TS 101 350 V6.0.1 (1998-08)

Technical Specification

**Digital cellular telecommunications system (Phase 2+);
General Packet Radio Service (GPRS);
Overall description of the GPRS radio interface;
Stage 2
(GSM 03.64 version 6.0.1 Release 1997)**

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

Reference

DTS/SMG-020364Q6 (ci00300r.PDF)

Keywords

Digital cellular telecommunications system,
Global System for Mobile communications
(GSM), General Packet Radio Service (GPRS)

ETSI

Postal address

F-06921 Sophia Antipolis Cedex - FRANCE

Office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16
Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Internet

secretariat@etsi.fr
http://www.etsi.fr
http://www.etsi.org

Contents

Intellectual Property Rights 6
Foreword 6
1 Scope 7
2 Normative references 7
3 Abbreviations, symbols and definitions 8
3.1 Abbreviations 8
3.2 Symbols 9
3.3 Definitions 9
4 Packet data logical channels 9
4.1 General 9
4.2 Packet Common Control Channel (PCCCH) 9
4.2.1 Packet Random Access Channel (PRACH) - uplink only 10
4.2.2 Packet Paging Channel (PPCH) - downlink only 10
4.2.3 Packet Access Grant Channel (PAGCH) - downlink only 10
4.2.4 Packet Notification Channel (PNCH) - downlink only 10
4.3 Packet Broadcast Control Channel (PBCCH) - downlink only 10
4.4 Packet Traffic Channels 10
4.4.1 Packet Data Traffic Channel (PDTCH) 10
4.4.2 Packet Associated Control Channel (PACCH) 10
5 Mapping of packet data logical channels onto physical channels 10
5.1 General 11
5.2 Packet Common Control Channels (PCCCH) 11
5.2.1 PCCCH on 51-multiframe 11
5.2.2 PCCCH mapped on 52-multiframe (PDCH) 11
5.2.2.1 Packet Random Access Channel (PRACH) 11
5.2.2.2 Packet Paging Channel (PPCH) 11
5.2.2.3 Packet Access Grant Channel (PAGCH) 12
5.2.3 Packet Notification Channel (PNCH) 12
5.3 Packet Broadcast Control Channel (PBCCH) 12
5.4 Packet Traffic Channels 12
5.4.1 Packet Data Traffic Channel (PDTCH) 12
5.4.2 Packet Associated Control Channel (PACCH) 12
5.5 Downlink resource sharing 13
5.6 Uplink resource sharing 13
6 Radio Interface (Um) 13
6.1 Radio Resource management principles 13
6.1.1 Allocation of resources for the GPRS 13
6.1.1.1 Master-Slave concept 14
6.1.1.2 Capacity on demand concept 14
6.1.1.3 Procedures to support capacity on demand 14
6.1.1.4 Release of PDCH not carrying PCCCH 14
6.1.2 Multiframe structure for PDCH 15
6.1.3 Scheduling of PBCCH information. 16
6.1.4 SMS cell broadcast 16
6.2 Radio Resource States 16
6.2.1 Correspondence between Radio Resource and Mobility Management States 16
6.2.2 Definition of Radio Resource States 17
6.2.2.1 No State in BSS and Wait State in MS 17
6.2.2.2 Transfer state 17
6.2.2.3 Measurement Report Reception state 17

6.3 Layered overview of radio interface ... 17
6.4 Physical RF Layer ... 18
6.5 Physical Link Layer ... 18
6.5.1 Layer Services ... 18
6.5.2 Layer Functions ... 18
6.5.3 Service Primitives ... 19
6.5.4 Radio Block Structure ... 19
6.5.5 Channel Coding ... 20
6.5.5.1 Channel coding for PDTCH ... 20
6.5.5.2 Channel coding for PACCH, PBCCH, PAGCH, PPCH and PNCH ... 22
6.5.5.3 Channel Coding for the PRACH ... 23
6.5.5.3.1 Coding of the 8 data bit Packet Random Access Burst ... 23
6.5.5.3.2 Coding of the 11 data bit Packet Random Access Burst ... 23
6.5.6 Cell Re-selection ... 23
6.5.6.1 Measurements for Cell Re-selection ... 24
6.5.6.2 Cell Re-selection Algorithm ... 24
6.5.6.3 Broadcast Information ... 25
6.5.6.4 Optional measurement reports and network controlled cell re-selection ... 26
6.5.7 Timing Advance ... 28
6.5.7.1 Initial timing advance estimation ... 28
6.5.7.2 Continuous timing advance update ... 28
6.5.7.2.1 Mapping on the multiframe structure ... 29
6.5.8 Power control procedure ... 31
6.5.8.1 MS output power ... 31
6.5.8.2 BTS output power ... 31
6.5.8.3 Measurements at MS side ... 31
6.5.8.3.1 Deriving the C value ... 32
6.5.8.3.2 Derivation of Channel Quality Report ... 33
6.5.8.4 Measurements at BSS side ... 33
6.5.9 Scheduling of idle frame activities ... 33
6.5.10 Discontinuous Reception (DRX) ... 34
6.6 Medium Access Control and Radio Link Control Layer ... 36
6.6.1 Layer Services ... 36
6.6.2 Layer Functions ... 36
6.6.3 Service Primitives ... 37
6.6.4 Model of Operation ... 37
6.6.4.1 Uplink State Flag ... 38
6.6.4.2 Temporary Flow Identity ... 38
6.6.4.3 Acknowledged mode for RLC/MAC operation ... 38
6.6.4.4 Unacknowledged mode for RLC/MAC operation ... 39
6.6.4.5 Mobile Originated Packet Transfer ... 39
6.6.4.5.1 Uplink Access ... 39
6.6.4.5.2 Dynamic allocation ... 41
6.6.4.5.2.1 Uplink Packet Transfer ... 41
6.6.4.5.2.2 Release of the Resources ... 42
6.6.4.5.3 Contention Resolution ... 43
6.6.4.5.4 Fixed Allocation ... 43
6.6.4.6 Mobile Terminated Packet Transfer ... 44
6.6.4.6.1 Packet Paging ... 44
6.6.4.6.2 Downlink Packet Transfer ... 45
6.6.4.6.3 Release of the Resources ... 46
6.6.4.7 Simultaneous Uplink and Downlink Packet Transfer ... 46
6.6.5 Layer Messages ... 47
6.6.5.1 Packet Channel Request message on the RACH ... 47
6.6.5.2 Packet Channel Request message on the PRACH ... 47
6.7 Abnormal cases in GPRS MS Ready State ... 47
6.7.1 RLC/MAC-Error Causes ... 47
6.7.2 Downlink Signalling Failure ... 48
6.7.3 Packet Channel Request Failure ... 48
6.7.4 Packet Nack or Absence of Response ... 48

6.8 PTM-M Data Transfer 48

Annex A (informative): Power Control Procedures 50

A.1 Open loop control 50

A.2 Closed loop control 50

A.3 Quality based control. 51

A.4 BTS power control 51

A.5 Example 52

Annex B (informative): Bibliography 54

Annex C (informative): Document change history 55

History 56

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available **free of charge** from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://www.etsi.fr/ipr or http://www.etsi.org/ipr).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Specification (TS) has been produced by the Special Mobile Group (SMG) of the European Telecommunications Standards Institute (ETSI).

This TS defines the overall description for lower-layer functions of the General Packet Radio Service (GPRS) radio interface (Um) within the digital cellular telecommunications system.

The contents of this TS is subject to continuing work within SMG and may change following formal SMG approval. Should SMG modify the contents of this TS, it will be re-released by SMG with an identifying change of release date and an increase in version number as follows:

Version 6.x.y

where:

6 indicates GSM Phase 2+ Release 1997;

x the second digit is incremented for all other types of changes, i.e. technical enhancements, corrections, updates, etc.;

y the third digit is incremented when editorial only changes have been incorporated in the specification.

1 Scope

This ETSI TS provides the overall description for lower-layer functions of the General Packet Radio Service (GPRS) radio interface (Um).

The overall description provides the following information:

- The services offered to higher-layer functions,
- The distribution of required functions into functional groups,
- A definition of the capabilities of each functional group and their possible distribution in the network equipment,
- Service primitives for each functional group, including a detailed description of what services and information flows are to be provided, and
- A model of operation for information flows within and between the functions.

This specification is applicable to the following GPRS Um functional layers:

- Radio Link Control functions,
- Medium Access Control functions, and
- Physical Link Control functions.

The overall GPRS logical architecture and the GPRS functional layers above the Radio Link Control and Medium Access Control layer are described in GSM 03.60 [2].This document describes the information transfer and control functions to be used across the radio (Um) interface for communication between the MS and the Network. Functions specific to other interfaces are described in GSM 03.60 [2].

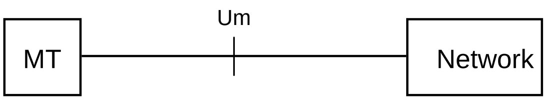


Figure 1: Scope of GPRS Logical Radio Interface Architecture

2 Normative references

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or

b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or

c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or

d) publications without mention of a specific version, in which case 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] GSM 02.60: "Digital cellular telecommunications system (Phase 2+); Stage 1 Service Description of the General Packet Radio Service (GPRS)".

[2] GSM 03.60: "Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Stage 2 ".

[3] GSM 05.01: "Digital cellular telecommunications system (Phase 2+); Physical layer on the radio path, General description".

[4] GSM 05.02: "Digital cellular telecommunications system (Phase 2+); Multiplexing and multiple access on the radio path".

[5] GSM 05.03: "Digital cellular telecommunications system (Phase 2+); Channel coding".

[6] GSM 05.04: "Digital cellular telecommunications system (Phase 2+); Modulation".

[7] GSM 05.05: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception".

[8] GSM 05.08: "Digital cellular telecommunications system (Phase 2+); Radio subsystem link control".

[9] GSM 05.10: "Digital cellular telecommunications system (Phase 2+); Radio subsystem synchronisation".

[10] GSM 01.04: "Digital cellular telecommunications system (Phase 2+); Abbreviations and acronyms".

[11] GSM 04.65: "Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Subnetwork Dependent Convergence Protocol (SNDCP)".

[12] GSM 04.64: "Digital cellular telecommunications system(Phase 2+); General Packet Radio Service (GPRS); Logical Link Control (LLC)".

3 Abbreviations, symbols and definitions

3.1 Abbreviations

In addition to abbreviations in GSM 01.04 and GSM 02.60 following abbreviations apply:

BCS	Block Check Sequence
BEC	Backward Error Correction
BH	Block Header
CS	Coding Scheme
CU	Cell Update
DSC	Downlink Signalling Counter
FH	Frame Header
GGSN	Gateway GPRS Support Node
HCS	Hierarchical Cell Structure
LLC	Logical Link Control
MAC	Medium Access Control
NCH	Notification Channel (for PTM-M on CCCH)
NSS	Network and Switching Subsystem
PACCH	Packet Associate Control Channel
PAGCH	Packet Access Grant Channel
PBCCH	Packet Broadcast Control Channel
PC	Power Control
PCCCH	Packet Common Control Channel
PDCH	Packet Data Channel
PDTCH	Packet Data Traffic Channel
PDU	Protocol Data Unit
PL	Physical Link
PNCH	Packet Notification Channel (for PTM-M on PCCCH)
PPCH	Packet Paging Channel
PRACH	Packet Random Access Channel
RLC	Radio Link Control

SGSN	Serving GPRS Support Node
SNDC	Subnetwork Dependent Convergence
TA	Timing Advance
TBF	Temporary Block Flow
TFI	Temporary Frame Identity
T	Block Type Indicator in Radio Block
TRAU	Transcoder and Rate Adapter Unit
USF	Uplink State Flag

3.2 Symbols

For the purposes of this TS the following symbols apply.

Gb	Interface between an SGSN and a BSC.
Um	Interface between MS and GPRS fixed network part. The Um interface is the GPRS network interface for providing packet data services over the radio to the MS.

3.3 Definitions

NOTE: The text in this subclause is informative. The normative text is in GSM 05.02 [4]. Where there is a conflict between these descriptions, the normative text has precedence.

In addition to the definitions in 02.60 and 03.60 the following definition applies:

Half Duplex MS: The half duplex MS is a multislot class type 1 MS (i.e., class 1 to 12) with the added capability of also being able to perform the half duplex GPRS procedures. The half duplex MS may operate using the GPRS procedures appropriate for a multislot class type 1 MS or it may operate using the half duplex GPRS procedures. The half duplex capability of the MS is signalled to the network in all resource allocation request messages and in the page response.

The half duplex GPRS procedures consist of the half duplex mobile originated packet transfer procedure and the half duplex mobile terminated packet transfer procedure. The mobile originated packet transfer procedure uses the fixed allocation mechanism (see subclause 6.6.4.4.2.2.). The half duplex mobile terminated packet transfer procedure uses the Mobile Terminated Packet Transfer Procedure (see subclause 6.6.4.6.)

Support of the half duplex GPRS procedures in the network is optional.

4 Packet data logical channels

NOTE: The text in this clause is informative. The normative text is in GSM 05.02 [4]. Where there is a conflict between these descriptions, the normative text has precedence.

4.1 General

This subclause describes the packet data logical channels that are supported by the radio subsystem. The packet data logical channels are mapped onto the physical channels that are dedicated to packet data.

The physical channel dedicated to packet data traffic is called a Packet Data Channel (PDCH).

4.2 Packet Common Control Channel (PCCCH)

PCCCH comprises logical channels for common control signalling used for packet data as described in the following subclauses.

4.2.1 Packet Random Access Channel (PRACH) - uplink only

PRACH is used by MSs to initiate uplink transfer, e.g., for sending data or Paging Response. The access burst is used to obtain the Timing Advance (TA).

4.2.2 Packet Paging Channel (PPCH) - downlink only

PPCH is used to page an MS prior to downlink packet transfer. PPCH uses paging groups in order to allow usage of DRX mode. PPCH can be used for paging of both circuit switched and packet data services. The paging for circuit switched services is applicable for class A and B GPRS MSs. Additionally, an MS that is currently involved in packet transfer, can be paged for circuit switched services on PACCH(see subclause 4.4.2).

4.2.3 Packet Access Grant Channel (PAGCH) - downlink only

PAGCH is used in the packet transfer establishment phase to send resource assignment to an MS prior to packet transfer. Additionally, resource assignment for a downlink packet transfer can be sent on PACCH (see subclause 4.4.2.) if the MS is currently involved in a packet transfer.

4.2.4 Packet Notification Channel (PNCH) - downlink only

PNCH is used to send a PTM-M (Point To Multipoint - Multicast) notification to a group of MSs prior to a PTM-M packet transfer. The notification has the form of a resource assignment for the packet transfer.

DRX mode shall be provided for monitoring PNCH. Furthermore, a “PTM-M new message” indicator may optionally be sent on all individual paging channels to inform MSs interested in PTM-M when they need to listen to PNCH.

4.3 Packet Broadcast Control Channel (PBCCH) - downlink only

PBCCH broadcasts packet data specific System Information. If PBCCH is not allocated, the packet data specific system information is broadcast on BCCH.

4.4 Packet Traffic Channels

4.4.1 Packet Data Traffic Channel (PDTCH)

PDTCH is a channel allocated for data transfer. It is temporarily dedicated to one MS or to a group of MSs in the PTM-M case. In the multislot operation, one MS may use multiple PDTCHs in parallel for individual packet transfer.

4.4.2 Packet Associated Control Channel (PACCH)

PACCH conveys signalling information related to a given MS. The signalling information includes e.g. acknowledgements and Power Control information. PACCH carries also resource assignment and reassignment messages, comprising the assignment of a capacity for PDTCH(s) and for further occurrences of PACCH. One PACCH is associated to one or several PDTCHs that are concurrently assigned to one MS.

5 Mapping of packet data logical channels onto physical channels

NOTE: The text in this clause is informative. The normative text is in GSM 05.02 [4]. Where there is a conflict between these descriptions, the normative text has precedence.

5.1 General

Different packet data logical channels can occur on the same physical channel (i.e. PDCH). The sharing of the physical channel is based on blocks of 4 consecutive bursts. The mapping in frequency of PDCH on to the physical channel shall be as defined in GSM 05.02.

On PRACH, access bursts are used. On all other packet data logical channels, radio blocks comprising 4 normal bursts are used. The only exception is some messages on uplink PACCH which comprise 4 consecutive access bursts (to increase robustness).

5.2 Packet Common Control Channels (PCCCH)

At a given time, the logical channels of the PCCCH are mapped on different physical resources than the logical channels of the CCCH.

The PCCCH does not have to be allocated permanently in the cell. Whenever the PCCCH is not allocated, the CCCH shall be used to initiate a packet transfer.

One given MS may use only a subset of the PCCCH, the subset being mapped onto one physical channel (i.e. PDCH).

The mapping of the PCCCH, when it exists, onto the physical channels shall follow one of the following rules:

- PCCCH is mapped on one or several physical channels according to a 51-multiframe. In that case it occupies the whole of the physical channels along with the PBCCH
- PCCCH is mapped on one or several physical channels according to a 52-multiframe, In that case the PCCCH, PBCCH and PDTCH share same physical channels (PDCHs).

This configuration is mutually exclusive on a cell i.e. the PCCCH is mapped either on a 51 or a 52-multiframe.

5.2.1 PCCCH on 51-multiframe

The existence and location of the PCCCH shall be broadcast on the cell.

The mapping of the PRACH, PPCH and PAGCH follows similar rules as the RACH, PCH and AGCH on each physical channel on which the PCCCH is mapped. It is simply mapped on different physical channels.

