

3GPP TSG GERAN#14  
7-11 April, 2003  
Münich, Germany

GP-030820

**Source:** Nokia

**Title:** GERAN *Iu mode* RLC/MAC Handbook

**Document for:** Information - to assist with MS/BSS Test Case development

---

## Table of Contents

<b>1. INTRODUCTION</b> .....	<b>2</b>
<b>2. DEFINITIONS</b> .....	<b>2</b>
<b>3. ABBREVIATIONS</b> .....	<b>3</b>
<b>4. MAIN CHARACTERISTICS</b> .....	<b>3</b>
4.1 PHYSICAL LAYER.....	3
4.1.1 Basic physical subchannel (BPSCH).....	3
4.1.2 Permitted channel combinations.....	3
4.1.2.1 DBPSCH.....	3
4.1.2.1.1 DBPSCH/F.....	3
4.1.2.1.2 DBPSCH/H.....	4
4.1.2.1.3 DBPSCH/S.....	4
4.1.2.2 SBPSCH.....	4
4.1.2.2.1 SBPSCH/F.....	4
4.1.2.2.2 SBPSCH/H.....	4
4.1.3 Multislot configurations.....	4
4.1.3.1 Multislot configurations for DBPSCH in <i>Iu</i> mode.....	5
4.1.3.2 Multislot configurations for dual transfer mode in <i>Iu</i> mode.....	5
4.2 RLC & MAC PROTOCOLS.....	5
4.2.1 Functionality.....	5
4.2.2 Protocol architecture.....	5
<b>5. RADIO LINK CONTROL PROTOCOL</b> .....	<b>6</b>
5.1 GENERAL.....	6
5.2 RLC OPERATION.....	7
5.2.1 NT-RLC operation.....	7
5.2.2 T-RLC operation.....	8
<b>6. MEDIUM ACCESS CONTROL PROTOCOL</b> .....	<b>8</b>
6.1 GENERAL.....	8
6.2 IDENTIFIERS.....	8
6.2.1 G-RNTI.....	8
6.2.2 RB Id, RRB Id, SRB Id and TFI.....	9
6.3 MAC STATE MACHINE.....	10
6.4 MAC OPERATION.....	11
6.4.1 MAC-Idle state.....	11
6.4.1.1 General procedures.....	11
6.4.1.1.1 Mobile station side.....	11
6.4.1.1.2 Network side.....	11
6.4.1.1.2.1 General.....	11
6.4.1.1.2.2 Broadcast of system information.....	11
6.4.1.2 Packet access procedure.....	12
6.4.1.3 Establishment of SBPSCH.....	12
6.4.1.4 Establishment of DBPSCH.....	13
6.4.2 MAC-Shared state.....	14
6.4.2.1 Contention resolution on SBPSCH.....	14
6.4.2.2 Establishment of additional TBFs on SBPSCH.....	15
6.4.2.3 Establishment of DBPSCH.....	15
6.4.2.4 Multiplexing.....	15
6.4.2.4.1 Dynamic allocation.....	15
6.4.2.4.2 Uplink control timeslot.....	15

6.4.2.4.3	SFACCH operation .....	16
6.4.3	<i>MAC-Dedicated state</i> .....	17
6.4.3.1	Contention resolution on DBPSCH .....	17
6.4.3.2	Establishment of additional DBPSCH or SBPSCH .....	17
6.4.3.3	Multiplexing .....	17
6.4.3.3.1	PDTCH, PACCH .....	17
6.4.3.3.2	TCH .....	18
6.4.3.3.3	FACCH, SACCH, SDCCH .....	18
6.4.4	<i>MAC-DTM state</i> .....	18
6.4.4.1	General .....	18
6.4.4.2	Establishment of TBFs on SBPSCH .....	18
6.4.4.3	Establishment of DBPSCH .....	18
6.4.4.4	Multiplexing .....	18
6.4.5	<i>Mapping of SRBs onto logical channels</i> .....	18
<b>7.</b>	<b>CIPHERING .....</b>	<b>19</b>
7.1	PRINCIPLE .....	19
7.2	LOCATION .....	19
7.3	OTHER DETAILS .....	20
7.3.1	<i>Ciphering parameters</i> .....	20
7.3.2	<i>Synchronization</i> .....	20
<b>8.</b>	<b>RLC/MAC CONTROL MESSAGES .....</b>	<b>20</b>
8.1	GENERAL .....	20
8.2	CHANGED RLC/MAC CONTROL MESSAGES .....	21
8.3	NEW RLC/MAC CONTROL MESSAGES .....	22
<b>9.</b>	<b>REFERENCES .....</b>	<b>22</b>

---

## 1. Introduction

This document provides a detailed description of the procedures of the GERAN *Iu mode* RLC and MAC protocols specified under 3GPP Release 5, in order to facilitate the development of the corresponding conformance test specifications.

The stage 2 specification of GERAN *Iu mode* RLC/MAC protocol is contained within the stage 2 description of GERAN *Iu* under 3GPP Release 5:

- 3GPP TS 43.051 Stage 2 Overall description

The stage 3 specification of GERAN *Iu mode* RLC/MAC protocol is contained within two complementary 3GPP TSs under 3GPP Release 5:

- 3GPP TS 44.160 Stage 3 RLC/MAC protocol (*Iu mode*)
- 3GPP TS 44.060 Stage 3 RLC/MAC protocol

3GPP TS 44.160 is the "mother" specification of GERAN *Iu mode* RLC/MAC protocol. 3GPP TS 44.160 contains procedures that are *Iu mode* specific only. Common procedures (to *A/Gb mode* and *Iu mode*) are specified in 3GPP TS 44.060 where clear statements are given about their applicability to *Iu mode*. The structure of 3GPP TS 44.160 follows that of 3GPP TS 44.060. A number of references to specific subclauses of 44.060 are therefore included throughout 3GPP TS 44.160. A reference to a (sub)clause of 3GPP TS 44.060 (e.g. subclause n.m), addresses the whole text under this (sub)clause including all dependent subclauses (e.g. all subclauses n.m.x). Within 3GPP TS 44.060, if a text applicable to *Iu mode* contains a reference to a (sub)clause of 44.060, this reference is also applicable to *Iu mode* unless explicitly stated otherwise. All RLC/MAC control messages are specified in 3GPP TS 44.060 regardless whether they are applicable in *A/Gb mode* only, *Iu mode* only, or both *Iu* and *A/Gb modes*.

It is recommended to use document and references mentioned within this text as guidance when developing the test cases in GERAN WG4 and WG5.

---

## 2. Definitions

For a complete listing of 3GPP definitions, refer to 3GPP TS 22.101.

**Block period:** sequence of timeslots on a SBPSCH or a DBPSCH used to convey one radio block.

There are 4 timeslots in this sequence for PDTCH, PACCH, SACCH, SDCCH, TCH/AHS, E-FACCH. There are 6 timeslots in this sequence for FACCH/H. There are 8 timeslots in this sequence for TCH/AFS and FACCH/F. There are 22 timeslots in this sequence for (E-)TCH/F.

**DCCH TBF mode:** refers to a TBF mapped onto a FACCH, SACCH or SDCCH.

**Radio block:** sequence of normal bursts carrying one RLC/MAC protocol data unit (see 3GPP TS 44.004).

(The one exception is a radio block occasionally used on PACCH consisting of a sequence of four access bursts, each carrying a repetition of one short RLC/MAC block.). There are 4 normal bursts in this sequence for PDTCH, PACCH, SACCH, SDCCH, TCH/AHS, E-FACCH. There are 6 normal bursts in this sequence for FACCH/H. There are 8 normal bursts in this sequence for TCH/AFS and FACCH/F. There are 22 normal bursts in this sequence for (E-)TCH/F.

**RLC non-transparent mode:** refers to either RLC acknowledged mode or RLC unacknowledged mode.

**TCH TBF mode:** refers to a TBF mapped onto a TCH.

**Iu mode:** refers to the operation of the mobile station when connected to the 3G CN through the *Iu* interface.

---

## 3. Abbreviations

For complete listing of 3GPP abbreviations, refer to 3GPP TS 21.905.

