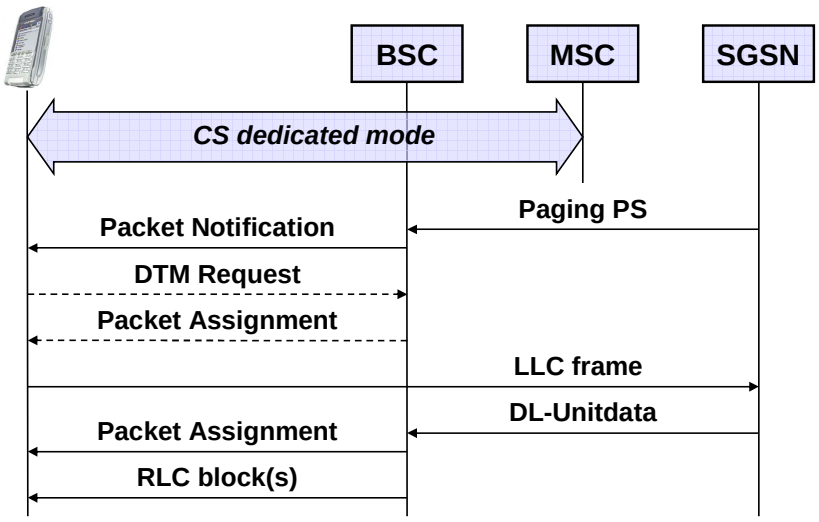

Figure 13 MT PS session establishment while in dedicated mode and Standby state (general case)

CS establishment while in packet transfer mode

When in packet transfer mode, either the MS or the network may initiate a CS connection establishment. In both cases, the packet session may be aborted and the establishment of the CS connection is initiated.

When the establishment of the CS connection is initiated by the network, the CS paging message may come directly from the MSC or via the SGSN if the Gs interface is present. The BSS is able to verify in both cases if the paged MS is in packet transfer mode and if so sends the CS page on the PACCH.

This paging co-ordination can be reused for GPRS MSs in mode of operation B, so that the MS does not need to listen to the PCH. This feature breaks the link between the presence of the Gs interface and the network capability to perform paging co-ordination.

Once on the DCCH, the MS requests the re-establishment of the packet resources by sending a ***DTM Request message***. The procedure to re-establish an aborted uplink TBF are identical to the MO session request. The procedure to re-establish an aborted downlink TBF is identical to the MT session request.

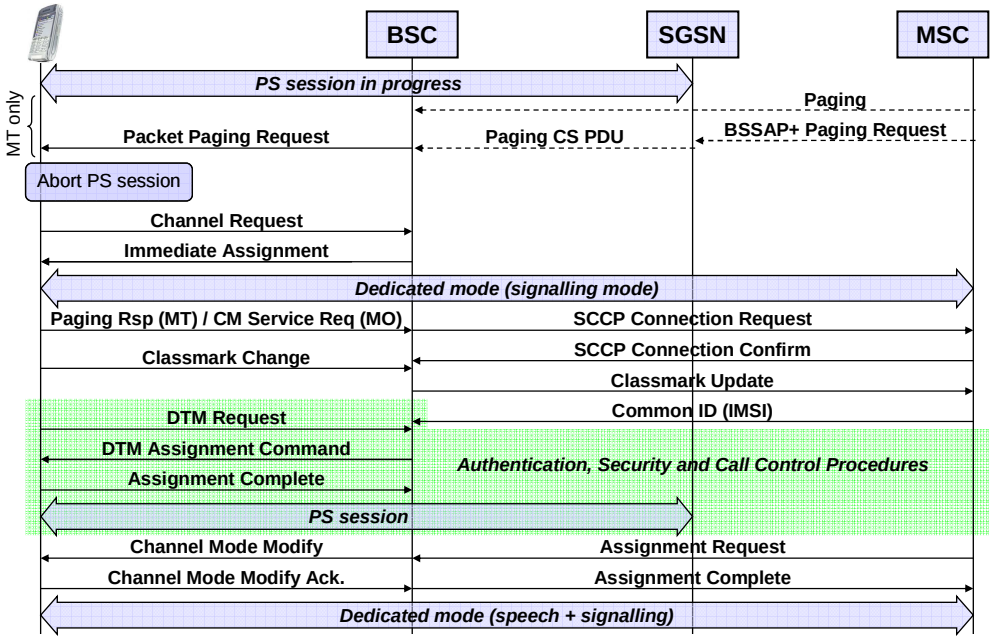

Figure 14 CS connection establishment while in packet transfer mode

Upon receiving the *Assignment Request* message from the MSC, the BSS may send one of the following messages to the MS:

- ***Channel Mode Modify*** message to modify the existing CS channel's mode, as shown in Fig. 12-14,
- ***DTM Assignment Command*** message to reallocate the CS resource and maintain some PS resources.
- ***Assignment Command*** message to reallocate the CS resource and drop the PS resources.