Since phase 1 and phase 2 MS can only see and use the CCCH, the use on the PCCCH can be optimised for GPRS e.g. a PRACH of 11 bits can be used on uplink.

5.2.2 PCCCH mapped on 52-multiframe (PDCH)

5.2.2.1 Packet Random Access Channel (PRACH)

The PRACH is mapped on one or several physical channels. The physical channels on which the PRACH is mapped are derived by the MS from information broadcast on the PBCCH or BCCH.

PRACH is determined by the Uplink State Flag marked as free (USF=FREE) that is broadcast continuously on the corresponding downlink (see subclause 6.6.4.1). Additionally, a predefined fixed part of the multiframe structure for PDCH can be used as PRACH only and the information about the mapping on the physical channel is broadcast on PBCCH. During those time periods an MS does not have to monitor the USF that is simultaneously broadcast on the downlink.

5.2.2.2 Packet Paging Channel (PPCH)

The PPCH is mapped on one or several physical channels. The exact mapping on each physical channel follows a predefined rule (see subclause 6.1.2), as it is done for the PCH.

The physical channels on which the PPCH is mapped, as well as the rule that is followed on the physical channels, are derived by the MS from information broadcast on the PBCCH.

5.2.2.3 Packet Access Grant Channel (PAGCH)

The PAGCH is mapped on one or several physical channels. The exact mapping on each physical channel follows a predefined rule (see subclause 6.1.2).

The physical channels on which the PAGCH is mapped, as well as the rule that is followed on the physical channels, are derived by the MS from information broadcast on the PBCCH.

5.2.3 Packet Notification Channel (PNCH)

The PNCH is mapped on one or several blocks on PCCCH. The exact mapping follows a predefined rule. The mapping is derived by the MS from information broadcast on the PBCCH.

NOTE: Exact mapping of PNCH on PCCCH is left for phase 2 of GPRS specification.

5.3 Packet Broadcast Control Channel (PBCCH)

The PBCCH shall be mapped on one or several physical channels. The exact mapping on each physical channel follows a predefined rule (see subclause 6.1.2), as it is done for the BCCH.

The existence of the PCCCH, and consequently the existence of the PBCCH, is indicated on the BCCH.

5.4 Packet Traffic Channels

5.4.1 Packet Data Traffic Channel (PDTCH)

One PDTCH is mapped onto one physical channel.

Up to eight PDTCHs, with different timeslots but with the same frequency parameters, may be allocated to one MS at the same time.

5.4.2 Packet Associated Control Channel (PACCH)

One PACCH is mapped onto one physical channel. PACCH is dynamically allocated on the block basis (not following a predefined fixed periodicity) and there is a fixed relationship between the position of PDCH(s) carrying PACCH and PDTCH(s). If a single PDTCH is assigned to one MS, the corresponding PACCH is allocated on the same physical channel. If multiple PDTCHs are assigned (i.e. multislot operation), PACCH is always allocated on one of the PDCHs on which PDTCHs are allocated respecting the MS multislot capability. The position of the PDCH carrying PACCH in respect to PDCH(s) carrying PDTCH(s) is either provided explicitly in the resource assignment message or is derived from the position of the associated PDTCH(s).

PACCH is of a bi-directional nature, i.e. it can dynamically be allocated both on the uplink and on the downlink regardless on whether the corresponding PDTCH assignment is for uplink or downlink.

When PDTCH(s) is assigned on the uplink, one corresponding downlink timeslot has continuously to be monitored by the MS for possible occurrences of PACCH. At the same time, the MS can use the uplink assignment for sending PACCH blocks whenever needed. In case of dynamic allocation, if the resource assigned by the network does not allow the multislot MS (see GSM 05.02, annex B) to monitor the USF on all the assigned PDCHs, the PACCH blocks shall be mapped on the first PDCH in the list of assigned PDCHs.

When PDTCH(s) is assigned on the downlink, every occurrence of an uplink PACCH block is determined by polling in one of the preceding downlink blocks (transferred on the same PDCH). At the same time, the network can schedule the occurrence of downlink PACCH blocks whenever needed.

During an uplink allocation a half duplex/fixed allocation MS using a fixed allocation must monitor the assigned PACCH timeslot during all blocks where the uplink is unassigned for three (or optionally two) consecutive timeslots. The network shall transmit a PACCH block to a half duplex MS using a fixed allocation only during a three (optionally two) timeslot gap in the uplink allocation on the PACCH.

During a downlink transmission the network shall not send downlink data to a half duplex/fixed allocation MS during uplink PACCH timeslots or in the timeslot preceding, or optionally, following the uplink PACCH block.

5.5 Downlink resource sharing

Different packet data logical channels can be multiplexed on the downlink on the same physical channel (i.e. PDCH). The type of message which is indicated in the block header allows differentiation between the logical channels. Additionally, the MS identity allows differentiation between PDTCHs and PACCHs assigned to different MSs.

The multiplexing applies to PPCH, PAGCH, PDTCH and PACCH. Some physical channels carry the four logical channels, whereas other physical channels carry only the PDTCH and PACCH (see subclause 6.1.2).

A message carrying a paging information indicates PPCH.

A message carrying an immediate assignment information indicates PAGCH.

A message carrying user data indicates PDTCH.

A message carrying associated signalling indicates PACCH.

A message carrying a PTM-M notification indicates PNCH.

5.6 Uplink resource sharing

Different packet data logical channels can be multiplexed on the uplink of the same physical channel (i.e. PDCH). The type of message which is indicated in the block header, allows differentiation between the logical channels. Additionally, the MS identity allows differentiation between PDTCHs and PACCHs assigned to different MSs.

The multiplexing applies to PRACH, PDTCH and PACCH. Some physical channels carry the three logical channels, whereas other physical channels carry only the PDTCH and PACCH.

A message carrying user data indicates PDTCH.

A message carrying associated signalling indicates PACCH.

The USF sent on the downlink shall be used to indicate that PRACH is allocated in the corresponding uplink block.

6 Radio Interface (Um)

The logical architecture of the GPRS Um interface can be described using a reference model consisting of functional layers as shown in Figure 3. Layering provides a mechanism for partitioning communications functions into manageable subsets.

Communication between the MS and the Network occurs at the Physical RF, Physical Link, Radio Link Control/Medium Access Control (RLC/MAC), Logical Link Control (LLC) and Subnetwork Dependent Convergence layers.

6.1 Radio Resource management principles

6.1.1 Allocation of resources for the GPRS

A cell supporting GPRS may allocate resources on one or several physical channels in order to support the GPRS traffic. Those physical channels (i.e. PDCHs), shared by the GPRS MSs, are taken from the common pool of physical channels available in the cell. The allocation of physical channels to circuit switched services and GPRS is done dynamically according to the "capacity on demand" principles described below.

Common control signalling required by GPRS in the initial phase of the packet transfer is conveyed on PCCCH, when allocated, or on CCCH. This allows the operator to have capacity allocated specifically to GPRS in the cell only when a packet is to be transferred.

6.1.1.1 Master-Slave concept

At least one PDCH, acting as a master, accommodates packet common control channels that carry all the necessary control signalling for initiating packet transfer (i.e. PCCCH), whenever that signalling is not carried by the existing CCCH, as well as user data and dedicated signalling (i.e. PDTCH and PACCH). Other PDCHs, acting as slaves, are used for user data transfer and for dedicated signalling.

6.1.1.2 Capacity on demand concept

The GPRS does not require permanently allocated PDCHs. The allocation of capacity for GPRS can be based on the needs for actual packet transfers which is here referred to as the "capacity on demand" principle. The operator can, as well, decide to dedicate permanently or temporarily some physical resources (i.e. PDCHs) for the GPRS traffic.

When the PDCHs are congested due to the GPRS traffic load and more resources are available in the cell, the Network can allocate more physical channels as PDCHs.

However, the existence of PDCH(s) does not imply the existence of PCCCH.

When no PCCCH is allocated in a cell, all GPRS attached MSs camp on the CCCH, as they normally do in the Idle state.

In response to a Packet Channel Request sent on CCCH from the MS that wants to transmit GPRS packets, the network can assign resources on PDCH(s) for the uplink transfer using the same assignment command as will be used on PCCCH. After the transfer, the MS returns to CCCH or is directed to a newly allocated PCCCH.

When PCCCH is allocated in a cell, all GPRS attached MSs camp on it. PCCCH can be allocated either as the result of the increased demand for packet data transfers or whenever there is enough available physical channels in a cell (to increase the quality of service). The information about PCCCH is broadcast on BCCH. When the PCCCH capacity is inadequate, it is possible to allocate additional PCCCH resources on one or several PDCHs. If the network releases the PCCCH, the MSs return to CCCH.

6.1.1.3 Procedures to support capacity on demand

The number of allocated PDCHs in a cell can be increased or decreased according to demand. The following principles can be used for the allocation:

- Load supervision:

  A load supervision function may monitor the load of the PDCHs and the number of allocated PDCHs in a cell can be increased or decreased according to demand. Load supervision function may be implemented as a part of the Medium Access Control (MAC) functionality. The common channel allocation function located in BSC is used for the GSM services.

- Dynamic allocation of PDCHs:

  Unused channels can be allocated as PDCHs to increase the overall quality of service for GPRS.

  Upon resource demand for other services with higher priority, de-allocation of PDCHs can take place.

6.1.1.4 Release of PDCH not carrying PCCCH

The fast release of PDCH is an important feature for possibility to dynamically share the same pool of radio resources for packet and circuit-switched services.

There are following possibilities:

- **Wait for all the assignments to terminate on that PDCH**

- **Individually notify all the users that have assignment on that PDCH**

  Packet Resource Reassignment message can be used for that purpose. The network side has to send such notifications on PACCH(s) individually to each affected MS, PACCH(s) being possibly assigned on different timeslots.

- **Broadcast the notification about de-allocation**

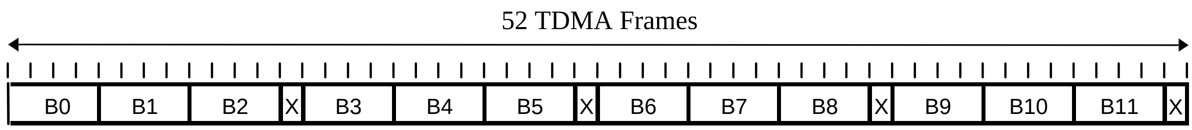
  Simple and fast method to broadcast the notification on all the PDCHs lying on the same carrier as the PDCH to be released. All MSs monitor the possible occurrences of PACCH on one channel and should capture such notification. A more efficient solution is to broadcast the notification only on PDCH(s) where the affected MSs' PACCH(s) are assigned.

In practice, a combination of all the methods can be used.

There may occur the case where an MS remains unaware of the released PDCH. In that case, such MS may cause some interference when wrongly assuming that the decoded Uplink State Flag (see Subclause 6.6.4.1.) denotes the following uplink block period reserved to it. After not getting proper response from the network, the MS would self break the RLC connection and back-off.

6.1.2 Multiframe structure for PDCH

The mapping in time of the logical channels is defined by a multiframe structure. The multiframe structure for PDCH consists of 52 TDMA frames, divided into 12 blocks (of 4 frames) and 4 idle frames according to Figure 2.



X = Idle frame
B0 - B11 = Radio blocks

Figure 2: Multiframe structure for PDCH

The mapping of logical channels onto the radio blocks is defined in the rest of this subclause by means of the ordered list of blocks (B0, B6, B3, B9, B1, B7, B4, B10, B2, B8, B5, B11).

One PDCH that contains PCCCH (if any) is indicated on BCCH. That PDCH is the only one that contains PBCCH blocks. On the downlink of this PDCH, the first block (B0) in the ordered list of blocks is used as PBCCH. If required, up to 3 more blocks on the same PDCH can be used as additional PBCCH. The total number of PBCCH blocks on this PDCH is indicated in the first PBCCH block by means of the BS_PBCCH_BLKS parameter (from 1 up to 4). On this PDCH, the first BS_PBCCH_BLKS blocks in the ordered list of blocks are reserved for PBCCH (e.g. blocks B0, B6 and B3 are used if BS_PBCCH_BLKS = 3 is required).

Any additional PDCH containing PCCCH is indicated on PBCCH. On these PDCHs the BS_PBCCH_BLKS first blocks in the ordered list of blocks are used for PDTCH or PACCH in the downlink. In all cases, the actual usage of the blocks is indicated by the message type.

On any PDCH with PCCCH (with or without PBCCH), the next BS_PAG_BLKS_RES blocks in the ordered list of blocks are used for PAGCH, PNCH, PDTCH or PACCH in the downlink. BS_PAG_BLKS_RES is a parameter broadcast on PBCCH. Its range is from 0 up to (12 - BS_PBCCH_BLKS). The remaining blocks in the ordered list are used for PPCH, PAGCH, PNCH, PDTCH or PACCH in the downlink. In all cases, the actual usage of the blocks is indicated by the message type. If the guard time between the last burst of a PBCCH block and the first burst of a following PCCCH block on another PDCH is less than 2 timeslot periods, that PCCCH block shall not be used for PPCH. This must be ensured by the parameter BS_PAG_BLKS_RES.

On an uplink PDCH that contains PCCCH, all blocks in the multiframe can be used as PRACH, PDTCH or PACCH. The use as PRACH is indicated by the USF = FREE.

Optionally, the first BS_PRACH_BLKS blocks in the ordered list of blocks are only used as PRACH, where BS_PRACH_BLKS is a parameter broadcast on PBCCH. For these BS_PRACH_BLKS blocks the USF shall always be set to FREE. The MS may chose to either ignore the USF (consider it as FREE) or use the USF to determine the

PRACH in the same way as for the other blocks. The remaining blocks in the multiframe are used as PRACH, PDTCH or PACCH under USF control.

On a PDCH that does not contain PCCCH, all blocks can be used as PDTCH or PACCH. The actual usage is indicated by the message type.

The idle frames can be used by the MS for signal measurements and BSIC identification.

6.1.3 Scheduling of PBCCH information.

An MS attached to GPRS shall not be required to monitor BCCH if a PBCCH exists. All system information relevant for GPRS and some information relevant for circuit switched services (e.g. the access classes) shall in this case be broadcast on PBCCH.

All system information may not fit into one Radio Block. As in GSM, it may be necessary to transmit some system information in defined multiframes and blocks within multiframes. The exact scheduling is FFS. The repeating period should not be longer than 8 multiframes (2 seconds).

When no PCCCH is allocated, the MS camps on CCCH and receives all system information on BCCH. Any necessary GPRS specific system information shall in that case be broadcast on BCCH.

6.1.4 SMS cell broadcast.

An MS attached to GPRS shall not be required to monitor the CBCH channel if a PCCCH exists.

6.2 Radio Resource States

The Mobility Management states are defined in GSM 03.60 [2].

6.2.1 Correspondence between Radio Resource and Mobility Management States

Table 1 provides the correspondence between Radio Resource states and Mobility Management states:

Table 1: Correspondence between RR and MM states

<table>
<tr><td>Radio Resource BSS</td><td>Transfer</td><td>Measurement report reception</td><td>No state</td><td>No state</td></tr>
<tr><td>Radio Resource MS</td><td>Transfer</td><td colspan="2">Wait
with Cell Update</td><td>Wait
with Routing Update</td></tr>
<tr><td>Mobility Management NSS and MS</td><td colspan="3">Ready</td><td>Standby</td></tr>
</table>

Each state is protected by a timer. The timers run in the MS and the network.

Transfer state is guarded by RLC protocol timers.

6.2.2 Definition of Radio Resource States

6.2.2.1 No State in BSS and Wait State in MS

There is no RLC context in the MS and the BSS.

The decision on whether paging the MS is on a Routing Area basis or not is under the SGSN responsibility.

If the SGSN does not start a mobile terminated transfer by a paging but sends the packet directly instead, the BSS can assume that the MS is in Wait/CU state, and therefore an assignment message can be sent immediately to the MS. The assignment message is sent to the MS in the cell indicated by the SGSN. This triggers the establishment of an RLC context that is used for the transfer of packets. The MS is then in Transfer state.

6.2.2.2 Transfer state

In Transfer state there is an RLC context in the MS and the BSS.

When a packet is received from the SGSN, it is sent on the current RLC instance.

There is a bi-directional PACCH between the MS and BSS.

When the assignment for a Temporary Block Flow (subclause 6.6.4.2) has been released, the RLC context may be erased.

If the NETWORK_CONTROL_ORDER (subclause 6.5.6.4) indicates that MSs shall send measurement reports to BSS, the transmission of the reports is maintained during the Transfer State.

6.2.2.3 Measurement Report Reception state

If BSS has ordered the MSs to report measurements (subclause 6.5.6.4), the BSS enters the Measurement Report Reception state. In this state, the BSS maintains one RLC context for each MS.

The state is entered from the RR No state when a measurement report arrives from an MS. This may occur when the MS is in Ready state and NETWORK_CONTROL_ORDER indicates that measurement reports shall be transferred (subclause 6.5.6.4).

The state is abandoned in favour of RR No state when no measurement reports arrives within a predefined time period. That occurs normally when the MS returns to the MM Standby state or when the NETWORK_CONTROL_ORDER indicates that the MS shall no longer send measurement reports to BSS (subclause 6.5.6.4).

6.3 Layered overview of radio interface

The GPRS radio interface can be modelled as a hierarchy of logical layers with specific functions. An example of such layering is shown in Figure 3. The various layers are briefly described in the following subclauses.