BPSCH	Basic physical sub-channel
DBPSCH	Dedicated BPSCH
MAC	Medium Access Control
NT-RLC	Non-transparent RLC
PDCP	Packet Data Convergence Protocol (layer 2 protocol)
RLC	Radio Link Control
RRC	Radio Resource Control (layer 3 protocol)
SBPSCH	Shared BPSCH
SFACCH	Shared FACCH
T-RLC	Transparent RLC

---

## 4. Main characteristics

### 4.1 Physical layer

#### 4.1.1 Basic physical subchannel (BPSCH)

The specification of GERAN *Iu mode* required the introduction of a new notion at the physical layer, namely basic physical subchannel (BPSCH). The definition of a BPSCH is given in 3GPP TS 43.051 §6.8.1 as follows:

A **basic physical subchannel** is defined as a basic physical channel or a part of a basic physical channel and an associated multiframe structure. A basic physical subchannel can either be shared (SBPSCH) or dedicated (DBPSCH).

NOTE: A basic physical channel is defined as a sequence of radio frequency channels and time slots. The basic physical channel uses the same timeslot in every TDMA frame. The TDMA frame number sequence is 0,1,.., FN\_MAX, where FN\_MAX is the maximum TDMA frame number for a hyperframe (i.e. all TDMA frames on a timeslot).

There is essentially no difference between a SBPSCH and a PDCH. Hence, while 3GPP TS 44.160 uses SBPSCH consistently with the use of DBPSCH, 3GPP TS 44.060 talks about PDCH.

There are two types of SBPSCH, namely SBPSCH/F (Full-rate) and SBPSCH/H (half-rate). A SBPSCH is for one or more users.

There are four types of DBPSCH, namely DBPSCH/F (full-rate), DBPSCH/H (half-rate), DBPSCH/S4 and DBPSCH/S8. A DBPSCH is for only one user and it always has an associated SACCH.

NOTE: DBPSCH/S is used to refer to both DBPSCH/S4 and DBPSCH/S8

#### 4.1.2 Permitted channel combinations

The permitted channel combinations are defined in 3GPP TS 45.002 §6.4.1.

##### 4.1.2.1 DBPSCH

###### 4.1.2.1.1 DBPSCH/F

The following channel combinations are possible for a DBPSCH full rate:

- i) TCH/F + FACCH/F + SACCH/TF;
- ii) TCH/F + FACCH/F + SACCH/TPF + EPCCH/F;
- iii) PDTCH/F + PACCH/F + SACCH/TF;
- iv) PDTCH/F + PACCH/F + SACCH/TPF + EPCCH/F;
- v) E-TCH/F + E-FACCH/F + SACCH/TF + E-IACCH/F;
- vi) O-TCH/F + O-FACCH/F + SACCH/TF;
- vii) O-TCH/F + O-FACCH/F + SACCH/TPF + EPCCH/F

#### 4.1.2.1.2 DBPSCH/H

The following channel combinations are possible for a DBPSCH half rate:

- i) TCH/H + FACCH/H + SACCH/TH;
- ii) TCH/H + FACCH/H + SACCH/TPH + EPCCH/H;
- iii) O-TCH/H + O-FACCH/H + SACCH/TH;
- iv) O-TCH/H + O-FACCH/H + SACCH/TPH + EPCCH/H;
- v) PDTCH/H + PACCH/H + SACCH/TH;
- vi) PDTCH/H + PACCH/H + SACCH/TPH + EPCCH/H.

#### 4.1.2.1.3 DBPSCH/S

The following channel combination is that of a DBPSCH/S4:

- i) SDCCH/4 + SACCH/C4.

The following channel combination is that of a DBPSCH/S8:

- i) SDCCH/8 + SACCH/C8.

### 4.1.2.2 SBPSCH

#### 4.1.2.2.1 SBPSCH/F

The following channel combinations are allowed:

- i) PDTCH/F + PACCH/F + PTCCH/F
- ii) PBCCH + PCCCH + PDTCH/F + PACCH/F + PTCCH/F

#### 4.1.2.2.2 SBPSCH/H

- i) PDTCH/H + PACCH/H

SBPSCH/H can only be used together with a DBPSCH/H on the same timeslot.

### 4.1.3 Multislot configurations

Multislot configurations for *Iu mode* of operation are defined in 3GPP TS 45.002 §§6.4.2.4 to 6.4.2.7.

### 4.1.3.1 Multislot configurations for DBPSCH in *Iu mode*

The multislot configurations for TCH on DBPSCH in *Iu mode* are equivalent to the multislot configurations for circuit switched connections in *A/Gb mode*. The use of PDTCHs on DBPSCH is new in Rel-5 *Iu mode*. Multislot configurations for DBPSCH may also consist of a mixed allocation of TCHs and PDTCHs. These new multislot configurations for DBPSCH are defined in 3GPP TS 45.002 §6.4.2.4.

### 4.1.3.2 Multislot configurations for dual transfer mode in *Iu mode*

For dual transfer mode in *Iu mode*, a multislot configuration comprises one or more DBPSCHs (in *A/Gb mode* only one DBPSCH can be allocated) and one or more SBPSCH/F (in *A/Gb mode* both SBPSCH/H and SBPSCH/F).

## 4.2 RLC & MAC protocols

### 4.2.1 Functionality

In addition to supporting the procedures of the RLC and MAC protocols for *A/Gb mode* in 3GPP Release 5 (except PFC and MS RAC handling), the RLC and MAC protocols of GERAN *Iu mode* are mainly characterized by:

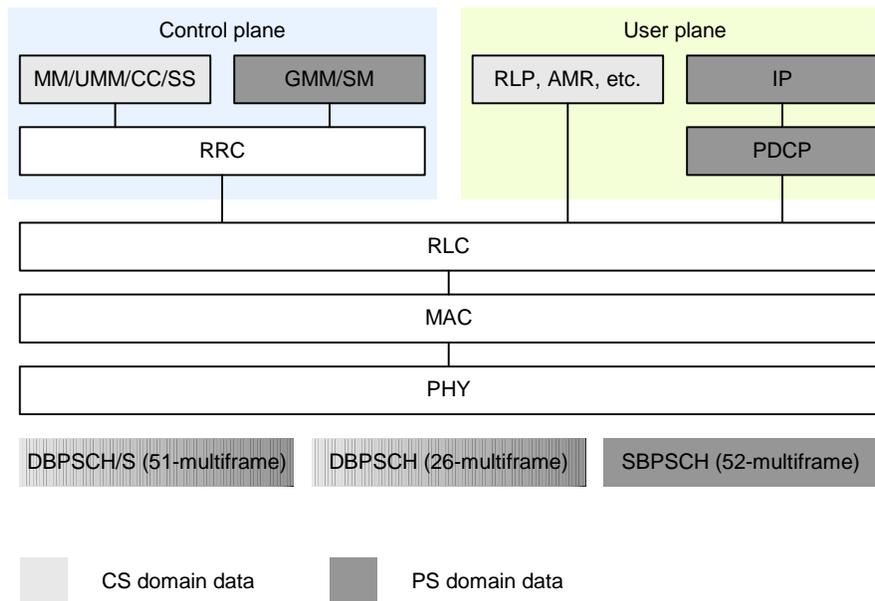
- Transfer of user-plane and control-plane data for both the *CS* and the *PS* CN domains
  - Mapping of RRC signalling (signalling radio bearers) onto logical channels
- PBCCH and PCCCH mandatory for both *network* and mobile station
- MAC state machine *instead of* RR operating modes
- Multiple TBFs
- Operation on dedicated channels (DBPSCH)
  - Assignment of DBPSCH
  - Operation on FACCH, SACCH and SDCCH *instead of* LAPDm
  - NT-RLC operation on TCH + FACCH (8-PSK only)
  - NT-RLC operation on PDTCH + PACCH
  - T-RLC operation
- Ciphering using the *same* algorithm as in UTRAN: Kasumi f8

### 4.2.2 Protocol architecture

The figure below illustrates the location in the protocol stack of the RLC and MAC protocols, taking into account both CN domains and their corresponding user and control planes. The differences compared to *A/Gb mode*, are:

- PDCP in *Iu mode* replaces LLC and SNDCP of *A/Gb mode*
  - PDCP is used to carry only *PS* user-plane data, by opposition to LLC which also carries *PS* control-plane data
  - PDCP protocol is defined in 3GPP TS 25.323 (common to both UTRAN and GERAN)
- RRC in *Iu mode* carries Non Access Stratum –NAS– signalling to/from the CN
  - *PS* control-plane data is carried by RRC in *Iu mode*, instead of LLC in *A/Gb mode*
  - *CS* control-plane data is carried by RRC in *Iu mode*, instead of RR in *A/Gb mode*