Enhanced CS establishment

If the MS and the network support enhanced CS establishment a CS connection may be established while in packet transfer mode, without release of the packet resources.

An MS that supports enhanced CS establishment determines whether or not the network supports enhanced CS establishment by reading the *GPRS Cell Options* included within system information messages.

Mobile-originated case

In the mobile-originated case, the MS requests a CS connection by sending the ***Packet CS Request*** message on PACCH to the network.

The MS is not allowed to send a Packet CS Request if the countdown procedure has been started on the uplink TBF and there are no downlink TBFs in progress. This ensures that the network has time to respond with a CS assignment before all the PS resources are dropped.

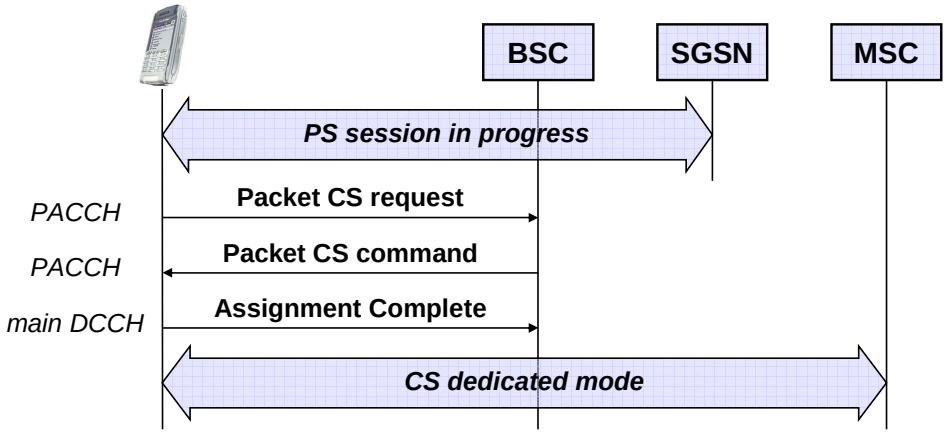

Figure 15 MS originated RR connection request procedure

Upon receipt of the ***Packet CS Request*** message, the network replies to the MS with a ***Packet CS Command*** message on PACCH that encapsulates one of RR messages:

- ***DTM Assignment Command***

  The network allocates both PS and CS resources to the MS by sending an *(RR) DTM Assignment Command* message. When the MS receives this message it starts CS connection establishment and enters DTM. The network may also reallocate PS resources in the *DTM Assignment Command* message. In this case the resulting channel combination must be TCH + PDTCH, SDCCH + PDTCH is not allowed.

  By omitting the PS resource description in the DTM Assignment Command, the network indicates that the current PS resources are maintained.

- ***Immediate Assignment***

  The network allocates only CS resources to the MS and orders the release of PS resources by sending an *(RR) Immediate Assignment* message. When the MS receives this message it releases the PS

connection and establishes the CS connection. When in dedicated mode the MS may request PS resources by procedures described earlier.

- ***Immediate Assignment Reject***

  The network rejects the CS request by sending an *(RR) Immediate Assignment Reject* message. When the MS receives this message it continues in packet transfer mode normally. The MS may later reinitiate the CS connection request.

If the PS resources have been dropped before the network has a chance to respond to the *Packet CS Request*, the network aborts the current DTM procedure. If the MS does not receive a *Packet CS Command* message after it has sent a corresponding *Packet CS Request* message, the MS drops any PS resources and start CS access procedures on the RACH.

Mobile-terminated case

In the mobile-terminated case the BSS sends to the MS a *Packet CS Command* message on PACCH when receiving a CS paging message from the core network. The *Packet CS Command* message encapsulates one of (RR) *DTM Assignment Command* or *Immediate Assignment*. Their meaning is the same as for the mobile-originating case.