The physical layer has been separated into two distinct sub-layers defined by their functions:

- Physical RF layer performs the modulation of the physical waveforms based on the sequence of bits received from the Physical Link layer. The Physical RF layer also demodulates received waveforms into a sequence of bits which are transferred to the Physical Link layer for interpretation.

- Physical Link layer provides services for information transfer over a physical channel between the MS and the Network. These functions include data unit framing, data coding, and the detection and correction of physical medium transmission errors. The Physical Link layer uses the services of the Physical RF layer.

The lower part of the data link layer is defined by following functions:

- The RLC/MAC layer provides services for information transfer over the physical layer of the GPRS radio interface. These functions include backward error correction procedures enabled by the selective retransmission of erroneous blocks. The MAC function arbitrates access to the shared medium between a multitude of MSs and the Network. The RLC/MAC layer uses the services of the Physical Link layer. The layer above RLC/MAC (i.e., LLC described in GSM 03.60 [2] and defined in GSM 04.64 [12]) uses the services of the RLC/MAC layer on the Um interface.

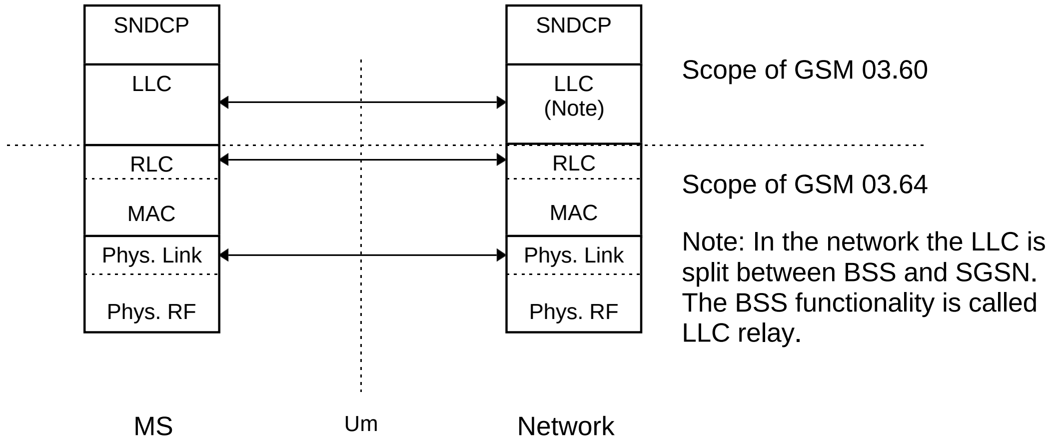


Figure 3: GPRS MS – Network Reference Model

6.4 Physical RF Layer

The GSM Physical RF layer is defined in GSM 05 series recommendations, which specify among other things:

- The carrier frequencies characteristics and GSM radio channel structures (GSM 05.02 [4]);
- The modulation of the transmitted wave forms and the raw data rates of GSM channels (GSM 05.04 [6]); and
- The transmitter and receiver characteristics and performance requirements (GSM 05.05 [7]).

The GSM physical RF layer shall be used as a basis for GPRS with possibility for future modifications.

6.5 Physical Link Layer

The Physical Link layer operates above the physical RF layer to provide a physical channel between the MS and the Network.

6.5.1 Layer Services

The purpose of the Physical Link layer is to convey information across the GSM radio interface, including RLC/MAC information. The Physical Link layer supports multiple MSs sharing a single physical channel.

The Physical Link layer provides communication between MSs and the Network.

The Physical Link layer control functions provide the services necessary to maintain communications capability over the physical radio channel between the Network and MSs. Radio subsystem link control procedures are currently specified in GSM 05.08 [8]. Network controlled handovers are not used in the GPRS service. Instead, routing updates and cell updates are used.

6.5.2 Layer Functions

The Physical Link layer is responsible for:

- Forward Error Correction (FEC) coding, allowing the detection and correction of transmitted code words and the indication of uncorrectable code words. The coding schemes are described in subclause 6.5.5.
- Rectangular interleaving of one Radio Block over four bursts in consecutive TDMA frames, as specified in GSM 05.03 [5].

- Procedures for detecting physical link congestion.

The Physical Link layer control functions include:

- Synchronisation procedures, including means for determining and adjusting the MS Timing Advance to correct for variances in propagation delay (radio subsystem synchronisation is currently specified in GSM 05.10 [9]);
- Monitoring and evaluation procedures for radio link signal quality;
- Cell (re-)selection procedures;
- Transmitter power control procedures; and
- Battery power conservation procedures, e.g. Discontinuous Reception (DRX) procedures.

6.5.3 Service Primitives

Table 2 lists the service primitives provided by the Physical Link layer:

Table 2: Service primitives provided by the Physical Link layer

Name	request	indication	response	confirm	comments
PL-DATA	x	x		x	used to transfer RLC/MAC layer PDU
PL-SYNC	x			x	used to request PL layer synchronisation on the radio channel
PL-NOSYNC		x			used to indicate that radio channel synchronisation has been lost or that a PL-SYNC has failed
PL-STATUS		x			used to indicate the quality of received transmissions, e.g. the bit error rate from each FEC block
PL-ERROR		x			used to indicate a Physical block error (Block Check Sequence indicates the error)

6.5.4 Radio Block Structure

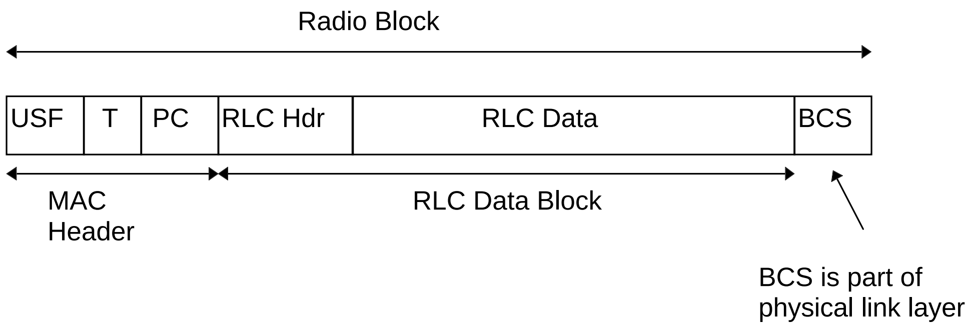
Radio Block consists of MAC Header, RLC Data Block or RLC/MAC Control Block, and BCS. It is always carried by four Normal Bursts.

MAC Header consists of USF, T, and PC fields.

RLC Data Block consists of RLC Header and RLC Data.

RLC/MAC Control Block consists of RLC and/or MAC signalling information elements.

The Radio Block definitions are clarified in Figure 4.



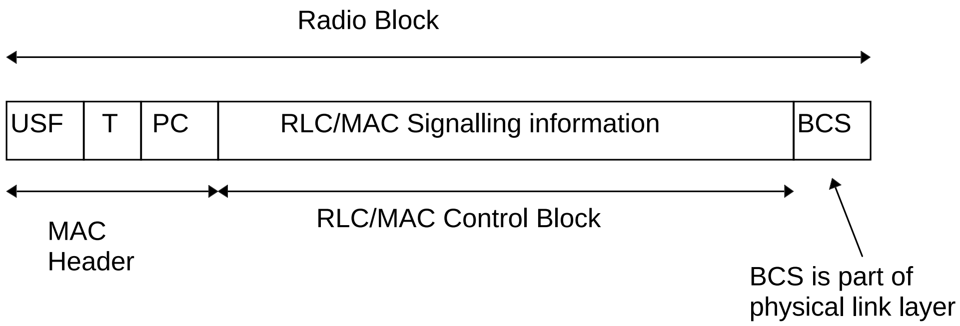


Figure 4: Radio Block structures

6.5.5 Channel Coding

NOTE: The text in this subclause is informative. The normative text is in GSM 05.03 [5]. Where there is a conflict between these descriptions, the normative text has precedence.

6.5.5.1 Channel coding for PDTCH

Four different coding schemes, CS-1 to CS-4, are defined for the Radio Blocks carrying RLC data blocks. The block structures of the coding schemes are shown Figure 5 and Figure 6 below. For the Radio Blocks carrying RLC/MAC Control blocks code CS-1 is always used (see subclause 6.5.5.2). The exception are messages that use the existing Access Burst [5] (e.g. Packet Channel Request). Additional coding scheme for the Access Burst that includes 11 information bits is described in subclause 6.5.5.3.2.

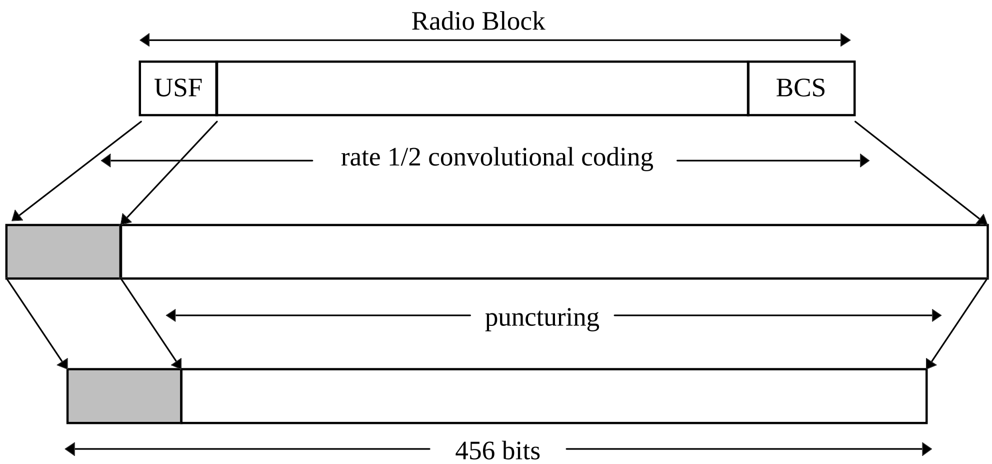


Figure 5: Radio Block structure for CS-1 to CS-3

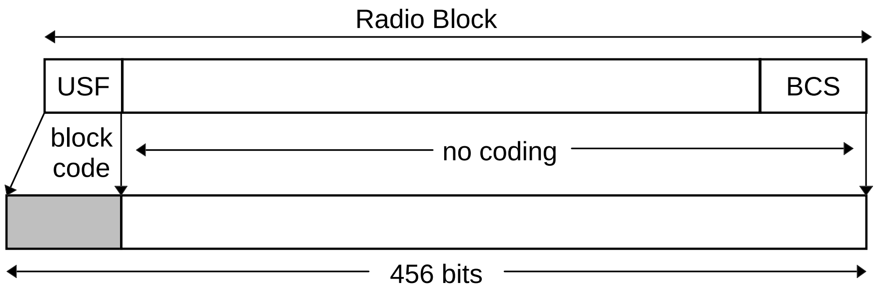


Figure 6: Radio Block structure for CS-4

The first step of the coding procedure is to add a Block Check Sequence (BCS) for error detection.

NOTE: Of implementation reasons it is convenient to regard the error detection as part of the Physical Link Layer, even though the Backward Error Correction procedures belong to the RLC.

For CS-1 - CS-3, the second step consists of pre-coding USF (except for CS-1), adding four tail bits and a convolutional coding for error correction that is punctured to give the desired coding rate.

For CS-4 there is no coding for error correction.

The details of the codes are shown in table 3, including:

- the length of each field;
- the number of coded bits (after adding tail bits and convolutional coding);
- the number of punctured bits;
- the data rate, including the RLC header and RLC information.

Table 3: Coding parameters for the coding schemes.

Scheme	Code rate	USF	Pre-coded USF	Radio Block excl. USF and BCS	BCS	Tail	Coded bits	Punctured bits	Data rate kb/s
CS-1	1/2	3	3	181	40	4	456	0	9.05
CS-2	≈2/3	3	6	268	16	4	588	132	13.4
CS-3	≈3/4	3	6	312	16	4	676	220	15.6
CS-4	1	3	12	428	16	-	456	-	21.4

CS-1 is the same coding scheme as specified for SDCCH in GSM 05.03 [5]. It consists of a half rate convolutional code for FEC and a 40 bit FIRE code for BCS (and optionally FEC).

CS-2 and CS-3 are punctured versions of the same half rate convolutional code as CS-1 for FEC. The coded bits are numbered starting from zero.

For CS-2 the punctured bits are number 4*i+3, i = 3,..., 146 except for i = 9, 21, 33, 45, 57, 69, 81, 93, 105, 117, 129 and 141. Hence none of the first 12 bits is punctured.

NOTE: For CS-2 the puncturing pattern has to be adjusted to the format of the future new TRAU frame format to be used on the Abis interface (e.g. more bits have to be punctured in order to give place for the RLC signalling).

For CS-3 the punctured bits are number 6*i+3 and 6*i+5, i = 2,..., 111.

CS-4 has no FEC.

CS-2 to CS-4 use the same 16 bit CRC for BCS. The CRC is calculated over the whole uncoded RLC Data Block including MAC Header. The generator polynomial is:

$G = 1+X^5 + X^{12} + X^{16}$.

The USF has 8 states, which are represented by a binary 3 bit field in the MAC Header.

For CS-1, the whole Radio Block is convolutionally coded and USF needs to be decoded as part of the data.

All other coding schemes generate the same 12 bit code for USF, which is shaded in the figures. For these cases the USF can be decoded either as a block code, with a minimum Hamming distance of 5, or as part of the data.

For CS-2 and CS-3, this is achieved by first mapping it into a 6 bit pre-coded value and then applying the convolutional code to the whole block without puncturing the first 12 coded bits, which only depends on USF.

For CS-4 the USF bits are directly mapped into the 12 bit block code.

Table 4 shows the USF coding. Note that, contrary to GSM 05.03, all binary fields are shown according to the field mapping convention with the bit representing the lowest order value to the right.

Table 4: USF coding (except for CS-1).

USF flag 8 states	Binary value	Pre-coded USF (for CS-2 and CS-3)	USF code word
R1	000	000 000	000 000 000 000
R2	001	101 001	110100 001011
R3	010	011 010	011 011 101 100
R4	011	110 011	101 111 100 111
R5	100	110 100	101 110 110 000
R6	101	011 101	011 010 111 011
R7	110	101 110	110 101 011 100
R8/FREE	111	000 111	000 001 010 111

NOTE: The USF is not used on the uplink.

In order to simplify the decoding, the stealing bits (defined in GSM 05.03) of the block are used to indicate the actual coding scheme. For this a backward compatible 8 bit block code with Hamming distance 5 is used. Table 5 shows the coding:

Table 5: Code words for coding scheme indication.

Coding scheme	code word
CS-1 = SDCCH	1111 1111
CS-2	0001 0011
CS-3	1000 0100
CS-4	0110 1000

All coding schemes are mandatory for MSs. Only CS-1 is mandatory for the network.

6.5.5.2 Channel coding for PACCH, PBCCH, PAGCH, PPCH and PNCH

The channel coding for the PACCH, PBCCH, PAGCH, PPCH and PNCH is corresponding to the coding scheme CS-1 presented in subclause 6.5.5.1.

6.5.5.3 Channel Coding for the PRACH

Two types of packet random access burst may be transmitted on the PRACH: an 8 information bits random access burst or an 11 information bits random access burst called the extended packet random access burst. The mobile must support both random access bursts. The channel coding for both burst formats is indicated in the following subclauses.

6.5.5.3.1 Coding of the 8 data bit Packet Random Access Burst

The channel coding used for the burst carrying the 8 data bit packet random access uplink message is identical to the coding of the random access burst as currently defined in GSM 05.03.

6.5.5.3.2 Coding of the 11 data bit Packet Random Access Burst

The burst carrying the extended packet random access uplink message contains 11 information bits d(0),d(1),...,d(10). Six parity bits p(0),p(1),...,p(5) are defined in such a way that in GF(2) the binary polynomial:

> $d(0)D^{16} + ... + d(11)D^{6} + p(0)D^{5} + ... + p(5)$, when divided by $D^{6} + D^{5} + D^{3} + D^{2} + D + 1$ yields a remainder equal to $D^{5} + D^{4} + D^{3} + D^{2} + D + 1$.

The six bits of the BSIC, {B(0),B(1),...,B(5)}, of the BS to which the Random Access is intended, are added bitwise modulo 2 to the six parity bits, {p(0),p(1),...,p(5)}. This results in six colour bits, C(0) to C(5) defined as C(k) = b(k) + p(k) (k = 0 to 5) where:

> b(0) = MSB of PLMN colour code
>
> b(5) = LSB of BS colour code.

This defines {u(0),u(1),..., u(20)} by:

> u(k) = d(k) for k = 0,1,...,10
>
> u(k) = C(k-11) for k = 11,12,...,16
>
> u(k) = 0 for k = 17,18,19,20 (tail bits)

The coded bits {c(0),c(1),..., c(41)} are obtained by the same convolutional code of rate 1/2 as for TCH/FS, defined by the polynomials:

> $G0 = 1 + D^{3} + D^{4}$
>
> $G1 = 1 + D + D^{3} + D^{4}$

and with:

> c(2k) = u(k) + u(k-3) + u(k-4)
>
> c(2k+1) = u(k) + u(k-1) + u(k-3) + u(k-4) for k = 0,1,...,20 ; u(k) = 0 for k < 0

6 coded bits are not transmitted. The bits not transmitted are still FFS.