- Signalling Radio Bearers –SRB– 3 and 4 are used to carry NAS signalling
- RLC in *Iu mode* carries control-plane data to/from RRC
  - RLC carries RRC signalling (SRB1 and SRB2)
  - RLC carries NAS signalling (SRB3 and SRB4)
- RLC in *Iu mode* carries PS user-plane data to/from PDCP instead of to/from LLC in *A/Gb mode*
- RLC in *Iu mode* carries CS user-plane data to/from CS protocols
- MAC in *Iu mode* carries RLC data on both SBPSCH and DBPSCH instead of SBPSCH only in *A/Gb mode*



**Figure 4.1: RLC and MAC protocols in the protocol stack**

## 5. Radio Link Control protocol

### 5.1 General

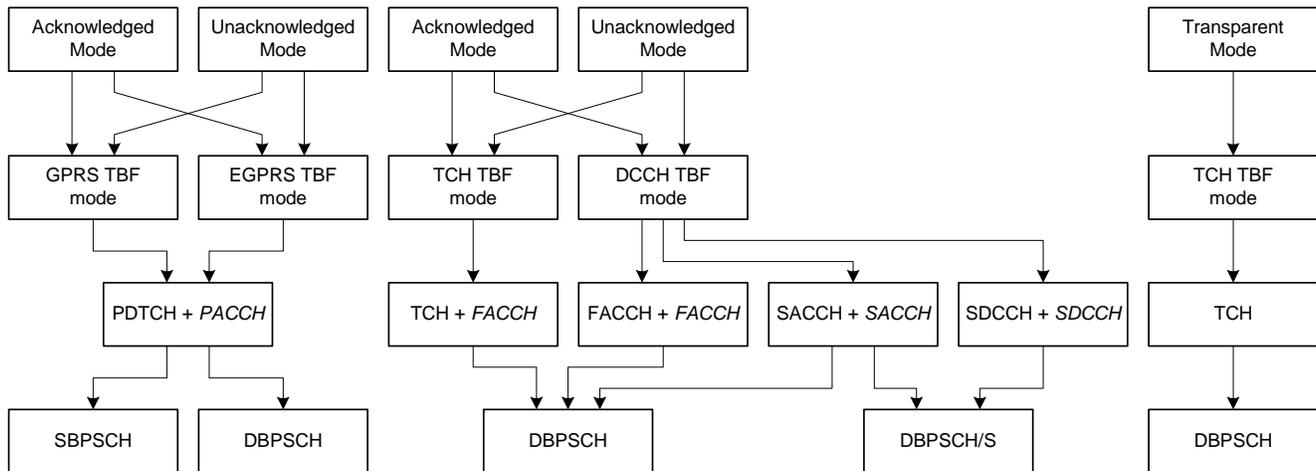
The RLC protocol of GERAN *Iu mode* differs mostly from (E)GPRS by its ability to operate on various logical channels. To support this variety, new TBF modes have been defined beside existing GPRS and EGPRS TBF modes, namely *TCH TBF mode* and *DCCH TBF mode* (see section 6).

The table below summarizes the traffic channel (i.e. for transfer of RLC data blocks) and associated control channel (i.e. for transfer of RLC/MAC control blocks) on which the RLC protocol runs, along with the corresponding TBF mode.

**Table 5.1 Traffic channels, control channels and TBF mode for RLC operation**

Traffic channel	PDTCH	TCH	FACCH	SACCH	SDCCH
Control channel	PACCH	FACCH	FACCH	SACCH	SDCCH
TBF Mode	GPRS/EGPRS	TCH	DCCH		
NOTE: Modulation (GMSK or 8-PSK) and rate (full-rate or half-rate) are not considered in this table					

The figure below represents as a function of the RLC mode, the alternative TBF modes, logical channels and basic physical subchannels used for transferring RLC data between two peer RLC instances. Any given RLC instance may operate in only one TBF mode, on only one logical channel alternative (e.g. PDTCH+PACCH) on only one basic physical channel type (e.g. SBPSCH). This leads to a total of 19 alternatives, as shown in appendix.

**Figure 5.1: RLC protocol alternatives**

## 5.2 RLC operation

### 5.2.1 NT-RLC operation

Non-transparent RLC operation comprises both acknowledged and unacknowledged modes.

The *parameters* for peer-to-peer operation defined in 3GPP TS 44.060 §9.1 also apply in the same way for DCCH TBF mode and TCH TBF mode as for GPRS TBF mode, with the following differences:

- DCCH TBF mode:
  - BSN is 4-bit long i.e. Sequence Number Space (SNS) is 16
  - Window Size (WS) is 8
  - Reported Block Bitmap (RBB) is 8-bit long
  - The value/range of other parameters are directly depending on the above-listed ones
- TCH TBF mode:
  - BSN is 8-bit long i.e. Sequence Number Space (SNS) is 256
  - Window Size (WS) is 128

- Reported Block Bitmap (RBB) is 128-bit long
- The value/range of other parameters are directly depending on the above-listed ones

The *procedures* for peer-to-peer operation defined in 3GPP TS 44.060 §9.1. also apply in the same way for DCCH TBF mode and TCH TBF mode as for GPRS TBF mode, with the exception of the following:

- DCCH TBF mode:
  - Acknowledgements may be received either within PACKET DBPSCH UPLINK/DOWNLINK ACK/NACK message or through piggy-backing within RLC/MAC block for data transfer (see 3GPP TS 44.160 §§ 11.4.2.3.1, 11.4.2.3.2).
- TCH TBF mode:
  - Acknowledgements are received within PACKET DBPSCH UPLINK/DOWNLINK ACK/NACK message sent on FACCH.

RLC/MAC block structures along with header fields are defined in 3GPP TS 44.160 clause 12

## 5.2.2 T-RLC operation

The RLC protocol has no functionality when in transparent mode. RLC SDUs are transferred to the MAC layer as they are i.e. without any alteration.

T-RLC operation is applicable for TCH TBF mode only.

# 6. Medium Access Control protocol

## 6.1 General

The MAC protocol of GERAN *Iu mode* differs mostly from (E)GPRS by the following characteristics:

- Operation on dedicated channels (new TBF modes introduced)
- Multiple TBFs
- New MAC state machine instead of the RR operating modes (e.g. packet transfer mode)
- New identifiers

## 6.2 Identifiers

New identifiers are introduced to identify the mobile station and the data flows. These identifiers are described in 3GPP TS 43.051 subclause 6.1.

### 6.2.1 G-RNTI

The GERAN Radio Network Temporary Identity (G-RNTI) is defined in 3GPP TS 44.118. It is used in *Iu mode* instead of the TLLI, to identify uniquely the mobile station in the radio access network. It is built in exactly the same way as the U-RNTI in UTRAN and contains a 20 bit S-RNTI and a 12 bit SBSC Id. The SBSC Id provides the identity of the serving BSC, while the S-RNTI provides the identity of the mobile station within its serving BSC. Both identifiers together provide a unique identification within the GERAN.

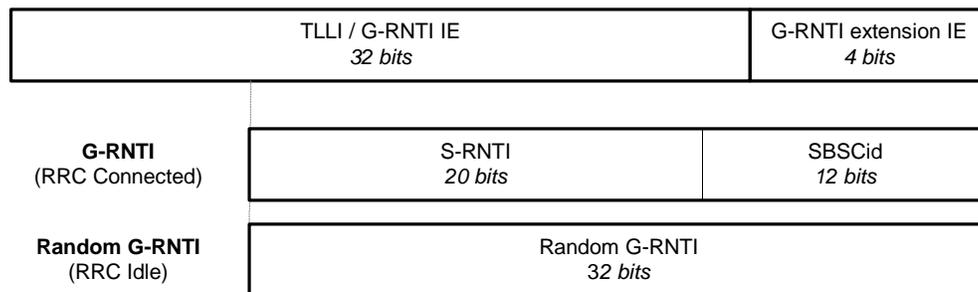
NOTE: While in RRC protocol, the G-RNTI is constructed as SBSC Id followed by the S-RNTI, it is constructed in the opposite way at RLC/MAC i.e. S-RNTI followed by the SBSC Id. This principle is followed in order for a mobile station to quickly check whether the GRNTI included in a message is its own or not.

If the MS has an RRC connection established, the mobile station has a G-RNTI assigned. If a mobile station in *Iu mode* has no RRC connection established, a random G-RNTI is calculated and used by the MS.