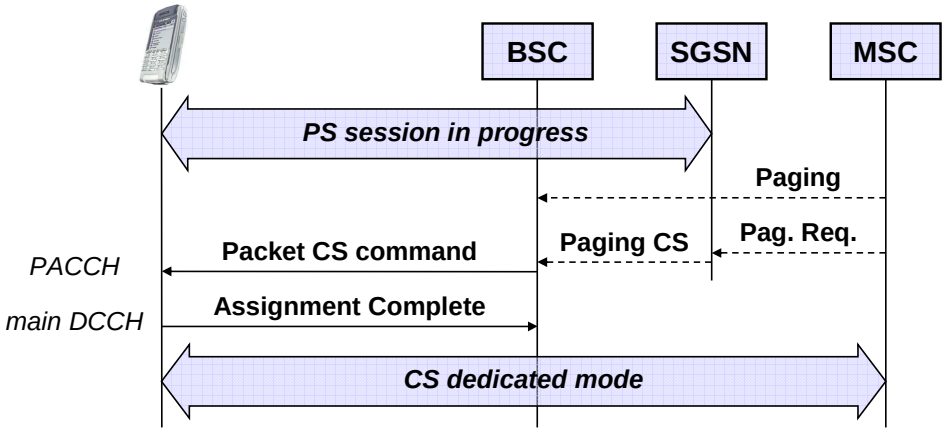

Figure 16 MS terminated RR connection establishment

Acronyms and Abbreviations

BSC	Base Station Controller
BSS	Base Station System
BSSGP	Base Station System GPRS Protocol.
BTS	Base Transceiver Station
CM	Connection Management
CPICH	Common Pilot Channel
CS	Circuit Switching
CS	Convergence Sublayer
DCCH	Dedicated Control Channel (logical channel)
DL	Downlink
DTM	Dual Transfer Mode
EGPRS	Enhanced GPRS
EHPLMN	Equivalent Home PLMN
EPLMN	Equivalent Public Land Mobile Network
FACH	Forward Access Channel (transport channel)
FDD	Frequency Division Duplex
GERAN	GSM/EDGE Radio Access Network
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
GTTP	GPRS Transparent Transport Protocol
HPLMN	Home PLMN
IMSI	International Mobile Subscriber Identity
LA	Location Area
LAC	Location Area Code
LAI	Location Area Identity
LAPD	Link Access Procedure for D-Channel
LLC	Logical Link Connection
MCC	Mobile Country Code
ME	Mobile Equipment
MNC	Mobile Network Code
MO	Mobile Originated
MS	Mobile Station
MSC	Mobile Services Switching Centre
PDCH	Packet Data Channel
PDTCH	Packet Data Traffic Channel
PDU	Packet Data Unit
PLMN	Public Land Mobile Network
PS	Packet Switching
PS	Presence Service
P-TMSI	Packet Temporary Mobile Subscriber Identity
RA	Routing Area

RAC	Routing Area Code
RLC	Radio Link Control
RLC	Release Complete Message
RSCP	Received Signal Code Power
SACCH	Slow Associated Control Channel
SCCP	Signalling Connection Control Part
SDCCH	Stand Alone Dedicated Control Channel
SGSN	Serving GPRS Support Node
SIM	Subscriber Identity Module
SM	Session-based Messaging
SoLSA	Support of Localised Service Area
TCH	Traffic Channel
TMSI	Temporary Mobile Subscriber Identity
TS	Time Slot
UL	Uplink
UMTS	Universal Mobile Telecommunication System
USIM	UMTS Subscriber Identity Module
UTRAN	UMTS Terrestrial Radio Access network
VPLMN	Visited PLMN

References

This section contains the locations of various specifications, document references and useful information where you can learn more about this subject.

[1] 23.060 General Packet Radio Service (GPRS); Service description; Stage 2

[2] 43.064 General Packet Radio Service (GPRS); Overall description of the GPRS radio interface; Stage 2

[3] 44.018 Mobile radio interface layer 3 specification; Radio Resource Control (RRC) protocol

[4] 22.060 General Packet Radio Service (GPRS); Service description; Stage 1

[5] 45.002 Multiplexing and multiple access on the radio path

[6] 43.055 Dual Transfer Mode (DTM); Stage 2

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