The false detection probability performance requirement shall be the same for the 11 bits random access burst as for the 8 bit random access burst, as defined in GSM 05.05. This means that for a BTS on a PRACH implementing the 11 bits access burst with a random RF input, the overall reception performance shall be such that less than 0.02 % of frames are assessed to be error free.

6.5.6 Cell Re-selection

NOTE: The text in this subclause is informative. The normative text is in GSM 03.22 and GSM 05.02. Where there is a conflict between these descriptions, the normative text has precedence.

In GPRS Standby and Ready states, cell re-selection is performed by the MS, except for a class A MS while in a circuit switched connection. The following cell re-selection criteria C31 and C32 are provided as a complement to the current GSM cell re-selection criteria. This provides a more general tool to make cell planning for GPRS as similar to existing planning in GSM as possible.

The algorithm described in subclause 6.5.6.2 is only applicable if the PBCCH is allocated. If the PBCCH is not allocated, then the MS shall perform cell re-selection according to the C2 criteria. Within a Routing Area, the MS shall use hysteresis when re-selecting a cell while in READY state. This hysteresis is applied to the C32 criteria (see subclause 6.5.6.2). As an option, the network operator may decide to use this hysteresis for the C31 criteria. This shall be indicated to the MS. The value of the hysteresis is given by the parameter GPRS_CELL_RESELECTION_HYSTERESIS which shall be broadcast on the PBCCH.

If the PBCCH is not allocated, the MS shall apply the parameter CELL_RESELECTION_HYSTERESIS to the C2 criteria. The CRH parameter is broadcast on the BCCH.

If the new cell is in a different routing area to the serving cell, then the MS shall apply a hysteresis , independent of whether the MS is in READY (This hysteresis is used instead of GPRS_CELL_RESELECT_HYSTERESIS) or STANDBY state, This hysteresis is given by the parameter RA_RESELECTION_HYSTERESIS and shall be broadcast on the PBCCH. If the PBCCH is not allocated, the MS shall use the CELL_RESELECTION_HYSTERESIS parameter which is broadcast on the BCCH.

6.5.6.1 Measurements for Cell Re-selection

The MS shall measure the received RF signal strength on the BCCH frequencies of the serving cell and the neighbour cells as indicated in the BA-GPRS list, and calculate the received level average (RLA) for each frequency, as specified in GSM 05.08. In addition the MS shall verify the BSIC of the cells. Only channels with the same BSIC as broadcast together with BA-GPRS on PBCCH shall be considered for re-selection.

In Wait state, the measurements and BSIC detection shall be made as for GSM in Idle mode as specified in 05.08 with the following modifications:

- The MS shall make one signal measurement on each frequency in the BA list in each DRX period.
- The MS shall make one attempt to check the BSIC for each of the 6 strongest cells every 14 DRX periods.

However, the requirements shall never be more stringent than for transfer state.

In Transfer state, the measurements and BSIC detection shall be made as for GSM in circuit switched mode as specified in 05.08, except for a half duplex MS which shall make the measurements as for GSM in Idle mode as specified in 05.08 but with the number of measurements made per second being 200, and the rate of BSIC detection shall be as for in circuit switched mode as specified in GSM 05.08. Some of the idle frames of the PDCH multiframe shall be used for BSIC detection, while the others are used for power control and timing advance procedures, see subclause 6.5.9.

When the number of downlink PDCHs assigned to certain types of multislot MS (see GSM 05.02, annex B) does not allow them to perform measurements within the TDMA frame, the network shall provide measurement windows to ensure that the MS will perform a number of measurements in line with the network requirements, up to 200 measurements per second. When dynamic allocation is used, the block period where the uplink acknowledgement is sent shall be used as the measurement window. During this block period, the network can only transmit on all downlink PDCHs in the list of assigned PDCHs up to and including the PDCH carrying the PACCH, so that the MS can perform measurements during unused PDCHs.

The network shall provide periodic intervals of inactivity during a transfer to or from a half duplex MS to allow the MS to make adjacent cell power measurements. The inactivity periods shall be distributed evenly in time in mobile terminated transfers and approximately evenly in time to mobile originated transfers. Parameters defining the inactivity periods are signalled in the Packet Resource Request, Packet Paging Request, and Downlink Inactivity Interval Notification messages.

The network shall provide periods of inactivity during a downlink transfer to a half duplex MS to allow the MS to perform BSIC detection. The length of the inactivity period is signalled in the Packet Ack/Nack for Downlink Transfer message. The network shall confirm the request with a Packet Inactivity Period Notification message. The MS shall confirm the Packet Inactivity Period Notification.

6.5.6.2 Cell Re-selection Algorithm

The following cell (re-)selection steps shall be followed ((s) and (n) denote serving cell and neighbour cell respectively).

1) Path loss criterion (C1)

The path loss criterion $C1 \geq 0$, as defined in GSM 05.08, shall be used as a minimum signal strength criterion for cell selection for GPRS in the same way as for GSM in Idle mode.

2) Signal strength threshold criterion (C31) for hierarchical cell structures (HCS)

The HCS signal strength threshold criterion (C31) shall be used to decide whether the cell is qualified for prioritised hierarchical cell re-selection.

$$C31(s) = RLA(s) - HCS\_THR(s) \geq 0 \qquad \text{(serving cell)}$$
$$C31(n) = RLA(n) - HCS\_THR(n) \geq 0 \qquad \text{(neighbour cell)}$$

where HCS_THR is the signal threshold for applying HCS re-selection.

3) Cell ranking (C32)

The cell ranking criterion (C32) shall be used to select cells among those with the same priority.

$$C32(s) = C1(s) + GPRS\_RESELECT\_OFFSET(s) \qquad \text{(serving cell)}$$
$$C32(n) = C1(n) + GPRS\_RESELECT\_OFFSET(n) - TEMPORARY\_OFFSET(n) * H(PENALTY\_TIME(n) - T(n)) \qquad \text{(neighbour cell)}$$

where

GPRS_RESELECT_OFFSET applies an offset and hysteresis value to each cell

$$H(x) = \begin{cases} 0 & \text{for } x < 0 \\ 1 & \text{for } x \geq 0 \end{cases}$$

TEMPORARY_OFFSET, PENALTY_TIME and T are defined in GSM 05.08.

4) Cell re-selection rules

The MS shall select the cell having the highest C32 value among those that have the highest priority class among those that fulfil the criterion $C31 \geq 0$.

The priority classes may correspond to different HCS layers. They may also be used for other purposes.

If no cells fulfil the criterion $C31 \geq 0$, the MS shall select the cell having the highest C32 value among all cells.

It shall be possible to order an MS in Ready state to send a measurement report to the network. The measurement report shall be regular packet transmission, addressed to the proper network entity.

It shall be possible for the network to order an individual MS in Ready state to perform cell re-selection to a cell appointed by the network, possibly in combination with a punishment parameter to prevent the MS immediate returning to the original cell. A network induces cell re-selection shall temporarily override the MS originated cell-selection.

6.5.6.3 Broadcast Information

A GPRS BA list shall be broadcast on PBCCH. It identifies the neighbour cells, including BSIC, that shall be considered for GPRS cell (re-)selection (not necessary the same as for GSM in Idle or circuit switched mode).

For each neighbour cell in this BA list, the parameters described below shall also be broadcast. In order to simplify the cell re-selection task for the MS, the C1 parameters, as defined in GSM 05.08, for all neighbour cells could also be broadcast on PBCCH.

The required parameters are shown in Table 6.

Table 6: Broadcast parameters

Parameter name	Description	Range	Bits	Channel
BA-GPRS	BCCH Allocation for GPRS cell re-selection.		See BCCH	PBCCH
BSIC(n)	Base Station Identity Code	0-63	6*n	PBCCH
Priority class (s+n) [FFS]	The HCS priority for the cells	0-7	3*(n+1)	PBCCH
HCS_THR(s+n)	HCS signal strength threshold	0-63	6*(n+1)	PBCCH
GPRS_RESELECT_OFFSET(s+n)	GPRS cell re-selection offset and hysteresis.	0-63	6(n+1)	PBCCH
TEMPORARY_OFFSET(n)	Additional offset for duration of PENALTY_TIME.	0-7	3*n	PBCCH
PENALTY_TIME(n)	Duration for which TEMPORARY_OFFSET is applied.	0-31	5*n	PBCCH
RXLEV_ACCESS_MIN(n)	See GSM 05.08	0-63	6*n	PBCCH
MS_TXPWR_MAX_CCH(n)	See GSM 05.08	0-31	5*n	PBCCH
Sum of bits			BA+31*n+[11*n]+21	

6.5.6.4 Optional measurement reports and network controlled cell re-selection

It shall be possible for the network to order the mobile stations to send measurement reports to the network and to suspend its normal cell re-selection, and instead to accept decisions from the network.

The degree to which the mobile station shall resign its radio network control shall be variable, and be ordered in detail by the parameter:

- NETWORK_CONTROL_ORDER.

The following actions shall be possible to order to the mobile stations:

NC0 **Normal MS control**
The MS performs autonomous cell re-selection.

NC1 **MS control with measurement reports**
The MS sends measurement reports to the network according to additional information in the message NC1. It continues its normal cell re-selection.

NC2 **Network control**
The MS sends measurement reports to the network according to additional information in the message NC2. It performs no cell re-selection on its own, and can only make a cell re-selection according to a cell re-selection command received from the network.

The time interval of the measurements shall be given by the parameter

- REPORTING_PERIOD REPORTING_PERIOD can take the values: 0.48, 0.96, 1.92, 3.84, 60, 120, 240, 480 seconds.

Two sets of parameters are broadcast on PBCCH and are valid in Transfer and Wait state respectively for all MSs in the cell. NETWORK_CONTROL_ORDER can also be sent individually to an MS on PACCH, in which case it overrides the broadcast parameter.

The measurement reports shall be sent individually from each MS as RLC transmissions, addressed to the RR management in BSS. The measurement reporting shall be maintained in the MS RR states Wait with Cell Update and Transfer and in the BSS RR states Measurement Report Reception and Transfer.

The measurement reports shall contain the measurements that the MS normally performs, as indicated by the BA-GPRS list, and shall include the following information:

- RXLEV serving cell;
- a quality measure for serving cell;
- number of valid neighbours;
- RXLEV up to 6 neighbours;
- broadcast frequency, identifying up to 6 neighbours.

The measurement report may contain RXLEV measurements, without BSIC verification, on additional frequencies, ordered for the benefit of frequency allocation schemes.

In Transfer state, the quality measure shall include the following measurements on the PDCH that contains PACCH:

- the average interference level γ_{ch} (see 6.5.8.3.2).

In Wait state, the quality measure shall include the following measurements on the PCCCH:

- the average interference level γ_{ch} (see subclause 6.5.8.3.2);
- a BER measure obtained from the PPCH of that MS.

The cell re-selection command shall include:

- target cell channel description (GSM 04.08);
- penalty to prevent immediate return (3 bits);
- penalty timer (5 bits).

Situations may appear where the network controlled cell re-selection procedures (NC1 or NC2 modes of operation) should not be used:

- When a class A mobile station is simultaneously involved in a circuit switched service and in a GPRS transfer. In this case, handover for the circuit switched service has precedence over GPRS network controlled cell re-selection. In order to avoid that measurements are reported twice by the MS (once for the GPRS resource, once for the circuit switched resource), thus leading to inefficient usage of the radio bandwidth, network controlled cell re-selection should not be activated in this case.
- When an MS is performing Anonymous Access, cell re-selection implying a change of Routeing Area results in the MS returning to the GPRS MM IDLE state, see GSM 03.60 [2]. Therefore, there might be cases where the network controlled cell re-selection would result in the Anonymous Access failing.

Since the BSS is not able to detect such situations, the MS shall inform the BSS when such a situation is encountered, so that the BSS can select a more appropriate mode of operation. This coordination procedure shall be as indicated hereafter:

- When an MS in Transfer or Wait state has been asked by the network to behave according to the NC1 or NC2 modes of operation and the MS encounters one of the above mentioned situations, it shall continue to report measurements and shall not obey to network controlled cell re-selection commands, if received and, in addition:
  - As soon as an uplink transmission opportunity occurs, the MS shall inform the network that the requested mode of operation should be suspended.
  - It shall be up to the network to decide whether to maintain or to change the mode of operation. The network shall reply with the value to be used.
  - The MS shall adapt its behaviour accordingly. If no answer is received from the network, the MS shall assume no change and shall continue to inform the network, as described above, until an answer is received.
- When the situation which triggered the above mentioned actions ends, and provided that the MS is still in Transfer or Wait state:

- As soon as an uplink transmission opportunity occurs, the MS shall inform the network that the initial mode of operation (NC1 or NC2) may resume.
- It shall be up to the network to decide whether to maintain or to change the mode of operation. The network shall reply with the value to be used.
- The MS shall adapt its behaviour accordingly. If no answer is received from the network, the MS shall assume no change (i.e. it shall continue to apply the last value received from the network) and it shall continue to inform the network, as described above, until an answer is received.

6.5.7 Timing Advance

The timing advance procedure is used to derive the correct value for timing advance that the MS has to use for the uplink transmission of radio blocks.

The timing advance procedure comprises two parts:

- initial timing advance estimation;
- continuous timing advance update.

6.5.7.1 Initial timing advance estimation

The initial timing advance estimation is based on the single access burst carrying the Packet Channel Request. The Packet Immediate Assignment or Packet Resource Assignment then carries the estimated timing advance value to the MS. This value shall be used by the MS for the uplink transmissions until the continuous timing advance update provides a new value (see subclause 6.5.7.2.).

Two special cases exist:

- when Packet Queuing Notification is used the initial estimated timing advance may become too old to be sent in the Packet Immediate Assignment
- when Packet Immediate Assignment is to be sent without prior paging (i.e., in the Ready state), no valid timing advance value may be available.

Then the network has three options:

- the Packet Polling Message can then be used to trigger the transmission of an access burst from which the timing advance can be estimated.
- Aa Packet Immediate Assignment can be sent without timing advance information. In that case it is indicated to the MS that it can only start the uplink transmission after the timing advance is obtained by the continuous timing advance update procedure.
- the Packet Immediate Assignment indicates that a default timing advance is to be used. That applies for cells with small enough radius.

6.5.7.2 Continuous timing advance update

MS in Transfer state shall use the continuous timing advance update procedure. The continuous timing advance update procedure is carried only on the PDCH which carries PACCH.

For uplink packet transfer, within the Packet Immediate Assignment or Packet Resource Assignment for Uplink , the MS is assigned resources on one or several uplink PDCHs with corresponding Uplink State Flags (USF) and Timing Advance Index (TAI).

For downlink packet transfer, within the Packet Resource Assignment for Downlink, the MS is assigned resources on one or several uplink PDCHs, Timing Advance Index (TAI) and the PDCH used for the continuous timing advance update procedure. The TAI is 4 bits allowing 16 different positions in groups of eight 52-multiframes (T0,T1,…T15).

On the uplink, the MS shall send in assigned idle slots a special access burst, which is used by the network to derive the timing advance. The position of the assigned idle slot is determined by the TAI assigned to the MS on that PDCH (see

Figure 7). These access bursts have cause value 01111111 for the 8 information bits access bursts, and 1111 1111 111 for the 11 information bits access burst.

The network analyses the received access burst and determines new timing advance values for all MSs performing the continuos timing advance update procedure on that PDCH. The new timing advance values shall be sent via a downlink signalling message (TA-message) mapped on the idle slots in the same way as SACCH (see Figure 7).

If an MS is allocated different TAI-values for simultaneous uplink and downlink packet transfer, the MS may chose to use any one or both of the idle slots determined by the TAI values to send access bursts. In case both slots are used, the MS shall use the received TA value corresponding to the last transmitted burst.

The mechanism works without knowledge of the MS identity by the BTS and there is no need for interactions between the BTS and the Packet Control Unit.

6.5.7.2.1 Mapping on the multiframe structure

Figure 7 shows the mapping of the uplink access bursts and downlink TA-messages on groups of eight 52-multiframes:

- the TAI value shows the position where a slot is reserved for a MS to send an access burst (e.g. T1 means 52-multiframe number n and idle slot number 2);
- every second, idle slot shall be used for uplink access bursts and every second PDCH multiframe starts a downlink TA-message.

52-multiframe number n:

uplink TAI=0 TAI=1

B0	B1	B2	0	B3	B4	B5	1	B6	B7	B8	2	B9	B10	B11	3

downlink TA_message 1 TA message 1

52-multiframe number n + 1:

uplink TAI=2 TAI=3

B0	B1	B2	4	B3	B4	B5	5	B6	B7	B8	6	B9	B10	B11	7

downlink TA message 1 TA message 1

52-multiframe number n + 2:

uplink TAI=4 TAI=5

B0	B1	B2	8	B3	B4	B5	9	B6	B7	B8	10	B9	B10	B11	11

downlink TA message 2 TA message 2

<u>52-multiframe number n + 3:</u>

uplink TAI=6 TAI=7

B0	B1	B2	12	B3	B4	B5	13	B6	B7	B8	14	B9	B10	B11	15

downlink TA message 2 TA message 2

<u>52-multiframe number n + 4:</u>

uplink TAI=8 TAI=9

B0	B1	B2	16	B3	B4	B5	17	B6	B7	B8	18	B9	B10	B11	19

downlink TA message 3 TA message 3

<u>52-multiframe number n + 5:</u>

uplink TAI=10 TAI=11

B0	B1	B2	20	B3	B4	B5	21	B6	B7	B8	22	B9	B10	B11	23

downlink TA message 3 TA message 3

<u>52-multiframe number n + 6:</u>

uplink TAI=12 TAI=13

B0	B1	B2	24	B3	B4	B5	25	B6	B7	B8	26	B9	B10	B11	27

downlink TA message 4 TA message 4

<u>52-multiframe number n + 7:</u>

uplink TAI=14 TAI=15

B0	B1	B2	28	B3	B4	B5	29	B6	B7	B8	30	B9	B10	B11	31

downlink TA message 4 TA message 4

B0 - B11 = Radio blocks
idle bursts are numbered from 0 to 31

Figure 7: Mapping of the uplink access bursts and downlink timing advance signalling messages

The BTS shall update the timing advance values in the next TA-message following the access burst. To illustrate this, an MS that transmits an access burst in idle slots 0, 2, 4, or 6 receives its updated timing advance value in TA message 2. This MS can also find this updated timing advance value in subsequent TA messages 3, 4, and 1, but only has to read these if TA message 2 was not received correctly.