The inclusion of the G-RNTI in RLC/MAC control messages is done in two parts:

- The first part (28 bits) is included within the codespace of the TLLI: TLLI / G-RNTI IE
- The rest (4 bits) is included within the body of the message: G-RNTI extension IE

The figure and the table below illustrate how the G-RNTI is constructed, and how it is included within the TLLI codespace.



**Figure 6.1: G-RNTI at RLC/MAC**

**Table 6.1: TLLI field**

31	30	29	28	27	26 to 0	Type of TLLI
1	1	T	T	T	T	Local TLLI
1	0	T	T	T	T	Foreign TLLI
0	1	1	1	1	R	Random TLLI
0	1	1	1	0	A	Auxiliary TLLI
0	1	1	0	X	X	Reserved
0	1	0	X	X	X	Reserved
0	0	0	0	G	G	Part of the assigned G-RNTI
0	0	0	1	R	R	Random G-RNTI

## 6.2.2 RB Id, RRB Id, SRB Id and TFI

The text below is mostly taken from 3GPP TS 43.051 subclause 6.1.4.

An RB Id (Radio Bearer Identity) identifies a RB (Radio Bearer). An RB Id has one of 32 possible values. Signalling radio bearers use RB Ids 0 to 4; user radio bearers use the rest. RB Ids are assigned at RB establishment and remain assigned until the radio bearer or the RRC connection is released.

An RRB Id (Reduced Radio Bearer Identity) identifies a TBF in DCCH TBF mode (i.e. on FACCH, SACCH or SDCCH). An RRB Id has one of 8 possible values. For such TBFs carrying SRBs, RRB Ids are implicitly assigned when the DBPSCH is assigned. For such TBFs carrying URBs, the mapping between RB Id and RRB Id is given by RRC at RB setup.

A TFI (Temporary Flow Identity) identifies a TBF (Temporary Block Flow) on PDTCHs. A TFI has one of 32 possible values. For SBPSCHs, when a TBF is established, one unique TFI is assigned across all SBPSCHs that carry the TBF, as in (E)GPRS. Uplink and downlink TFIs are independent, i.e., assignment of a TFI in one direction does not constrain the TFI used in the other direction. The GERAN establishes the association between RB Id and TFI when the TBF is

established. For DBPSCHs, TFIs are implicitly assigned to TBFs when the corresponding RB is allocated on the DBPSCH, and remain assigned until the RB is deallocated from the DBPSCH. For each RB on a DBPSCH, the TFI equals the RB Id.

A TBF on one or more TCHs is the only user of the TCHs; hence, no specific MAC-layer identifier is needed.

An SRB Id (Signalling Radio Bearer Identity) identifies a SRB (Signalling Radio Bearer). An SRB Id has one of 4 possible values. SRB Id is used only on SFACCH.

## 6.3 MAC State Machine

In *Iu mode*, the RR operating modes are not used. Instead new MAC states are defined based on the radio resources assigned to a given MS.

- MAC-Idle state: no radio resources allocated
- MAC-Shared state: one or more SBPSCH(s) allocated
- MAC-Dedicated state: one or more DBPSCH(s) allocated (see note 1)
- MAC-DTM state: one or more SBPSCH(s) allocated *and* one or more DBPSCH(s) allocated (see note 2)

NOTE 1: A mobile station may not have more than one DBPSCH/S assigned. If a mobile station has a DBPSCH/S assigned, it may not be assigned any other BPSCH

NOTE 2: It should be noted that the MAC-DTM state is irrespective of the CN domains to which the MS is connected, contrarily to dual transfer mode in Release 99 where the MS is connected to both CS and PS domains.

The figure below represents the MAC state machine ruling the operation of the MAC protocol in *Iu mode*. The *green arrows* represent allocation of resources and trigger MAC state transitions. The *red arrows* represent release of resources and trigger MAC state transition. The *orange arrows* represent allocation/release of resources which do not trigger any MAC state transition. The *blue arrows* represent a change of radio resources (dedicated  $\Leftrightarrow$  shared) using RRC procedure and trigger MAC state transition.

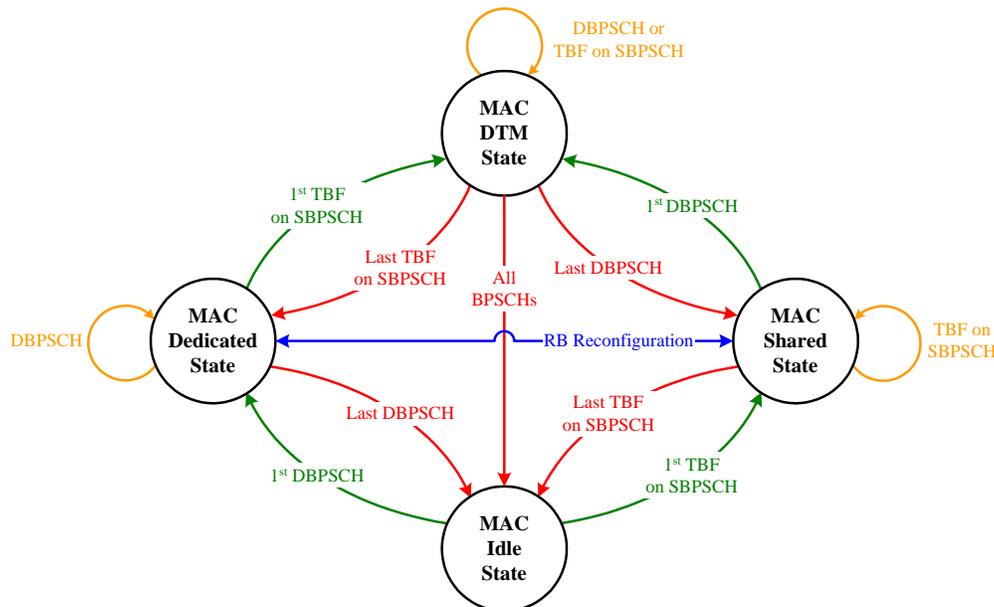


Figure 6.2: MAC state machine

To account for the variety of RLC operations (e.g. on PDTCH, TCH, SDCCH, etc.), two new TBF modes have been defined beside existing GPRS and EGPRS TBF modes, namely *TCH TBF mode* and *DCCH TBF mode*. These new TBF modes are defined in 3GPP TS 44.160 §5.2.1.

## 6.4 MAC operation

### 6.4.1 MAC-Idle state

#### 6.4.1.1 General procedures

##### 6.4.1.1.1 Mobile station side

The following general procedures have been changed in *Iu mode* compared to *A/Gb mode*:

- Cell reselection
  - The only difference compared to *A/Gb mode* is the selection of the mode of operation *Iu mode* or *A/Gb mode*. A mobile station that supports *Iu mode* shall operate in *Iu mode* in a cell that supports *Iu mode*, unless ordered otherwise
- Acquisition of system information on BCCH and PBCCH
  - The main difference here lies in the acquisition of *Iu mode*-related/specific system information
- Discontinuous reception
  - The computation of DRX parameters is defined in 3GPP TS 44.118. The paging group of the mobile station is computed accordingly in the RRC protocol and notified to the MAC protocol
  - DRX applies on PCCCH only, given CCCH are not used in *Iu mode*.
- G-RNTI is used instead of TLLI. See section 6.2.1.

##### 6.4.1.1.2 Network side

###### 6.4.1.1.2.1 General

The main change brought in *Iu mode* compared to *A/Gb mode* is the broadcast of *Iu mode*-related/specific system information on BCCH and PBCCH.

*Packet control channels* (PBCCH and PCCCH) are mandatory for both network and mobile station in *Iu mode*. It is possible to have GERAN cells that support both *A/Gb mode* and *Iu mode* of operation. In this case, the packet control channels are visible to both *A/Gb mode* (GPRS) and *Iu mode*.

###### 6.4.1.1.2.2 Broadcast of system information

In a cell supporting *Iu mode*, either SYSTEM INFORMATION TYPE 13 message or SYSTEM INFORMATION TYPE 13alt message are required. See GERAN *Iu mode* RRC Handbook in GP-030821.

The introduction of GERAN *Iu mode*, required changes to PACKET SYSTEM INFORMATION TYPE 3 and PACKET SYSTEM INFORMATION TYPE 3bis messages, as well a new PACKET SYSTEM INFORMATION TYPE 16 message:

- The Cell Bar Qualify 3 (CBQ3) parameter is added to PACKET SYSTEM INFORMATION TYPE 3 message and provides the barring status of the serving cell. CBQ3 is defined in 3GPP TS 44.018.