An MS entering the Transfer state shall ignore the TA-messages until the MS has sent its first access burst. This is to avoid the use of timing advance values, derived from access bursts sent by the MS that previously used the same TAI.

6.5.8 Power control procedure

Power control shall be supported in order to improve the spectrum efficiency and to reduce the power consumption in the MS.

For the uplink, the MS shall follow a flexible power control algorithm, which the network can optimise through a set of parameters. It can be used for both open loop and closed loop power control.

For the downlink, the power control is performed in the BTS. Therefore, there is no need to specify the actual algorithms, but information about the downlink performance is needed. Therefore the MSs have to transfer Channel Quality Reports to the BTS.

All calculations in this subclause are done in dBm.

Power control is not applicable to point-to-multipoint multicast services.

6.5.8.1 MS output power

The MS shall calculate the power value to be used on each channel, CH, assigned to the MS:

$$P_{CH} = \min(\Gamma_{CH} - \alpha\, C, P_{Max}), \quad (1)$$

where

Γ_{CH} is an MS and channel specific power control parameter. It is sent to the MS in any resource assigning message. Further, the network can, at any time during a packet transfer, send new Γ_{CH} values to the MS on the downlink PACCH.

$\alpha \in [0,1]$ is a system parameter. Its default value is broadcast on the PBCCH. Further, MS and channel specific values can be sent to the MS together with Γ_{CH}.

C is the received signal level at the MS.

P_{Max} is the maximum allowed output power in the cell (broadcast parameter) or the MS power class whichever is the smallest.

Equation (1) is not used to determine the output power when access bursts are used (Packet Channel Request and Packet Polling Response), in which case P_{Max} shall be used.

6.5.8.2 BTS output power

The BTS shall use constant power on those PDCHs which have PCCCH functionality. On the other PDCHs, downlink power control may be used. Thus, a procedure may be implemented in the network to control the power of the downlink transmission based on the Channel Quality Reports. The algorithm needs not to be specified here and can be optimised by the network operator.

6.5.8.3 Measurements at MS side

A procedure shall be implemented in the MS to monitor periodically the downlink Rx signal level and quality from its serving cell. The measurements are done on the assigned PDCH(s) if the MS is transferring data, otherwise the measurements are done on PCCCH or BCCH.

6.5.8.3.1 Deriving the C value

This subclause comprises information about how the MS shall derive the C value in (1).

Wait state

In Wait state, the MS shall periodically measure the signal strength of the PCCCH or, if PCCCH is not existing, the BCCH.

When PCCCH exists, the MS shall measure the signal strength of N_{AVG} Radio Blocks during a measurement period of T_{AVG} multiframes (multiframe of PDCH).

When PCCCH does not exist, the MS shall measure the signal strength of N_{AVG} blocks (of CCCH or BCCH) during a measurement period of T_{AVG} multiframes (multiframe of CCCH).

The C value for each Radio Block is calculated:

$$C_{block\ n} = SS_{block\ n} + Pb_{block\ n}\ . \qquad (2)$$

$SS_{block\ n}$ is the mean of the signal strength of the four normal bursts that consists the block.

$Pb_{block\ n}$ is the BTS output power reduction (relative to the maximum BTS output power used in the cell), which is transferred in the MAC Header of the Radio Block. If the block is not received correctly, the corresponding measurement is discarded. The corrected C value provides a measure of the path loss (Path loss = BTS maximum output power - $C_{block\ n}$).

Finally, the $C_{block\ n}$ values are filtered with a running average filter:

$$C_n = (1-a) * C_{n-1} + a * C_{block\ n},\ C_0=0, \qquad (3)$$

where a is the forgetting factor:

$a = 1/MIN(n, N_{AVG})$.

An RMS value of the corrected signal levels may also be derived and included in the channel quality report (see subclause 6.5.7.3.2) [FFS].

The current C_n value shall be used in (1) when the MS transfers its first Radio Block.

N_{AVG} and T_{AVG} are broadcast on PBCCH or, if PBCCH does not exist, on BCCH.

Transfer state

In Transfer state, the MS measures the signal strength only on the PDCH where the MS receives/transmits PACCH. For each downlink Radio Block $C_{block\ n}$ shall be derived according to (2). Finally, the $C_{block\ n}$ value parameters are filtered with a running average filter:

$$C_n = (1-b) * C_{n-1} + b * C_{block\ n}, \qquad (4)$$

where b is the forgetting factor:

$b = 1/(12*T_{AVG\_T})$.

C_0 is obtained from the measurements done when not transferring data.

The C value in (1) (and thus P_{CH}) shall be updated to the current C_n value every T_{AVG_T} multiframes or whenever the MS receives new Γ_{CH} values (and perhaps also a new α value). Further, if the broadcast parameter UPDATE_C is set, then the MS shall update the C value each time a new C_n value is obtained.

A half duplex MS transferring a packet in the uplink shall not update C (and thus P_{CH}) for the duration of its uplink allocation.

UPDATE_C and T_{AVG_T} are broadcast on PBCCH or, if PBCCH does not exist, on BCCH.

6.5.8.3.2 Derivation of Channel Quality Report

The channel quality is measured as the interference signal level during the idle frames of the multiframe, when the serving cell is not transmitting.

Transfer state

In Transfer state, the MS shall measure the interference signal strength of all eight channels (slots) on the same carrier as the assigned PDCHs. Some of the idle frames shall be used for this, while the others are used for BSIC identification and timing advance signalling, see subclause 6.5.9.

The MS may not be capable of measuring all eight channels when allocated some configurations of channels. The MS shall measure as many channels as its allocation allows considering its multislot capability.

The slots that the MS measures on can be either idle or used by SACCH. The MS shall therefore, for each slot, take the minimum signal strength $SS_{CH,n}$ of two consecutive idle frames. Thus the SACCH frames are avoided (except for a TCH/H with two MSs) and only the interference is measured. The measured interference shall be average in a running average filter:

$$\gamma_{CH,n} = (1-d) * \gamma_{CH,n-1} + d * SS_{CH,n}, \gamma_{CH,0} = 0 \qquad (5)$$

where d is the forgetting factor:

$d = 1/MIN(n, N_{AVG\_I})$.

For each slot, the MS shall perform at least N_{AVG_I} measurements of $SS_{CH,n}$ before valid γ_{CH} values can be determined.

The MS shall transfer the 8 γ_{CH} values and the C value (see subclause 6.5.8.3.1) to the network in the Channel Quality Report included in the ACK/NACK message.

N_{AVG_I} is broadcast on PBCCH or, if PBCCH does not exist, on BCCH.

Wait state

In wait state, the MS shall measure the interference signal strength on certain channels which are indicated on the PBCCH. If no channels are indicated or if PCCCH does not exist, the MS shall not perform these measurements.

These measurements shall be made in the idle frames in the same way as described above and averaged with a running average filter according to (5).

For each channel, the MS shall perform at least N_{AVG_I} interference measurements during a period of T_{AVG_I} multiframes (multiframe of PDCH) before valid γ_{CH} values can be determined. Upon entering Transfer state, the 8 lowest $\gamma_{CH,n}$ values and the C value (see 6.5.8.3.1) shall be transferred to the network in the Channel Quality Report included in the Packet Resource Request or Packet Paging Response. If none of these messages are used, no Channel Quality Report is sent.

T_{AVG_I} and N_{AVG_I} are broadcast on PBCCH.

On network command

When the MS is in Wait state, the network may request an MS to do interference measurements of certain channels, TCHs or PDCHs. The MS shall, in such case, do the measurements and filtering in the same way as described above, except that the channels to be measured and the filtering parameters are given in the Measurement Order. The averaged measurements shall then be transferred to the network as a Measurement Performed message.

6.5.8.4 Measurements at BSS side

A procedure shall be implemented in the BSS to monitor the uplink Rx signal level and quality on each uplink PDCH, active as well as inactive.

The BSS shall also measure the Rx signal level and the quality of a specific MS packet transfer.

6.5.9 Scheduling of idle frame activities

The MS shall use the idle frames of the PDCH multiframe for the following tasks:

- BSIC identification for cell selection (6.5.6.1)
- Continuous timing advance procedures (6.5.7.2)
- Interference measurements for power control (6.5.8.3.2)

It is not necessary to exactly specify the scheduling of these tasks.

The idle frames required for timing advance signalling is stated in 6.5.7.2.1. During the frames when the MS receives TA-messages it can also make interference measurements. During the frames when the MS transmits access bursts it may also be possible to make measurements on some channels.

The MS shall schedule the BSIC identification as efficiently as possible, using the remaining idle frames and also considering the requirements for interference measurements. When the MS is synchronised to a BTS, it knows the timing of the SCH. Therefore, only a few certain idle frames are required for BSIC identification. In those frames it may also be possible to make measurements on some channels. When the MS shall synchronise to a new BTS, it has to prioritise that task. It may then use half of the idle frames, i.e. the same amount as available for circuit switched connections.

The remaining idle frames shall be used for interference measurements.

6.5.10 Discontinuous Reception (DRX)

NOTE: The text in this subclause is informative. The normative text is in GSM 05.02 [4]. Where there is a conflict between these descriptions, the normative text has precedence.

DRX (sleep mode) shall be supported when the MS is in RR Wait with Cell Update or Wait with Routing Update states. DRX is independent from MM states Ready and Standby.

Negotiation of DRX parameters is per MS. An MS may choose to use DRX or not together with some operating parameters. The following parameters are established:

- **DRX/non-DRX indicator**
  It indicates whether the MS uses DRX or not.
- **DRX period**
  A conditional parameter for MSs using DRX to determine the right paging group. The DRX period is defined by the parameter SPLIT_PG_CYCLE according to Table 8. This results in a DRX period of about 15.36/SPLIT_PG_CYCLE seconds.
- **Non-DRX timer**
  A conditional parameter for MSs using DRX to determine the time period within which the non-DRX mode is kept after leaving the Transfer state. The support for this feature is optional on the network side and the information about the maximum supported value for the timer in the cell is broadcast on PBCCH.

An MS in DRX mode is only required to monitor the radio blocks defined by its paging group in the same way as in GSM 05.02. The paging group for GPRS is defined as:

PAGING_GROUP (0 ... N-1) = ((IMSI mod 1000) mod (KC * N) +
Max((n * N) div SPLIT_PG_CYCLE, n)) mod N
for n = 0, ... , Min(N, SPLIT_PG_CYCLE) -1

where

KC = number of (P)CCCH in the cell =
BS_PCC_CHANS for PCCCH,
BS_CC_CHANS for CCCH.

N = number of paging blocks “available” on one (P)CCCH =
(12 - BS_PAG_BLKS_RES - BS_PBCCH_BCLKS) * 64 for PCCCH,
(9 - BS_AG_BLKS_RES) * 64 for CCCH,
(3 - BS_AG_BLKS_RES) * 64 for combined CCCH-SDCCH.

IMSI = International Mobile Subscriber Identity, as defined in GSM 03.03.

mod = Modulo.

div = Integer division.

This paging group definition is optional on CCCH for both BTS and MS. If not supported, the same definition as in GSM 05.02, shall be used. The parameters used to define the paging group for GPRS are shown in the Table 7, together with the corresponding GSM parameters which they replace in the other formulas in GSM 05.02. BS_PCC_CHANS is the number of PDCHs containing PCCCH.

An MS in non-DRX mode is required to monitor all the radio blocks where PCCCH may be mapped on the PDCH defined by its paging group.

When page for circuit-switched services is conveyed on PPCH, it follows the same scheduling principles as the page for packet data. The same is valid for scheduling of resource assignments for downlink packet transfers for MSs in Ready State (i.e. where no paging is performed).

The MS may need to monitor also PNCH in the case of PTM-M services.

NOTE: Paging reorganisation may be supported in the same way as for circuit switched GSM.

Table 7: Parameters for DRX operation

Parameter	GPRS		Corresponding GSM parameters
	PCCCH	CCCH	CCCH
DRX period	SPLIT_PG_CYCLE	BS_PA_MFRMS *) SPLIT_PG_CYCLE **)	BS_PA_MFRMS
Blocks not available for PPCH per multiframe	BS_PAG_BLKS_RES + BS_PBCCH_BLKS	BS_AG_BLKS_RES	BS_AG_BLKS_RES
Number of physical channels containing paging	BS_PCC_CHANS	BS_CC_CHANS	BS_CC_CHANS

*) Only when DRX period split is not supported.
**) Only when DRX period split is supported.

Table 8: Coding of parameter SPLIT_PG_CYCLE

Broadcast code	Parameter value	Broadcast code	Parameter value
0	DRX not used	81	112
1 to 64	1 to 64 respectively	82	116
65	71	83	118
66	72	84	128
67	74	85	141
68	75	86	144
69	77	87	150
70	79	88	160
71	80	89	171
72	83	90	176
73	86	91	192
74	88	92	214
75	90	93	224
76	92	94	235
77	96	95	256
78	101	96	288
79	103	97	320
80	107	98	352
		99 to 127	reserved; interpreted as 1

6.6 Medium Access Control and Radio Link Control Layer

The Medium Access Control (MAC) and Radio Link Control (RLC) layer operates above the Physical Link layer in the reference architecture.

6.6.1 Layer Services

The MAC function defines the procedures that enable multiple MSs to share a common transmission medium, which may consist of several physical channels. The MAC function provides arbitration between multiple MSs attempting to transmit simultaneously and provides collision avoidance, detection and recovery procedures. The operations of the MAC function may allow a single MS to use several physical channels in parallel, but not on the same time slot number.

The RLC function defines the procedures for a bitmap selective retransmission of unsuccessfully delivered RLC Data Blocks.

6.6.2 Layer Functions

The GPRS MAC function is responsible for:

- Providing efficient multiplexing of data and control signalling on both uplink and downlink, the control of which resides on the Network side. On the downlink, multiplexing is controlled by a scheduling mechanism. On the uplink, multiplexing is controlled by medium allocation to individual users (e.g., in response to service request).

- For mobile originated channel access, contention resolution between channel access attempts, including collision detection and recovery.

- For mobile terminated channel access, scheduling of access attempts, including queuing of packet accesses.

- Priority handling.

The GPRS RLC function is responsible for:

- Interface primitives allowing the transfer of Logical Link Control layer PDUs (LLC-PDU) between the LLC layer and the MAC function.

- Segmentation and re-assembly of LLC-PDUs into RLC Data Blocks.

- Backward Error Correction (BEC) procedures enabling the selective retransmission of uncorrectable code words.

NOTE: The Block Check Sequence for error detection is provided by the Physical Link Layer.

6.6.3 Service Primitives

Table 9 lists the service primitives provided by the RLC/MAC layer to the upper layers:

Table 9: Service primitives provided by the RLC/MAC layer to the upper layers

Name	request	indication	response	confirm	comments
RLC/MAC-DATA	x	x			used for the transfer of upper layer PDUs. Acknowledged mode of operation in RLC is used. The upper layer shall be able to request high transmission quality via a primitive parameter.
RLC/MAC-UNITDATA	x	x			used for the transfer of upper layer PDUs. Unacknowledged mode of operation in RLC is used.
RLC/MAC-PTM_DATA	x	x			used for transfer of PTM information. Unacknowledged mode of operation in RLC is used. The repeat count specifies the number of re-transmissions in the RLC level.
RLC/MAC-PAGING	x	x	x	x	used to page MS
RLC/MAC-STATUS		x			used to indicate that the network is unable to deliver data, e.g., the number of RLC re-transmissions or the number of random accesses has been exceeded

6.6.4 Model of Operation

Each PDCH is a shared medium between multiple MSs and the Network. Direct communication is possible only between an MS and the Network.

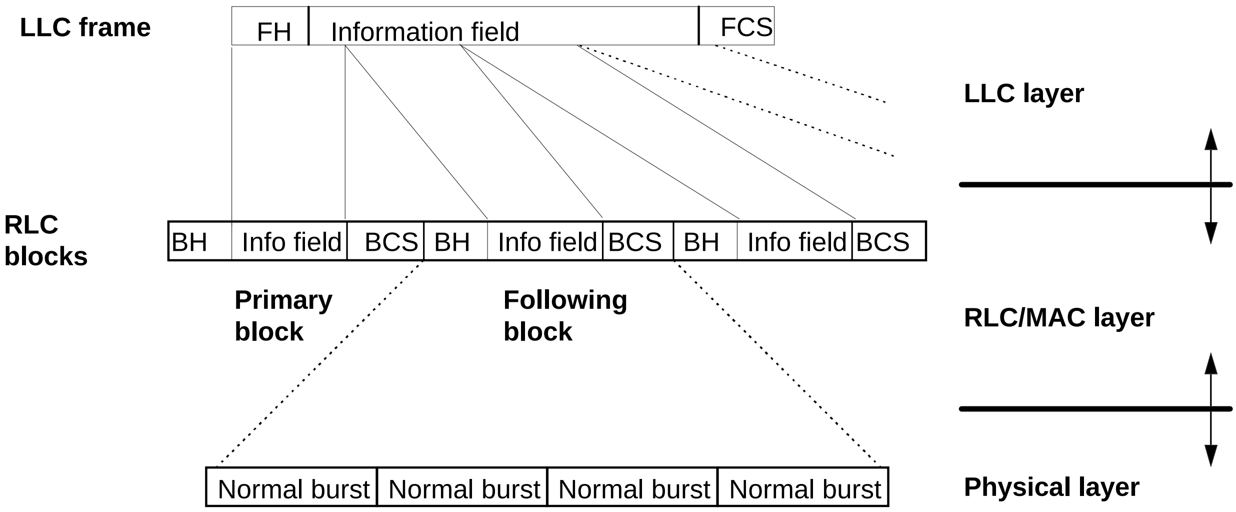
The GPRS radio interface consists of asymmetric and independent uplink and downlink channels. The downlink carries transmissions from the Network to multiple MSs and does not require contention arbitration. The uplink is shared among multiple MSs and requires contention control procedures.

The allocation of radio resources by the PLMN and the use of these resources by the MSs can be broken down into two parts:

- The PLMN allocates radio resources for the GPRS (uplink and downlink) in a symmetric manner.
- The allocated uplink and downlink radio resources for point-to-point, point-to-multipoint multicast or group call service types are used independently of each other. Dependent allocation of uplink and downlink shall be possible, in order to allow simple MSs to transfer data simultaneously in both directions. Allocation of several PDTCHs for one MS is possible.

The access to the GPRS uplink uses a Slotted-Aloha based reservation protocol. The Access Burst specified in GSM 05.01 [3] is used. The Packet Channel Request sent by an MS is responded by a Packet Immediate Assignment message indicating the uplink resources reserved for the MS.

The Network Protocol Data Units (N-PDU) are segmented into the Subnetwork Protocol Data Units (SN-PDU) by the Subnetwork Dependent Convergence (SNDC) protocol and SN-PDUs are encapsulated into one or several LLC frames. LLC frames are of variable length. The maximum size of the LLC frame is 1600 octets minus BSSGP protocol control information. See GSM 03.60 [2] for information on SNDC and LLC. The details on SNDC can be found in GSM 04.65 [11] and the details on LLC can be found in GSM 04.64 [12]. LLC frames are segmented into RLC Data Blocks. At the RLC/MAC layer, a selective ARQ protocol (including block numbering) between the MS and the Network provides retransmission of erroneous RLC Data Blocks. When a complete LLC frame is successfully transferred across the RLC layer, it is forwarded to the LLC layer.



FH = Frame Header
FCS = Frame Check Sequence
BH = Block Header
BCS = Block Check Sequence
(When SDCCH coding is used, BCS corresponds to the Fire code)

Figure 8: Transmission and reception data flow

6.6.4.1 Uplink State Flag

The Uplink State Flag (USF) is used on PDCH to allow multiplexing of Radio blocks from a number of MSs.

When the SDCCH coding scheme is used, the USF comprises 3 bits at the beginning of each Radio Block that is sent on the downlink. It enables the coding of 8 different USF states which are used to multiplex the uplink traffic.

On PCCCH, one USF value is used to denote PRACH (USF=FREE). The other USF values USF=R1/R2/...R7 are used to reserve the uplink for different MSs. On PDCHs not carrying PCCCH, the eight USF values USF=R1/R2/.../R8 are used to reserve the uplink for different MSs. One USF value shall be used to prevent collision on uplink channel, when MS without USF is using uplink channel. The USF points either to the next uplink Radio Block or the sequence of 4 uplink Radio Blocks starting with the next uplink Radio Block.

The MS shall send the Packet Channel Request in one of the four bursts on the Radio Block used for PRACH (indicated by setting USF=FREE). In the access, the burst is selected randomly.

6.6.4.2 Temporary Flow Identity

The method of implementing the selective ARQ protocol on the RLC level includes the assignment of a Temporary Flow Identity (TFI) to each Temporary Block Flow (TBF) transmitted to/from an MS. One TBF may comprise a number of LLC frames. The assigned TFI is unique among concurrent LLC frame transfer sequences in a cell and is used instead of the MS identity in the RLC/MAC layer. The TFI is assigned in a resource assignment message that precedes the transfer of LLC frames belonging to one TBF to/from the MS. The same TFI is included in every RLC header belonging to a particular TBF as well as in the control messages associated to the LLC frame transfer (e.g. acknowledgements) in order to address the peer RLC entities. The length of TFI is 7 bits.

6.6.4.3 Acknowledged mode for RLC/MAC operation

The transfer of RLC Data Blocks in the acknowledged RLC/MAC mode is controlled by a selective ARQ mechanism coupled with the modulo-128 numbering of the RLC Data Blocks within one Temporary Block Flow. The sending side (the MS or the network) transmits blocks within a window of 64 blocks and the receiving side periodically sends temporary Packet Ack/Nack message. Every such message acknowledges all correctly received RLC Data Blocks up to an indicated block number, thus “moving” the beginning of the sending window on the sending side. Additionally, the bitmap that starts at the same RLC Data Block is used to selectively request erroneously received RLC Data Blocks for retransmission. The sending side then retransmits the erroneous RLC Data Blocks, eventually resulting in further sliding the sending window. The temporary Packet Ack/Nack message does not include any change in the current assignment (and thus does not have to be acknowledged when sent on downlink). A missing temporary Packet Ack/Nack is not critical and a new one can be issued whenever.

When receiving uplink data from a MS the network shall maintain a count of the number of erroneous blocks received from the MS and allocate additional resources automatically. The allocation may be communicated in a packet Ack/Nack or an unsolicited resource assignment on the PACCH.

6.6.4.4 Unacknowledged mode for RLC/MAC operation

The transfer of RLC Data Blocks in the unacknowledged RLC/MAC mode is controlled by the modulo-128 numbering of the RLC Data Blocks within one Temporary Block Flow and does not include any retransmissions. The receiving side extracts user data from the received RLC Data Blocks and attempts to preserve the user information length by replacing missing RLC Data Blocks by dummy information bits.

The same mechanism and message format for sending temporary acknowledgement messages is used as for acknowledged mode in order to convey the necessary control signalling (e.g. monitoring of channel quality for downlink channel or timing advance correction for uplink transfers). The fields for denoting the erroneous RLC blocks may be used as an additional measure for channel quality (i.e. parameter for link adaptation). The sending side (the MS or the network) transmits a number of radio blocks (e.g. 64 blocks) and then polls the receiving side to send a temporary Packet Ack/Nack message. Further, the transfer of data does not even have to be interrupted when receiving such temporary Ack/Nack message if the MS is capable of sending and receiving in the same TDMA frames for that particular channel assignment. The temporary Packet Ack/Nack message does not include any change in the current assignment. A missing temporary Packet Ack/Nack is not critical and a new one can be obtained whenever.

6.6.4.5 Mobile Originated Packet Transfer

6.6.4.5.1 Uplink Access

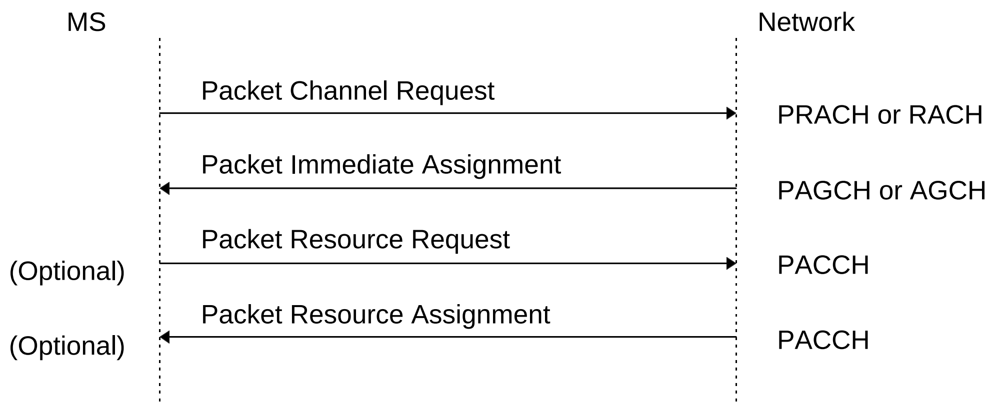


Figure 9: Access and allocation for the one or two phase packet access, uplink packet transfer

An MS initiates a packet transfer by making a Packet Channel Request on PRACH or RACH. The network responds on PAGCH or AGCH respectively. It is possible to use one or two phase packet access method (see Figure 9).

In the one phase access, the Packet Channel Request is responded by the network with the Packet Immediate Assignment reserving the resources on PDCH(s) for uplink transfer of a number of Radio blocks. The reservation is done accordingly to the information about the requested resources that is comprised in the Packet Channel Request. On RACH, there is only one cause value available for denoting GPRS and the network can assign uplink resources on 1 or 2 PDCHs. On PRACH, the Packet Channel Request may contain more adequate information about the requested resources and, consequently, uplink resources on one or several PDCHs can be assigned by using the Packet Immediate Assignment message.

In the two phase access, the Packet Channel Request is responded with the Packet Immediate Assignment which reserves the uplink resources for transmitting the Packet Resource Request. The Packet Resource Request message carries the complete description of the requested resources for the uplink transfer. Thereafter, the network responds with the Packet Resource Assignment reserving resources for the uplink transfer.

There is also a case where the network side, in the Packet Immediate Assignment, reserves uplink resources for transmission of a number of Radio blocks (i.e. one phase access) but the MS is not satisfied with the assigned resources (e.g. only on 1 time slot). In such case, the MS can override the one step access by sending the Packet Resource Request on the assigned resource (i.e. MS initiated two phase access).

The Packet Immediate Assignment and the Packet Resource Assignment messages include Timing Advance (TA) and Power Control (PC) information.

If there is no response to the Packet Channel Request within predefined time period, the MS makes a retry after a random backoff time.

On PRACH there is used a 2-step approach including a long-term and a short-term estimation of the persistence (see Figure 10). The optimal persistence of the mobile stations is calculated at the network side.

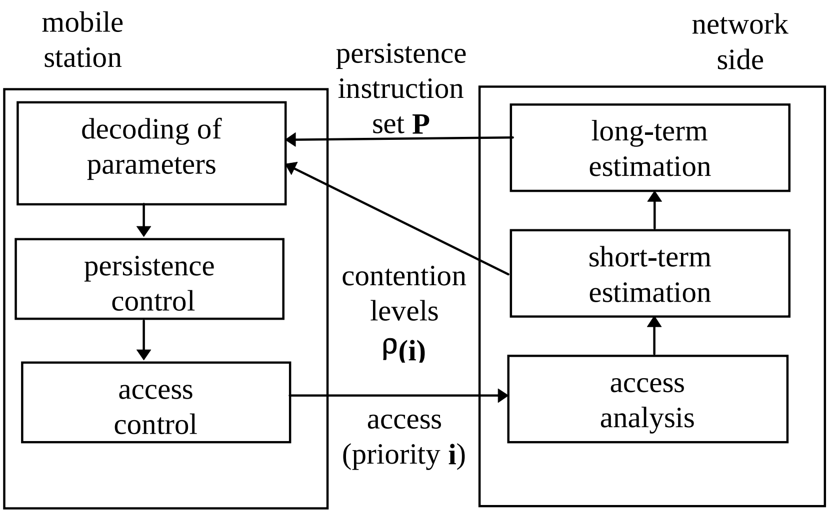


Figure 10: Basic principle of random access traffic control

The actual persistence values depend on:

- the priority i of the packet to be transmitted;
- the amount of traffic within higher priority classes;
- the amount of traffic within the own priority class.

The short-term estimation indicates the contention level ρ, which comprises 4 classes (1, 2, 3 and 4). The values of the actual contention level ρ(i) for each priority i (i = 1..4), where priority 1 represents the highest priority, are broadcast on the PBCCH.

The long-term estimation is realized as a set of access parameters k_{ij} for all priorities i and contention levels ρ(i) and is broadcast only occasionally on the PBCCH to the MS.

In the MS a function is predefined to decode the received access parameters. It results a value π(ρ(i)), which is used to calculate the access probability of the given priority:

$$\pi(\rho(i)) = 1/2^{k_{ij}} \quad \text{for } k_{ij} \neq 15 \qquad (6)$$

$$\pi(\rho(i)) = 0 \quad \text{for } k_{ij} = 15$$

The access probability p(i) for the priority i is calculated as follows:

$$p(i) = \prod_{k=1}^{i} \pi(\rho(k)) \qquad (7)$$

The resulting access probability p(i) is compared with a generated random number r=1/2^k, k=rand[0...15] ($k\in N$). If p(i)>r, the MS is allowed to send the random access. The determination of number of slots belonging to the MS's PRACH between two successive Packet Channel Request messages (excluding the slots containing the messages themselves) is defined in GSM 04.08. If p(i)<r, the MS suppresses the sending of the random access and restarts the backoff procedure.

Optionally, the existing backoff algorithm on RACH can be used on PRACH.

On RACH, the existing backoff algorithm shall be used.

Occasionally, more Packet Channel Requests can be received than can be served. To handle this, a Packet Queuing Notification is transmitted to the sender of the Packet Channel Request. The notification includes information that the Packet Channel Request message is correctly received and Packet Immediate Assignment may be transmitted later. Packet Queuing Notification can be concatenated with the Packet Immediate Assignment to another MS in the same downlink Radio Block. If the Timing Advance information becomes inaccurate for an MS, the Packet Polling can be used to estimate the new Timing Advance before issuing the Packet Immediate Assignment.

6.6.4.5.2 Dynamic allocation

6.6.4.5.2.1 Uplink Packet Transfer

The Packet Immediate Assignment message includes the list of PDCHs and the corresponding USF value per PDCH. A unique TFI is allocated and is thereafter included in each RLC Data and Control Block related to that Temporary Block Flow. The MS monitors the USFs on the allocated PDCHs and transmits Radio blocks on those which currently bear the USF value reserved for the usage of the MS.

If the resource assigned by the network does not allow the multislot MS (see GSM 05.02, annex B) to monitor the USF on all the assigned PDCHs, the following rules shall apply:

- Whenever the MS receives its USF on one downlink PDCH (e.g. on timeslot 0 while timeslots 0, 2 and 3 were assigned), it shall consider the corresponding uplink block and all subsequent ones from the list of assigned PDCHs as allocated (e.g. on 0, 2 and 3). Hence, if the network allocates a block to this MS on an assigned PDCH, it shall also allocate blocks to this MS on all subsequent PDCHs in the list. For each allocated block, the network shall set the USF to the value reserved for the usage of that MS. These rules apply on a block period basis.

- During block periods where it is transmitting, the MS shall monitor the USF on each PDCH in the list of assigned PDCHs, up to and including the first PDCH currently used for transmission. This rule applies on a block period basis. For example, if timeslots 0, 2 and 3 have been assigned and blocks are currently allocated on timeslots 2 and 3, then during this block period the MS monitors USF on timeslots 0 and 2. If the reserved value of USF is found on timeslot 0, then the next allocated blocks shall be on timeslots 0, 2 and 3. If the reserved value of USF is found on timeslot 2, then the next allocated blocks shall be on timeslots 2 and 3. And so on for the subsequent block periods.

Because each Radio Block includes an identifier (TFI), all received Radio blocks are correctly associated with a particular LLC frame and a particular MS, thus making the protocol highly robust. By altering the state of USF, different PDCHs can be "opened" and "closed" dynamically for certain MSs thus providing a flexible reservation mechanism. Additionally, packets with higher priority and pending control messages can temporarily interrupt a data transmission from one MS.

The channel reservation algorithm can also be implemented on assignment basis. This allows individual MSs to transmit a predetermined amount of time without interruptions.

The MS may be allowed to use the uplink resources as long as there is queued data on the RLC/MAC layer to be sent from the MS. It can comprise a number of LLC frames. In that sense the radio resources are assigned on the initially "unlimited" time basis. Alternatively, the uplink assignment for each assignment may be limited to a number of radio blocks (e.g. in order to offer more fair access to the medium at higher loads).

The selective ARQ operation for the acknowledged RLC/MAC mode is described in Subclause 6.6.4.3. The acknowledgement procedure of the LLC layer is not combined with the acknowledgement procedure on the underlying RLC/MAC layer. The unacknowledged RLC/MAC mode operation is described in Subclause 6.6.4.4.

Figure 11 shows an example of message sequence for the (multislot) uplink data transfer with one resource reassignment and possible RLC Data Block re-transmissions.