- Neighbour cell information for dual *Iu mode* and *A/Gb mode* capable cells and *Iu mode* only capable cells is also added to PACKET SYSTEM INFORMATION TYPE 3 and PACKET SYSTEM INFORMATION TYPE 3bis messages:
  - *Iu mode Neighbour Cell Parameters* are introduced to specify *Iu mode* (and *A/Gb mode*) capable neighbouring cells (BA(GPRS)) and their corresponding cell selection parameters. The *Iu mode Neighbour Cell Parameters* are specified in PSI3 and in at least one instance of PSI3bis. If one instance of PSI3bis is not sufficient to specify the cell selection parameters of all *Iu mode* capable neighbouring cells, the remaining *Iu mode* capable neighbouring cells are specified in consecutive instances of PSI3bis. If all information fits within the PSI3 message, one instance of PSI3bis without any *Iu mode Neighbour Cell Parameters* is broadcast.
  - *Iu mode Only Neighbour Cell Parameters* are introduced to specify *Iu mode* only capable neighbouring cells and their corresponding cell selection parameters. The *Iu mode Only Neighbour Cell Parameters* are specified in PSI3 and in at least one instance of PSI3bis. If one instance of PSI3bis is not sufficient to specify the cell selection parameters of all *Iu mode* only capable neighbouring cells, the remaining *Iu mode* only capable neighbouring cells are specified in consecutive instances of PSI3bis. If all information fits within the PSI3 message, one instance of PSI3bis without any *Iu mode Only Neighbour Cell Parameters* is broadcast.
  - The PACKET SYSTEM INFORMATION TYPE 16 message is a new PSI message for *Iu mode* only. It includes e.g. GRA Id List, *Iu mode* NMO Support, CN Domain List, CN Domain Specific DRX Cycle Length Coefficient, 3G LAC, 3G RAC and GRA and Cell Update Timer parameters. PSI16 is described in 3GPP TS 44.060 §11.2.25c.

The acquisition of consistent sets of system information is the same as in *A/Gb mode* but also accounts for the new *Iu mode*-specific messages/information elements.

#### 6.4.1.2 Packet access procedure

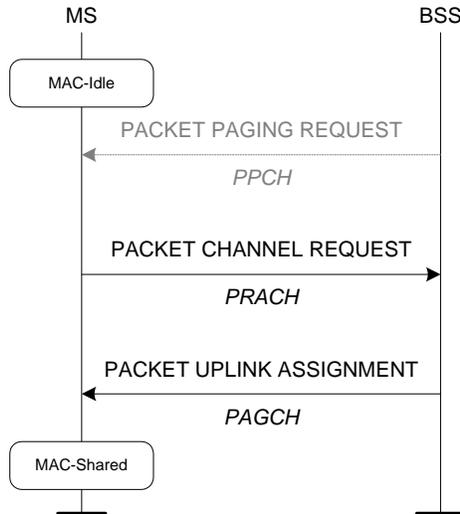
Random access on the PRACH is performed as in *A/Gb mode*. The only differences in *Iu mode* are the new access causes introduced on (EGPRS) PACKET CHANNEL REQUEST messages and their usage:

- One phase access request in RLC unacknowledged mode
- Dedicated channel request
- Emergency call

The packet access procedure (i.e. access on the PRACH, and selection of the appropriate random access cause) is defined in 3GPP TS 44.160 §7.2.3.1.1.

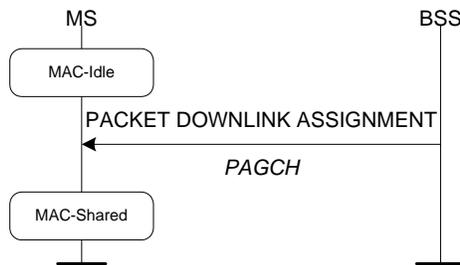
#### 6.4.1.3 Establishment of SBPSCH

The figures below describe the TBF establishment on SBPSCH initiated by the mobile station or the network on PCCCH.



**Figure 6.3: SBPSCH establishment in uplink**

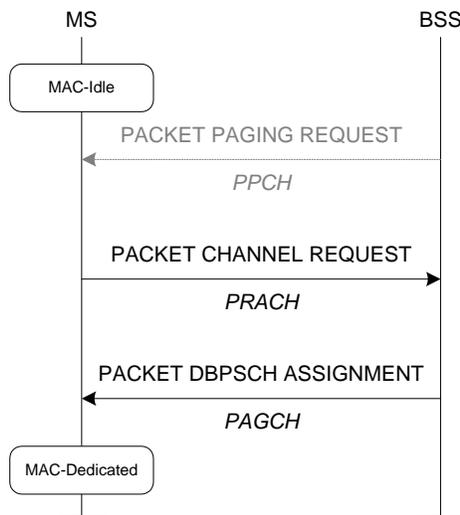
**NOTE:** In the signalling flow above, the Packet Channel Request stands for either the 8-bit PACKET CHANNEL REQUEST message, the 11-bit PACKET CHANNEL REQUEST message or the EGPRS PACKET CHANNEL REQUEST message.



**Figure 6.4: SBPSCH establishment in downlink**

#### 6.4.1.4 Establishment of DBPSCH

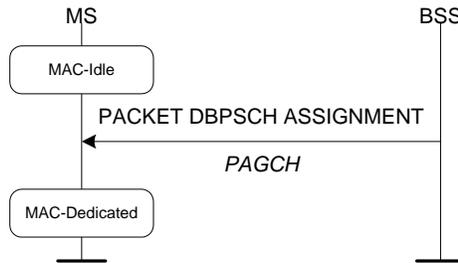
The figures below describe the assignment of DBPSCH initiated by the mobile station or the network on PCCCH.



**Figure 6.5: DBPSCH establishment in uplink**

NOTE 1: In the signalling flow above, the Packet Channel Request stands for either the 8-bit PACKET CHANNEL REQUEST message, the 11-bit PACKET CHANNEL REQUEST message or the EGPRS PACKET CHANNEL REQUEST message.

NOTE 2: A PACKET DBPSCH ASSIGNMENT message shall follow a PACKET CHANNEL REQUEST containing a dedicated channel request.

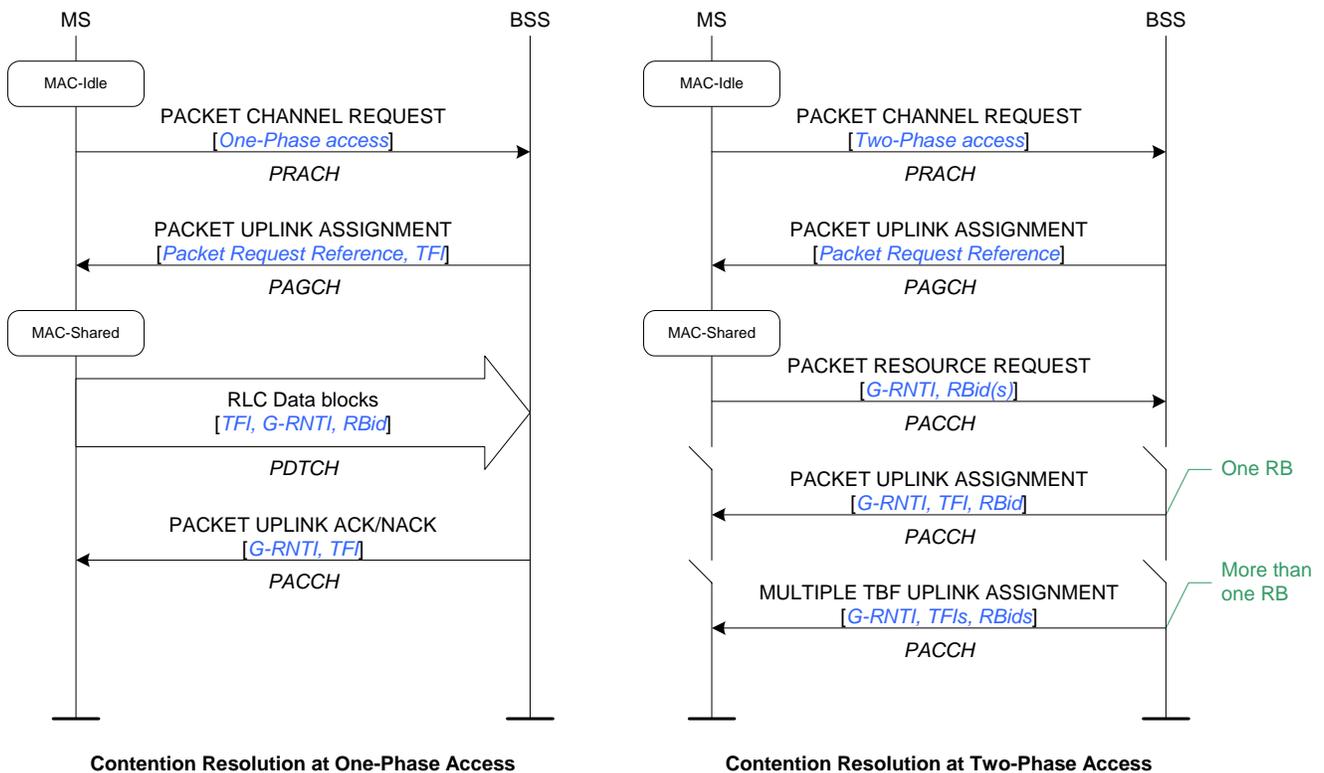


**Figure 6.6: DBPSCH establishment in downlink**

## 6.4.2 MAC-Shared state

### 6.4.2.1 Contention resolution on SBPSCH

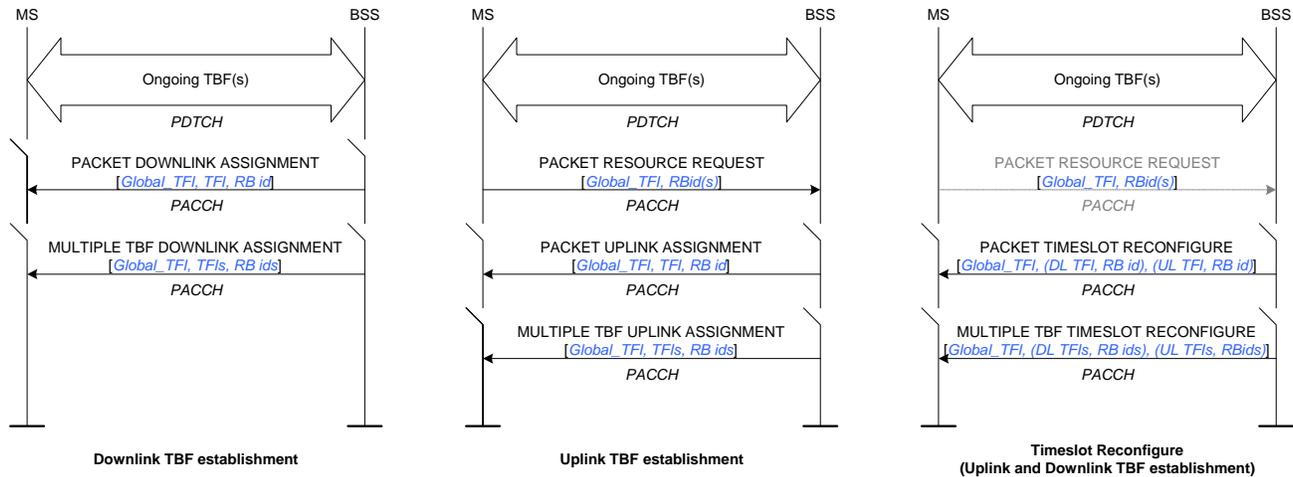
The figure below illustrates the contention resolution procedure for a TBF establishment on SBPSCH using one-phase access and two-phase access. Note that for one-phase access this procedure is followed regardless of the RLC mode used (acknowledged/unacknowledged).



**Figure 6.7: Contention resolution on SBPSCH**

### 6.4.2.2 Establishment of additional TBFs on SBPSCH

The figure below illustrates the alternatives for additional TBFs establishment on SBPSCH for already established radio bearers, when the MS is already in MAC-Shared state. Note that it is not allowed to request additional TBFs while contention resolution is not completed. RRC procedures (radio bearer set-up/reconfiguration) also apply.



**Figure 6.8: Additional TBF establishment on PACCH**

TBF release mechanisms are the same as in *A/Gb mode*.

### 6.4.2.3 Establishment of DBPSCH

The establishment of DBPSCH while in MAC-Shared state is done through radio bearer set-up/reconfiguration procedures specified in 3GPP TS 44.118.

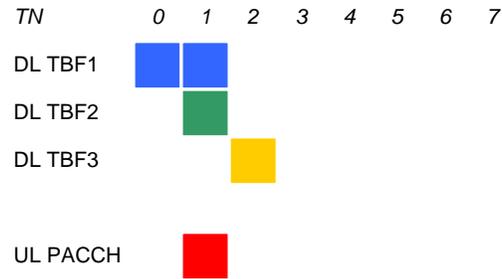
### 6.4.2.4 Multiplexing

#### 6.4.2.4.1 Dynamic allocation

In MAC-Shared state, dynamic allocation or extended dynamic allocation is used to schedule TBFs, as in *A/Gb mode*.

#### 6.4.2.4.2 Uplink control timeslot

Due to multiple TBFs and mobile station's multislot class constraints, a restriction applies on the uplink timeslot used for PACCH. An uplink control timeslot is included which enables to map the PACCH/U of a downlink TBF on a timeslot that is not assigned to this TBF in downlink, as depicted on the figure below. In this example, the downlink TBF3 is assigned an Uplink Control Timeslot TN=1 at TBF assignment. TBF3 can be identified in uplink messages (e.g. PACKET DOWNLINK ACK/NACK messages) with its downlink TN and TFI.



Example with multislot class 4 MS

**Figure 6.9: Uplink control timeslot**

#### 6.4.2.4.3 SFACCH operation

SFACCH –shared FACCH– allows for stealing radio resources from a given TBF to send SRB data from an SRB for which *no* TBF is currently established. Effectively, SFACCH consists in multiplexing RLC instances onto a single TBF.

The following requirements shall be followed:

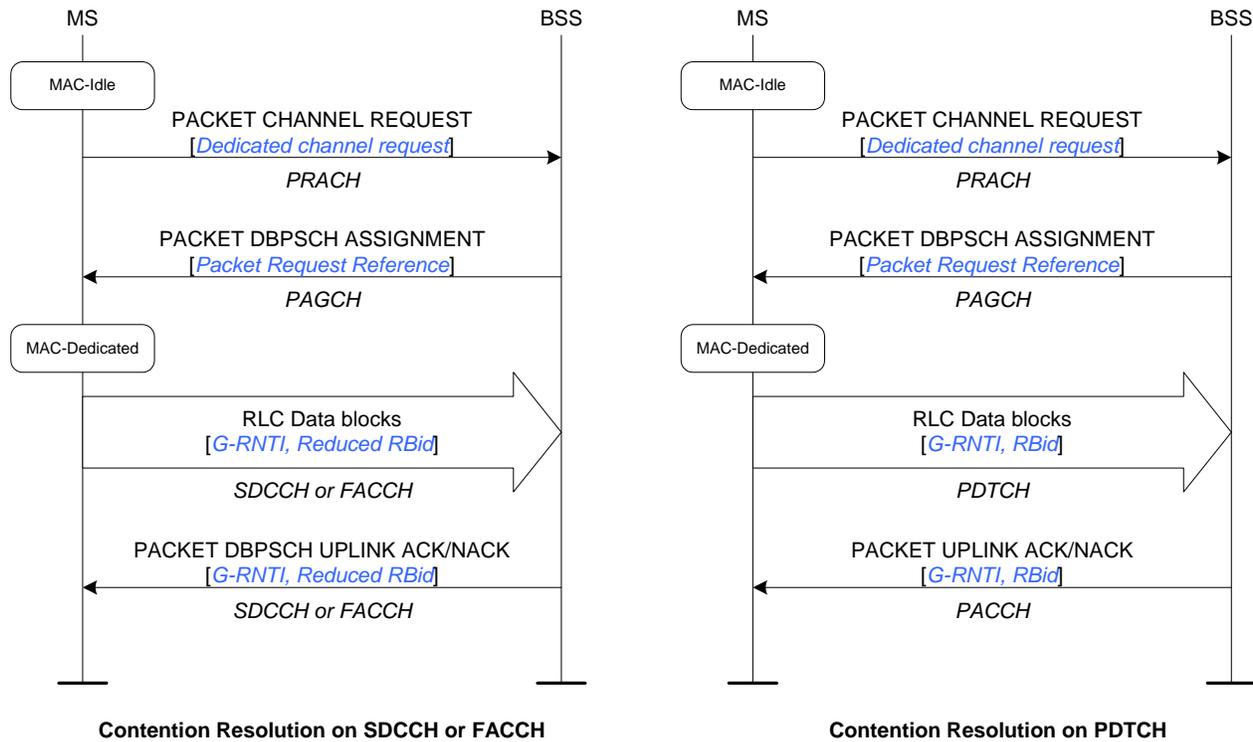
- SFACCH can be used on SBPSCH only
- Only RLC/MAC blocks for data transfer can be sent on SFACCH. All RLC/MAC control blocks are sent on PACCH
- No other (modulation and) coding schemes than CS-1 can be used for SFACCH, regardless of the TBF mode of the TBF from which resources are stolen.
- The indication of a RLC/MAC block sent on SFACCH is done as follows:
  - An RLC/MAC block sent on SFACCH shall include the TFI of the TBF from which resources are stolen
  - An RLC/MAC block sent on SFACCH shall use the payload type “00” as for an RLC/MAC block sent on PDTCH
  - An RLC/MAC block sent on SFACCH shall contain the optional octet 3:
    - The optional octet 3 shall contain the ME bit combination equal to “00” in the RLC/MAC header. This allows for distinction between an RLC/MAC block sent on SFACCH and an RLC/MAC block sent on PDTCH
    - The RLC instance of the SRB to which an RLC/MAC block sent on SFACCH belongs is identified with the SRBid included in the optional octet 3 of the RLC/MAC header. This also allows for distinction between various SRBs stealing resources from the same TBF
- The Countdown Value included in the RLC/MAC header of an uplink RLC/MAC block sent on SFACCH shall correspond to the RLC instance of the SRB to which this RLC/MAC block belongs. This allows for the network to allocate more resource accordingly if needed
- The RLC acknowledgement for the SRB data sent on SFACCH shall be sent on PACCH of the same TBF in either PACKET UPLINK ACK/NACK or PACKET DOWNLINK ACK/NACK message depending on the direction. The RBid of the SRB that is being acknowledged shall be included in the acknowledgement message. The TFI in this message shall identify the TBF from which radio resources were stolen with SFACCH