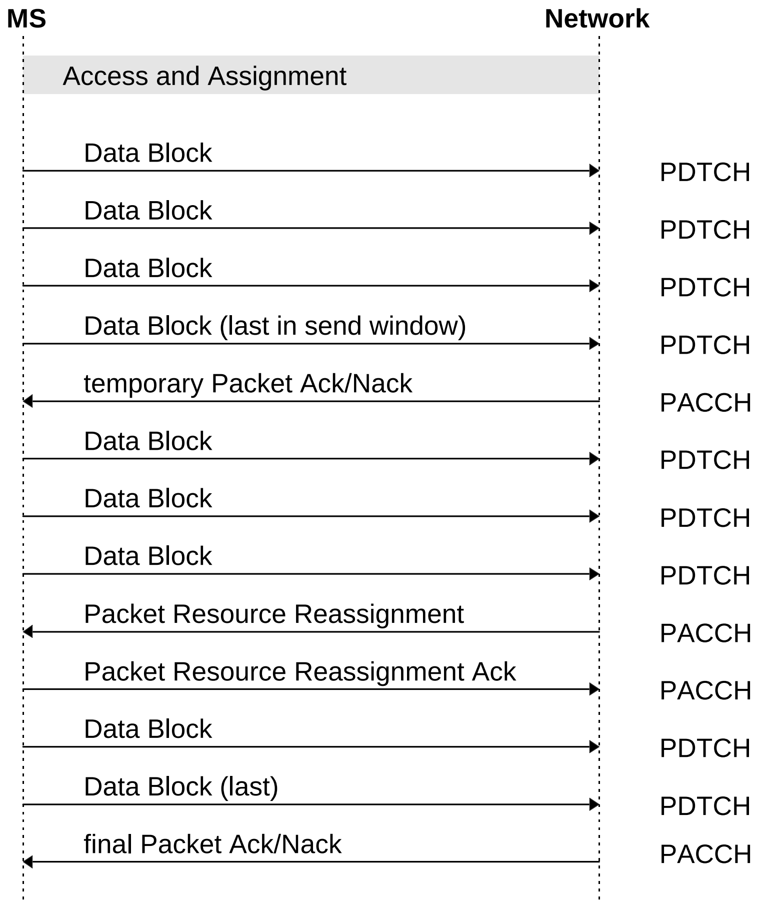


Figure 11: An example of dynamic allocation uplink data transfer

6.6.4.5.2.2 Release of the Resources

The release of the resources is normally initiated from the MS by indicating the last RLC Data Block to be sent (or alternatively to countdown the last couple of blocks).

Further, the premature release or change of assignment for one MS can be initiated by the network. In the case of release, the MS is ordered to interrupt the Temporary Block Flow and back-off. The MS shall then reorganize the uplink buffer and issue a new Packet Channel Request to continue the uplink transfer with the RLC Data Blocks containing untransferred (i.e. on the RLC/MAC layer unacknowledged) LLC frames. In the case of the change in assignment, the Packet Resource Reassignment message is issued. The MS acknowledges the Packet Resource Reassignment message in an immediate reserved block period on the uplink. Upon correct reception of the Packet Resource Reassignment Ack, the old resources may be reused (i.e. USFs).

The normal release of resources for RLC connection carrying a mobile originated packet transfer, the mechanism based on acknowledged final Packet Ack/Nack combined with timers is used.

After the MS has sent its last RLC Data Block (indicated by the countdown field), the acknowledgement is expected from the network side. By sending the last block, the MS may no longer use the same assignment unless a negative acknowledgement arrives. It also means that the network side may reallocate the same USF(s) to some other user as soon as all the RLC Data Blocks belonging to that Temporary Block Flow are correctly received; that regardless of the possible later errors in the acknowledgements.

The next step, in the case of all RLC Data Blocks being correctly received, is that the network sends Packet Ack/Nack which is to be immediately acknowledged in the reserved uplink block period. It must be possible for the network not to use the mechanism of acknowledgement for Packet Ack/Nack in which case the release of the resources procedure relies only on timers. The TFI can be reused for another assignment either upon the reception of the acknowledgement for Packet Ack/Nack or after expiry of the guard timer.

6.6.4.5.3 Contention Resolution

Contention resolution is an important part of RLC/MAC protocol operation, especially because one channel allocation can be used to transfer a number of LLC frames.

There are two basic access possibilities, one phase and two phase access as defined in Subclause 6.6.4.4.1.

The two phase access is inherently immune for possibility that two MSs can perceive the same channel allocation as their own. Namely the second access phase, the Packet Resource Request, uniquely identifies the MS by its TLLI. The same TLLI is included in the Packet Resource Assignment and no mistake is possible.

The one phase access is somewhat insecure and an efficient contention resolution mechanism has to be introduced.

The first part of the solution is the identification of the MS. The presentation of sending MS on the RLC/MAC level is necessary not only for contention resolution but also to be able to establish RLC protocol entity for that Temporary Block Flow on the network side. Additionally, the TLLI is necessary to be able to match simultaneous uplink and downlink packet transfers by taking into consideration multislot capability of that MS.

In order to uniquely identify the MS when sending on uplink, the RLC Header for the first RLC Data Block on uplink is extended to include the TLLI.

The second part of the solution is the notification from the network side about who owns the allocation. That is solved by the inclusion of the TLLI in the temporary Packet Ack/Nack. This message can be sent in an early stage, even before the receive window for RLC/MAC protocol operation is full. By doing so, the contention is resolved after the first occurrence of Packet Ack/Nack. The possibility of RLC Data Blocks being captured from “wrong” MS, thus destroying the LLC frame, shall be covered for by retransmissions on the LLC layer.

6.6.4.5.4 Fixed Allocation

Fixed allocation uses the Packet Fixed Immediate Assignment or Packet Fixed Resource Assignment message to communicate a detailed fixed uplink resource allocation to the MS. The fixed allocation consists of a start frame, slot assignment, and block assignment bitmap representing the assigned blocks per timeslot. The MS waits until the start frame indicated and then transmits radio blocks on those blocks indicated in the block assignment bitmap. A MS receiving this allocation is free to transmit on the uplink without monitoring the downlink for the USF. If the current allocation is not sufficient, the MS may request additional resources in one of the assigned uplink blocks. A unique TFI is allocated and is thereafter included in each RLC data and control block related to that Temporary Block Flow. Because each Radio Block includes an identifier (TFI), all received Radio blocks are correctly associated with a particular LLC frame and a particular MS.

The number of blocks an MS requests in the initial and subsequent allocation request messages shall only account for the number of data and control blocks it intends to send. The MS shall not request additional blocks for the retransmission of erroneous blocks.

The selective ARQ operation for the acknowledged RLC/MAC mode is described in Subclause 6.6.4.3. The acknowledgement procedure of the LLC layer will not be combined with the acknowledgement procedure on the underlying RLC/MAC layer. The unacknowledged RLC/MAC mode operation is described in Subclause 6.6.4.4.

Figure 12 shows an example of message sequence for the (multislot) uplink data transfer with one resource reassignment and possible RLC Data Block re-transmissions.

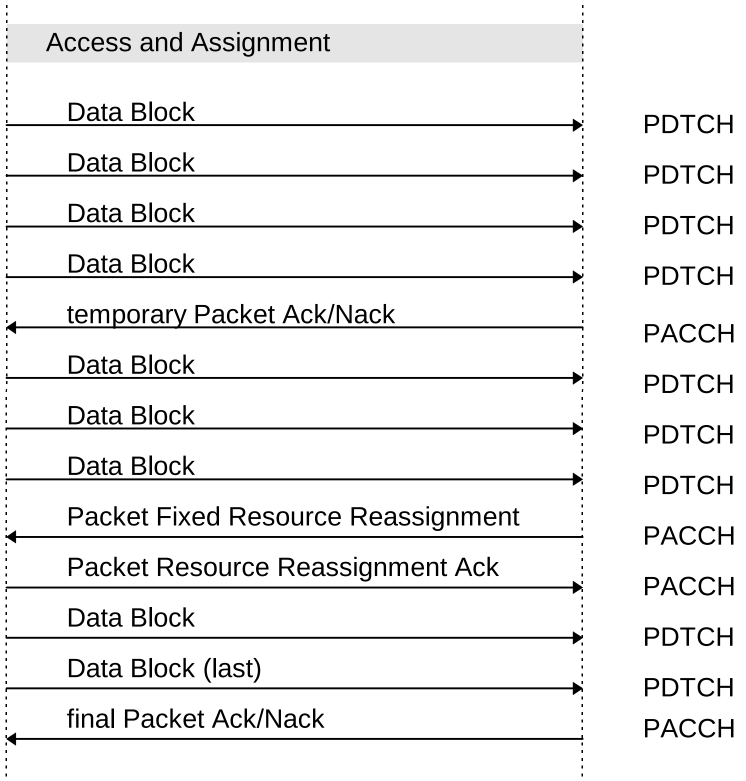


Figure 12: An example of fixed allocation uplink data transfer

6.6.4.6 Mobile Terminated Packet Transfer

6.6.4.6.1 Packet Paging

The Network initiates packet transfer to an MS that is in Standby state by sending a Packet Paging Request on the downlink PPCH or PCH. The MS responds to the Packet Paging Request by initiating a procedure for page response. The RLC/MAC Packet Paging Response message contains TLLI, as well as a complete LLC frame including also TLLI (see Figure 13). The message sequence described in figure 13 below is conveyed either on PCCCH or on CCCH. After the Packet Paging Response, the mobility management state of the MS is Ready.

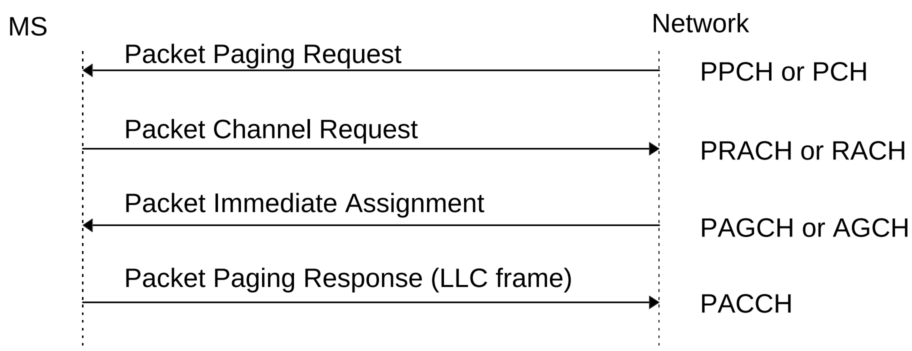


Figure 13: Paging message sequence for Paging, downlink packet transfer.

The paging procedure is followed by the Packet Resource Assignment (Figure 14) and packet transfer procedures (Figure 15).

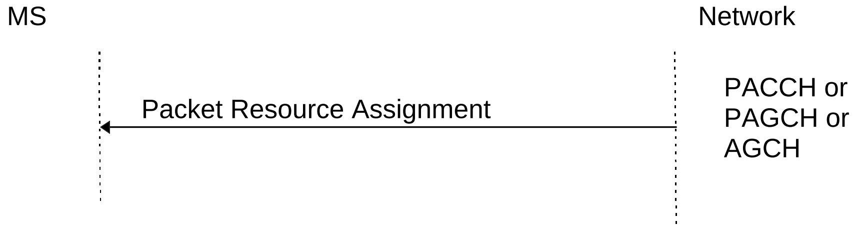


Figure 14: **Downlink PDTCH Assignment in GPRS Ready state using Packet Resource Assignment message.**

6.6.4.6.2 Downlink Packet Transfer

Transmission of a packet to an MS in the Ready state is initiated by the Network using the Packet Resource Assignment message (see Figure 14). In case there is PCCCH allocated in the cell, the Packet Resource Assignment is transmitted on PAGCH. In case there is no PCCCH allocated in the cell, the Packet Resource Assignment is transmitted on AGCH. The Packet Resource Assignment message includes the list of PDCH(s) that will be used for downlink transfer as well as the PDCH carrying the PACCH. The Timing Advance and Power Control information is also included, if available. Otherwise, the MS may be requested to respond with an Access Burst (see also Subclause 6.5.7 on timing advance procedures). The MS multislot capability needs to be considered.

Multiplexing the Radio blocks destined for different MSs on the same PDCH downlink is enabled with an identifier, e.g. TFI, included in each Radio Block. The interruption of data transmission to one MS is possible.

The network sends the Radio blocks belonging to one Temporary Block Flow on downlink on the assigned downlink channels.

The acknowledged (i.e. selective ARQ operation) and unacknowledged RLC/MAC mode operation is described in Subclauses 6.6.4.3 and 6.6.4.4. The sending of Packet Ack/Nack is obtained by the occasional network initiated polling of the MS. The MS sends the Packet Ack/Nack message in a reserved Radio Block which is allocated together with polling. Unassigned USF value is used in the downlink Radio Block which corresponds to the reserved uplink Radio blocks. Further, if the MS wants to send some additional signalling or uplink data, it may be indicated in the Packet Ack/Nack message.

Figure 15 shows an example of message sequence for (multislot) downlink data transfer with one resource reassignment and possible RLC Data Block re-transmissions.

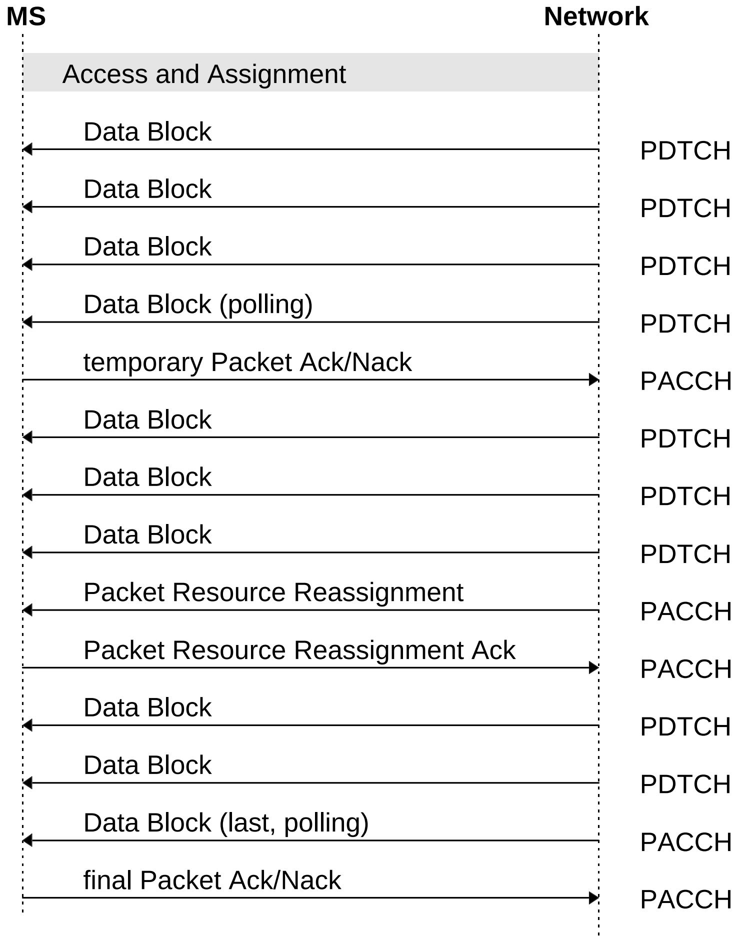


Figure 15: An example of downlink data transfer

6.6.4.6.3 Release of the Resources

The release of the resources is initiated by the network by terminating the downlink transfer and polling the MS for a final Packet Ack/Nack.

It is possible for the network to change the current downlink assignment. The first way to obtain that would be to terminate the current Temporary Block Flow, and after the MS starts to monitor the PCCCH, initiate a new one with a new assignment. The second method would be to explicitly change the downlink assignment by using the Packet Resource Reassignment which then has to be acknowledged by the MS in an immediate reserved block period on the uplink.

The handling of TFI and USF is steered with the same timer that runs on both the MS and the network side after the last RLC Data Block is sent to the MS. When it expires, the current assignment becomes invalid for the MS and both USF and TFI can be reused by the network. Further, USF and TFI may be reused already upon the reception of the final Packet Ack/Nack from the MS.

6.6.4.7 Simultaneous Uplink and Downlink Packet Transfer

During the ongoing uplink Temporary Block Flow, the MS continuously monitors one downlink PDCH for possible occurrences of Packet Resource Assignment messages on PACCH (see Figure 11). The MS is therefore reachable for downlink packet transfers that can then be conveyed simultaneously on the PDCH(s) that respect the MS multislot capability.

If the MS wants to send packets to the network during the ongoing downlink Temporary Block Flow, it can be indicated in the acknowledgement that is sent from the MS. By doing so, no explicit Packet Channel Requests have to be sent to the network. Further, the network already has the knowledge of which PDCH(s) that particular MS is currently using so that the uplink resources can be assigned on the PDCH(s) that respect the MS multislot capability. This method may introduce an extra delay when initiating the uplink packet transfer but only for the first LLC frame in a sequence.

6.6.5 Layer Messages

The following Subclauses introduce the messages of the RLC/MAC protocol along with the required information elements in each message. The coding is not addressed, and only the semantical contents are explained.

NOTE: The text in this subclause is informative. The normative text is in GSM 04.08. Where there is a conflict between these descriptions, the normative text has precedence.

6.6.5.1 Packet Channel Request message on the RACH

Two cause values (01110xxx and 01111xxx) in Channel Request message on RACH are reserved for GPRS usage. Cause value 01110xxx is used to indicate request for single slot uplink transmission and the cause value 01111xxx is used in one phase access to indicate request for double slot uplink transmission. Three bits are used for random number.

6.6.5.2 Packet Channel Request message on the PRACH

The information that is coded in a Packet Channel Request message sent on the PRACH is indicated in Table 10. The actual length of each information element depends on the length of the Packet Channel Request message. Two codings exist, one for the existing length of the Access Burst (8 bits), and one for an extended length (11 bits).

Table 10: Information fields in Packet Channel Request on PRACH

Information content	Values
Type of channel needed	PDTCH SDCCH TCH/F TCH/H or TCH/F Reserved for future use
Priority	Priority associated to the Radio Resource request (4 priority levels).
Number of needed Radio Blocks	This applies only when a PDTCH is requested. This optimises the one step approach for the sending of signalling messages which should fit in a few Radio Blocks. A few typical number of blocks should be defined. Values are e.g. 1, 2, 4, or more than 4 Radio Blocks.
Multislot class	Reduced set of Multislot classes (the most common classes). A precise Multislot class may be given in Packet Resource Request message.
Random value	Coded on the remaining bits.

For each of the services, all the possible combinations of the parameters are identified in the technical specifications defining GPRS Stage 3 (e.g. the combination of channel needed and priority to use).

For GPRS transfer, the priorities are mapped on the GPRS QoS.

6.7 Abnormal cases in GPRS MS Ready State

6.7.1 RLC/MAC-Error Causes

The RLC/MAC error causes and procedures to handle these can be found in GSM 03.22, 04.08, and 05.08.

6.7.2 Downlink Signalling Failure

The quality of the channels for downlink signalling is determined by the downlink signalling counter DSC. Its operation is described in GSM 05.08. In case a PPCH is allocated, the counter is initialized to max[10, (90/64)*SPLIT_PG_CYCLE].

6.7.3 Packet Channel Request Failure

Packet Channel Request Failure is an abnormal case of MS by receiving no Packet Immediate Assignment (Ack or Nack) within a random backoff time on PAGCH or AGCH after transmission initiated on PRACH or RACH.

Only if ”random access retry to another cell” is allowed (PBCCH or BCCH parameter bit FFS), the MS shall follow the cell re-selection procedure defined for the call re-establishment procedure in GSM 05.08 based on BA(GPRS) after the maximum number of random access attempts has been reached.

Otherwise if ”random access retry to another cell” is not allowed (PBCCH or BCCH parameter bit FFS), the MS shall follow the normal RLC/MAC procedure.

6.7.4 Packet Nack or Absence of Response

When sending data blocks on PDTCH, a Packet Ack/Nack shall be sent on PACCH. If no responses have been received or only Packet Nacks have been received within a predefined time, then the MS shall use a leaky bucket type measurement in order to determine when to perform cell re-selection.

Packet Nack or Absences of Response shall use a Packet Ack/Nack counter (PAN) initialised to Z upon RLC connection establishment. If Nack or no response is received within a predefined time, then PAN decrements by X. If Packet Ack is received, then PAN increments by Y but never exceeding Z. The parameters X, Y and Z are broadcast on PBCCH or BCCH. When PAN ≤ 0 is reached, a cell re-selection procedure is triggered, as for the Packet Channel Request Failure (subclause 6.7.3 above).

NOTE: A possible implementation could be as follows. The parameters X, Y and Z as well as the RETRY bit “random access retry to another cell” (subclause 6.7.3 above) shall be broadcast on PBCCH or BCCH in intervals not longer than every 8 multiframes (~2 s). The parameter values for X and Y: 0,1,2,3,4,5,6,7; for Z: 4,8,12,16,20,24,28,32; for RETRY: allowed 1, not allowed 0. The leaky bucket procedure will be disabled by setting X=Y=0. Other timers and counters are defined in the RLC/MAC Protocol Operation.

6.8 PTM-M Data Transfer

NOTE: The stage 3 specification for PTM-M data transfer is left for phase 2 of GPRS specification.

PTM-M data, in the form of individual LLC frames, is mapped into RLC/MAC-PTM_DATA primitive and distributed from SGSN to the BSS representing the cells that are defined by a geographical area parameter. To the cells concerned, the BSS for each PTM-M LLC frame:

- Optionally, sends a “PTM-M new message” indicator on all individual paging channels on PCCCH if allocated, otherwise on CCCH. The indication refers to a PTM-M notification channel PNCH on PCCCH or NCH on CCCH, where a notification for the new PTM-M message can be received.

  If the indicator option is not supported, or if an MS can not receive the indicator when expected, e.g. because the corresponding block in the multiframe structure is used for other purposes than paging, the MS must read the notification channel.

- Sends a PTM-M notification on PNCH or NCH. The notification has the form of a Packet Resource Assignment for the PTM-M LLC frame. The notification includes a group identity IMGI, a unique LLC frame identifier (in the form of an N-PDU number together with a segment offset, see GSM 04.65) and an allocation of a TFI to be used in all RLC blocks of the LLC frame.

- Transmits the PTM-M LLC frame on the assigned downlink resources.

Transfer of PTM-M data is carried out without any ARQ on the RLC/MAC and LLC layers. Instead, each LLC frame is retransmitted a specified number of times. For each retransmission, the above procedure is performed. The PTM-M notification (resource assignment) includes the unique LLC frame identifier as in the first transmission but a new allocation of TFI.

An MS accumulates correctly received RLC blocks from each transmission to assemble an LLC frame.

The dimensioning of PNCH shall be scaleable depending on capacity requirements.

An NCH may, if capacity allows, be used as a shared notification channel for PTM-M and Advanced Speech Call Items (ASCI).

An MS only interested in PTM-M needs to listen only to PNCH/NCH.

Annex A (informative): Power Control Procedures

Power control is important for spectrum efficiency as well as for power consumption in a cellular system. For good spectrum efficiency quality based power control is required. Power control for a packet oriented connection is more complicated than for a circuit switched connection, since there is no continuos two-way connection.

The power control formula for the MS is specified in subclause 6.5.8.1 (formula 1):

$P = \Gamma CH - \alpha\, C$ (all power calculations in dB)

This is a flexible tool that can be used for different power control algorithms. For the BTS, there is no need to specify any algorithm, but a similar formula can be used. The following are examples of possible algorithms for uplink power control:

- Open loop control.
  With this method the output power is based on the received signal strength assuming the same path loss in uplink and downlink. This is useful in the beginning of a packet transmission.
- Closed loop control.
  With this method the output power is commanded by the network based on signal strength measurements made in the BTS in a similar way as for a circuit switched connection.
- Quality based control.
  This method can be used in combination with any of the two methods above.

A.1 Open loop control

A pure open loop is achieved by setting $\alpha = 1$ and keeping Γ_{CH} constant. The output power will than be:

$P = \Gamma_{CH} - C$

The value Γ_{CH} can be calculated as follows to give a target value for the received signal, SS_b, at the BTS.

The received signal strength at the MS:
$SS_m = P_{BTS} - P_b - L$

where P_{BTS} = BTS maximum output power
P_b = BTS power reduction due to power control (transferred to MS)
L = path loss

The C value (normalised signal strength):
$C = SS_m + P_b = P_{BTS} - L$

The MS output power: $P = \Gamma_{CH} - C = \Gamma_{CH} - P_{BTS} + L$

The received signal strength at the BTS:
$SS_b = P - L = \Gamma_{CH} - P_{BTS}$

The constant value of Γ_{CH}:
$\Gamma_{CH} = P_{BTS} + SS_b$

A.2 Closed loop control

A pure closed loop is achieved by setting $\alpha = 0$. The output power will than be:

$P = \Gamma_{CH}$

In this case, Γ_{CH} is the actual power level commanded by network. It can be based on the received signal level measured at the BTS. Power control commands can be sent when required in order to achieve the target received signal strength.

A.3 Quality based control.

In order to achieve the best performance the power control should be quality based. The algorithm must also consider the path loss for stability. The algorithm is not specified, it is the responsibility of the manufacturer and/or the operator.

An example of a quality based power control algorithm is:

$$P_{n+1} = P_{max} - \alpha\, ((C/I_n - C/I_{min}) - (P_n - P_{max})) = P_{ref} - \alpha\, (C/I_n - P_n)$$

where P is the output power from the MS.
C/I is the received carrier to interference value at the BTS.
P_{max} ,C/I_{min} and P_{ref} are reference values.
α is a weighting factor.
n is the iteration index.

In the closed loop case, this formula determines Γ_{CH}:
$\Gamma_{CH} = P_{n+1}$.

For the open loop case, we rewrite the formula. The carrier to interference can be written:
$C/I = C_{BTS} - I_{BTS} = P - L - I_{BTS}$

where C_{BTS} is the received signal level at the BTS.
I_{BTS} is the received interference level at the BTS.

thus $P_{n+1} = P_{ref} - \alpha\, (P_n - L_n - I_{BTS,n} - P_n) = P_{ref} + \alpha\, (L_n + I_{BTS,n})$

As shown above, the path loss is:
$L = P_{BTS} - C$

The formula can therefore be written as (dropping the iteration index):

$$P = P_{ref} + \alpha\, (P_{BTS} - C + I_{BTS}) = \Gamma_{CH} - \alpha\, C$$

Thus, for the open loop case:
$\Gamma_{CH} = P_{ref} + \alpha\, (P_{BTS} + I_{BTS})$

The interference level I_{BTS} is measured in the BTS. The parameter Γ_{CH} is estimated based on these measurements, considering the appropriate weighting factor α, and the known parameters P_{ref} and P_{BTS}. The Γ_{CH} values are transferred to the MS in the Packet Assignment command, the Ack/Nack messages or in Power Control commands.

A.4 BTS power control

The same algorithm as above can be used for downlink power control. The formula for quality based control in the MS

$$P_{n+1} = P_{ref} + \alpha\, (L_n + I_{BTS,n})$$

can be written for the BTS as:

$$Pd_{n+1} = P_{ref} + \alpha\, (L_n + \gamma_{CH,n})$$

where Pd is the BTS output power (equal to $P_{BTS} - P_b$).
γ_{CH} is the received interference level at the MS.

Substituting the path loss and dropping the iteration index gives:
$P_d = P_{ref} + \alpha\, (P_{BTS} - C + \gamma_{CH})$

The received signal C and interference γ_{CH} is measured in the MS and transferred to the BTS, which can calculate the output power.

A.5 Example

Figure A.1 illustrates an example of the uplink power control function.

In the wait state, the MS measures the C value on PPCH with an intensity of N_{AVG} measurements per T_{AVG} multiframes. Meanwhile, the BSS measures the interference of the candidate PDCHs in order to have Γ_{CH} values ready for the first transfer period. This is transferred to the MS in the Packet Assignment command.

In the transfer state, the MS measures the C value on the assigned PDCHs and updates its output power once every T_{AVG_T} multiframe. The BSS updates the MS specific Γ_{CH} values at the same rate. The updated Γ_{CH} values are transferred to the MS in the Ack/Nack messages or in Power Control commands only when needed, i.e. when the interference level has changed.

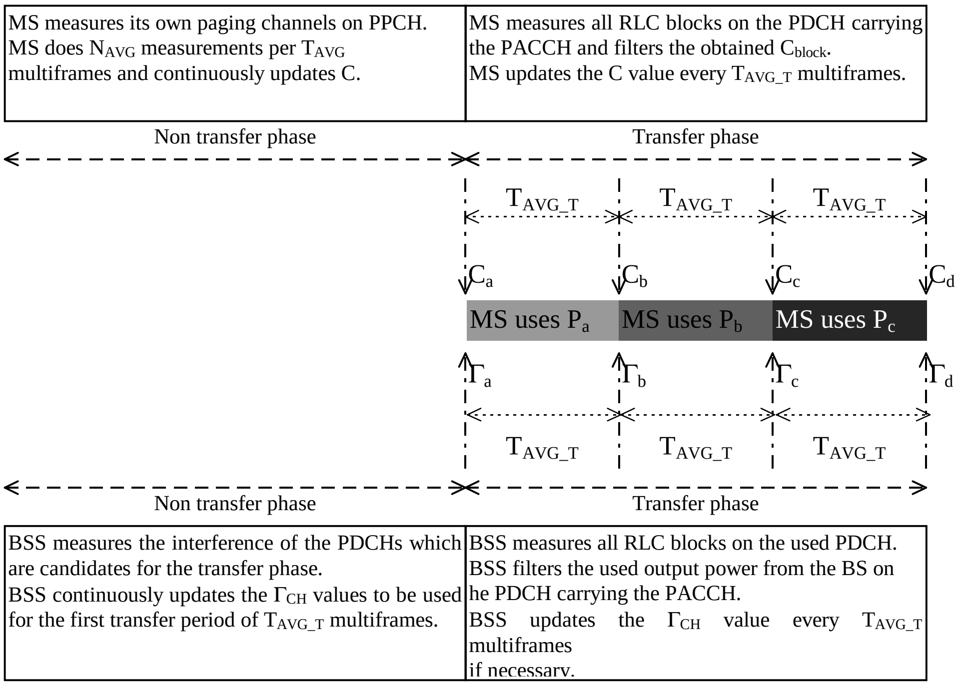


Figure A.1: Traffic example of uplink power control

Figure A.2 illustrates an example of the downlink power control function.

In the Wait state, the MS measures the C value on PPCH with an intensity of N_{AVG} measurements per T_{AVG} multiframes and the γ_{CH} values on some candidate PDCHs with an intensity of N_{AVG_I} measurements per T_{AVG_I} multiframes. These values are transferred to the BTS in the Packet Paging Response, and used to calculate the output power for the first transfer period.

In the Transfer state, the MS measures the C value on the PDCH where the MS transmits PACCH and the γ_{CH} values on all channels on the same carrier. These are transferred to the BTS in the Ack/Nack messages. The BSS then updates the output power.

If the Packet Paging Response is not sent, the BTS may use the maximum power for the first transfer period. In this case the polling for Ack/Nack should be set as soon as possible to get the measured values.

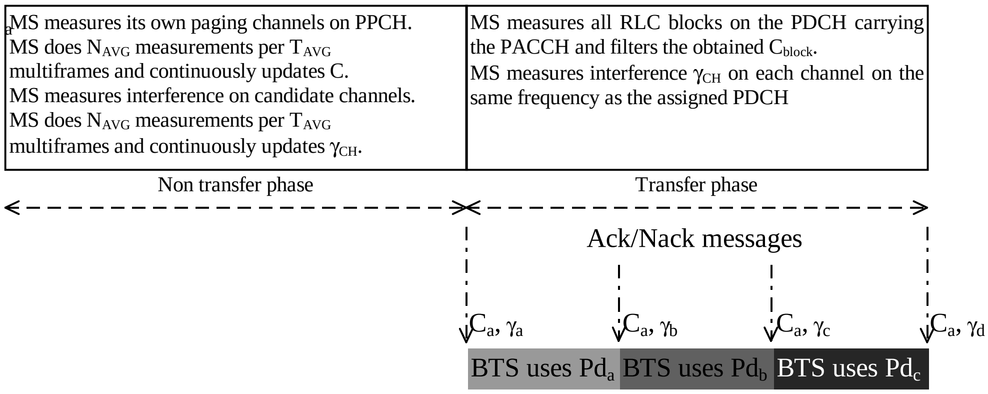


Figure A.2: Traffic example of downlink power control

Annex B (informative): Bibliography

1) ITU-T I.130, Method for the Characterization of Telecommunication Services Supported by an ISDN

2) ITU-T Q.65, Stage 2 of the Method for Characterization of the Services Supported by an ISDN

3) DIS 8886, OSI Data Link Service Definition

4) DIS 10022, OSI Physical Service Definition

5) ISO 10039, Medium Access Control Service Definition

6) ISO 4335, HDLC Procedures

7) ISO 7478, Multilink Procedures

8) ISO 7498, OSI Basic Reference Model and Layer Service Conventions

Annex C (informative): Document change history

SPEC	SMG#	CR	PHA	VERS	NEW_VER	SUBJECT
03.64	s22	NEW	2+	2.1.1	5.0.0	GSM 03.64 GPRS Stage 2 Radio
03.64	s23	A022	R97	5.0.0	5.1.0	Unacknowledged mode of RLC/MAC operation
03.64	s23	A023	R97	5.0.0	5.1.0	Improved RLC Service Primitives
03.64	s23	A024	R97	5.0.0	5.1.0	Enhancements to dynamic allocation
03.64	s23	A025	R97	5.0.0	5.1.0	Clarifications to DRX
03.64	s23	A026	R97	5.0.0	5.1.0	Optimisation for network control cell reselection
03.64	s23	A027	R97	5.0.0	5.1.0	Abnormal Cases in GPRS MS Ready State: Leaky Bucket Procedure
03.64	s23	A029	R97	5.0.0	5.1.0	Multiframe structure (details) (revision of SMG2 GPRS 301/97)
03.64	s23	A030	R97	5.0.0	5.1.0	Abnormal Cases in GPRS MS Ready State
03.64	s23	A031	R97	5.0.0	5.1.0	Cell Re-Selection in GPRS
03.64	s23	A032	R97	5.0.0	5.1.0	Definition of PACCH
03.64	s23	A033	R97	5.0.0	5.1.0	Clarifications on Timing advance procedure
03.64	s23	A035	R97	5.0.0	5.1.0	Bit order for USF coding in GPRS
03.64	s23	A036	R97	5.0.0	5.1.0	PTM-M
03.64	s23	A037	R97	5.0.0	5.1.0	Contention resolution
03.64	s23	A039	R97	5.0.0	5.1.0	Deleting parameter XHYST
03.64	s24	A031	R97	5.1.0	5.2.0	Clarification on the use of hysteresis for cell re-selection
03.64	s25	A043	R97	5.2.0	6.0.0	Clarification of the use of TAI
03.64	s25	A049	R97	5.2.0	6.0.0	USF granularity for dynamic allocation
03.64	s26		R97	6.0.0	6.0.1	Editorial changes for Publication

History

Document history		
V6.0.1	August 1998	Publication

ISBN 2-7437-2499-4
Dépôt légal : Août 1998