SFACCH is defined in 3GPP TS 44.160 §8.1a. See 3GPP TS 44.160 §12.4 for RLC/MAC block formats.

## 6.4.3 MAC-Dedicated state

### 6.4.3.1 Contention resolution on DBPSCH

The figure below illustrates the contention resolution procedure for a TBF establishment on DBPSCH. Note the similarities with one-phase access procedure.



**Figure 6.9: Contention resolution on DBPSCH**

### 6.4.3.2 Establishment of additional DBPSCH or SBPSCH

The establishment of additional TBFs on DBPSCH is handled by RRC through Radio Bearer Set-up/Reconfiguration procedures.

The establishment of TBFs on SBPSCH (which in turn triggers a transition to MAC-DTM state) is handled by RRC through DTM request, Radio Bearer Set-up/Reconfiguration procedures.

The release of DBPSCH is under control of RRC. Any failure identified at layer 2 is notified to RRC.

### 6.4.3.3 Multiplexing

#### 6.4.3.3.1 PDTCH, PACCH

On DBPSCH, the TFI included in an RLC/MAC block equals the RBid of the radio bearer to which this RLC/MAC block belongs.

The USF is used like in dynamic allocation to schedule TBFs in uplink direction.

The following rules apply:

- A TBF1 may steal the radio block(s) allocated to a TBF2 by a USF in case this TBF2 has nothing to send

- A TBF1 without any USF assigned may steal one radio block allocated to a TBF2 by a USF. This is used instead of PACKET RESOURCE REQUEST message. This triggers the assignment of a USF to TBF1 by the network through a PACKET UPLINK ASSIGNMENT message
- A mobile station may ignore the USF if one and only one TBF has data to send in uplink: MS need not wait for USF for sending data

The transfer of RLC/MAC blocks on PDTCH (DBPSCH) is defined in 3GPP TS 44.160 § 9.2.4.

#### 6.4.3.3.2 TCH

No multiplexing applies on TCH. There is one and only one radio bearer per TCH. Signalling is sent on FACCH.

The transfer of RLC/MAC blocks on TCH+FACCH is defined in 3GPP TS 44.160 §9.2.2.

#### 6.4.3.3.3 FACCH, SACCH, SDCCH

No USF is used to schedule uplink transmissions. The MS sends according to the following priorities between radio bearers SRB2>SRB1>SRB3>SRB4>URB and according to the transfer of RLC/MAC blocks on FACCH, SACCH, SDCCH defined in 3GPP TS 44.160 §9.2.3..

The reduced RBid is used to identify the corresponding TBF

### 6.4.4 MAC-DTM state

#### 6.4.4.1 General

The MAC-DTM state definition is independent on the CN domains to which the mobile station is connected, contrarily to dual transfer mode in *A/Gb mode*.

No contention resolution applies in MAC-DTM state.

#### 6.4.4.2 Establishment of TBFs on SBPSCH

The establishment of TBFs on SBPSCH may be done either through RRC procedures (radio bearer set-up/reconfiguration) or TBF establishment on PACCH for already established radio bearers as in MAC-Shared state.

#### 6.4.4.3 Establishment of DBPSCH

The establishment of DBPSCH is done through RRC procedures (radio bearer set-up/reconfiguration).

The SBPSCH follow the DBPSCH similarly to DTM in Rel'99.

#### 6.4.4.4 Multiplexing

Exclusive allocation is only applicable on SBPSCH/H. Multiplexing mechanisms of DBPSCH and SBPSCH apply.

### 6.4.5 Mapping of SRBs onto logical channels

It is the responsibility of the MAC protocol to map SRB data onto the appropriate logical channel, as specified in 3GPP TS 44.160 §5.6.

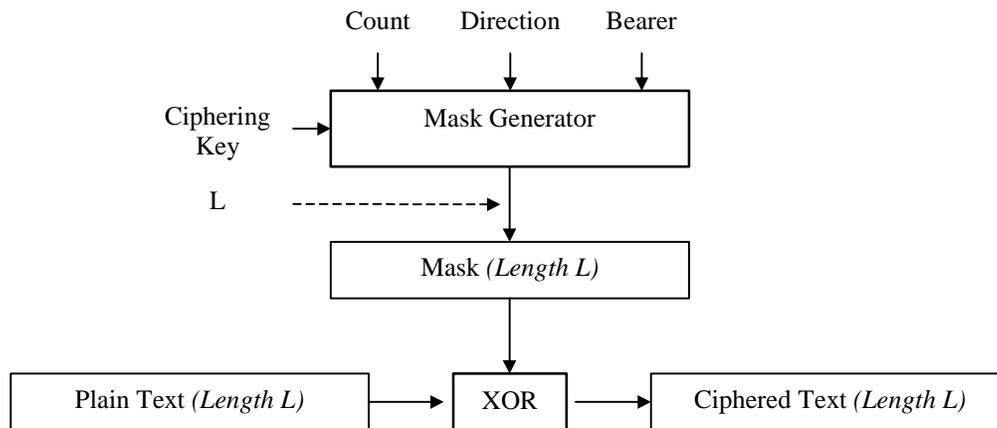
In downlink direction, the network is responsible for this mapping. In uplink direction, the mapping rules are defined per MAC-State and SRB. These rules shall be followed by all mobile stations.

## 7. Cipherng

### 7.1 Principle

Cipherng is intended to avoid any unauthorized acquisition of data from a third party. The details of the cipherng function at RLC/MAC are given in 3GPP TS 44.160 clause 13. The key of the cipherng process resides in the mask generator, using the same algorithm as in UTRAN: Kasumi f8.

The principle of cipherng is depicted below (see 3GPP TS 43.051 clause 7). See further 3GPP TS 33.102 for a detailed description of the security architecture.



**Figure 7.1: Cipherng Principle**

Cipherng is started/stopped upon order from RRC only. Besides, cipherng applies only when the mobile station and the BSS know each other. Hence, cipherng may only apply between the mobile station and the serving BSS once contention resolution is successfully completed i.e. cipherng in uplink (resp. downlink) can start when contention resolution is completed on mobile station side (resp. BSS side). The same principle is followed in UTRAN (see 3GPP TS 33.102).

### 7.2 Location

Cipherng is performed in RLC and MAC sublayers as follows:

- MAC ciphers transparent RLC data
- MAC ciphers RLC/MAC control messages.
  - Only RLC/MAC control messages related to radio resource handling and data acknowledgements may be cipherng. They are listed in 3GPP TS 44.160 clause 13. Some RLC/MAC header fields, as well as some information elements in the message shall always be left uncipherng to e.g. allow other MSs on the same SBPSCH to decode the broadcast part of the message.
- RLC ciphers non-transparent RLC data (i.e. RLC PDUs)

## 7.3 Other details

### 7.3.1 Ciphering parameters

The parameters used for ciphering are shown in figure 7.1 above. Their definition is given in 3GPP TS 44.160 §13.1.

- The *ciphering key* is provided to RLC & MAC protocols by the RRC protocol. Along with Kasumi f8, it provides the 3G security level of UMTS. It is 128-bit long. There is a unique ciphering key per CN domain. Ciphering of RRC signalling is done with the most recent ciphering key available.
- The *count* input ensures that two blocks from the same flow are ciphered differently. It is 32-bit long.
  - When available (NT-RLC), the RLC Block Sequence Number is used as the LSBs of the count. Otherwise (T-RLC, or for RLC/MAC control messages), a *17-bit TDMA frame number* is used as the LSBs of the count. This TDMA frame number is described in 3GPP TS 44.160 §13.4.2.1: it is built based on T1, T2 and T3 parts of the 22-bit TDMA frame number defined in 3GPP TS 45.002.
  - The MSBs of the count contains the *Hyper Frame Number* (HFN) to build up the 32-bit count. The HFN to use for a given RB per direction is notified by RRC to the RLC and MAC sublayers.
  - Upon cycle of the count input, a new ciphering key must be used to avoid using the same ciphering configuration twice for the same bearer.
- The *direction* indicates the direction in which the data to cipher is sent. It ensures that two blocks sent belonging to the same bearer, but sent in opposite direction are ciphered differently. It is 1 bit.
- The *bearer* identifies, when applicable, the bearer to which the data to cipher belongs. It contains the RB Id when available (ciphering of NT-RLC data and T-RLC data). It equals zero in case the RB Id is not available (ciphering of RLC/MAC control messages). It is 5-bit long.
- The *length* indicates the length in bits of the data to cipher

The exact set-up and values of these parameters are defined in 3GPP TS 44.160 §13.3 for ciphering at the RLC sublayer, and 3GPP TS 44.160 §13.4 for ciphering at the MAC sublayer.

### 7.3.2 Synchronization

Ciphering requires an exact synchronization of the parameters (see section 7.3.1) used as input to the ciphering algorithm between the GERAN and the mobile station.

While *direction*, *bearer*, and *length* are always synchronized i.e. cannot be desynchronised, desynchronization may affect the *count* input through different HFN being used in the mobile station and the GERAN. Such desynchronization of the HFN occurs at abnormal failure of the radio resources detected by the transmitter at layer 2, and may be of up to 1 unit only: the transmitting side's HFN is in this case one higher (mod HFN range) than the receiving side's HFN. In such a case, the transmitting side will inform the receiving side of the least significant bit of its HFN (HFN\_LSB) at next request/assignment of resources for this radio bearer in this direction.

## 8. RLC/MAC control messages

### 8.1 General

This section (8) highlights the existing RLC/MAC control messages that have been changed to support *Iu mode* of operation, as well as new RLC/MAC control messages introduced for *Iu mode* of operation. These new messages are exclusive to *Iu mode* of operation in 3GPP Release 5.

All RLC/MAC control messages and the corresponding error handling are defined in 3GPP TS 44.060 §11.

## 8.2 Changed RLC/MAC control messages

The tables below list the existing RLC/MAC control messages that have been changed for supporting *Iu mode* of operation. The changes are also described briefly.

**Table 7.2.1 Uplink RLC/MAC control messages**

Message name	Change
PACKET CONTROL ACKNOWLEDGEMENT	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> <li>– RRBP handling: the UL PACCH may be on a different timeslot than the one on which the RRBP was received (due to multiple TBF): timeslot of the RRBP to be indicated</li> <li>– New message type for access burst formats, due to the RRBP handling</li> </ul>
PACKET CELL CHANGE FAILURE	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> </ul>
(EGPRS) PACKET CHANNEL REQUEST	<ul style="list-style-type: none"> <li>– New access causes: One phase access request in RLC unack mode Dedicated channel request Emergency call</li> </ul>
(EGPRS) PACKET DOWNLINK ACK/NACK	<ul style="list-style-type: none"> <li>– Iu mode channel request description</li> <li>– RB Id (SFACCH)</li> </ul>
PACKET UPLINK DUMMY CONTROL BLOCK	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> </ul>
PACKET MEASUREMENT REPORT	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> </ul>
PACKET ENHANCED MEASUREMENT REPORT	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> </ul>
PACKET RESOURCE REQUEST	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> <li>– Iu mode channel request description</li> <li>– HFN least significant bit</li> </ul>

**Table 7.2.2 Downlink RLC/MAC control messages**

Message name	Change
PACKET ACCESS REJECT	<ul style="list-style-type: none"> <li>– Iu mode reject structure added: rejection per RB or per MS</li> </ul>
PACKET CELL CHANGE ORDER	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> </ul>
PACKET DOWNLINK ASSIGNMENT	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> <li>– RB Id</li> <li>– Uplink control timeslot (due to Multiple TBFs)</li> <li>– HFN least significant bit</li> </ul>
PACKET MEASUREMENT ORDER	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> </ul>
PACKET PAGING REQUEST	<ul style="list-style-type: none"> <li>– Repeated Iu page Info: allows for GERAN page; CN page</li> </ul>
PACKET POLLING REQUEST	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> </ul>
PACKET SYSTEM INFORMATION TYPE 3	<ul style="list-style-type: none"> <li>– CBQ3</li> <li>– Iu mode neighbour cell parameters</li> </ul>
PACKET SYSTEM INFORMATION TYPE 3bis	<ul style="list-style-type: none"> <li>– Iu mode neighbour cell parameters</li> <li>– Iu mode only neighbour cell parameters</li> </ul>
PACKET UPLINK ACK/NACK	<ul style="list-style-type: none"> <li>– Uplink TFI = RB Id on DBPSCH</li> <li>– G-RNTI instead of TLLI (in contention resolution identifier)</li> <li>– RB Id (SFACCH)</li> </ul>
PACKET UPLINK ASSIGNMENT	<ul style="list-style-type: none"> <li>– G-RNTI instead of TLLI</li> <li>– RB Id (for mapping TBF with RB in a given direction)</li> </ul>
PACKET TIMESLOT RECONFIGURE	<ul style="list-style-type: none"> <li>– RB Id for UL and DL TBF</li> <li>– Uplink control timeslot (due to Multiple TBFs)</li> </ul>

## 8.3 New RLC/MAC control messages

The table below lists the new RLC/MAC control messages that have been introduced for supporting *Iu mode* of operation.

**Table 7.3.1 Uplink RLC/MAC control messages**

Message name	Role
PACKET DBPSCH DOWNLINK ACK/NACK	– Transfer of downlink acknowledgement on FACCH, SACCH or SDCCH
HANDOVER ACCESS	– Same role as GSM Handover Access: notify the network the MS has moved to the new cell during a handover

**Table 7.3.2 Downlink RLC/MAC control messages**

Message name	Role
PACKET DBPSCH ASSIGNMENT	– Assignment of a DBPSCH to the MS
MULTIPLE TBF DOWNLINK ASSIGNMENT	– Assignment of multiple downlink TBFs
MULTIPLE TBF UPLINK ASSIGNMENT	– Assignment of multiple uplink TBFs
MULTIPLE TBF TIMESLOT RECONFIGURE	– Reconfiguration of multiple uplink and downlink TBFs
PACKET SYSTEM INFORMATION TYPE 16	– Iu specific system information
PACKET DBPSCH UPLINK ACK/NACK	– Transfer of uplink acknowledgement on FACCH, SACCH or SDCCH
PHYSICAL INFORMATION	– Same role as GSM Physical Information: provision of timing advance after a handover

## 9. References

The table below lists 3GPP specifications relating with the RLC/MAC protocol of GERAN *Iu mode*. For the latest specifications refer to [www.3gpp.org](http://www.3gpp.org).

Number	Title	Responsible	Release
<b>Stage 3 (Functional Description)</b>			
3GPP TS 43.051	GERAN Iu mode overall description Stage 2	3GPP GERAN	3GPP Rel 5
<b>Stage 3 (Protocol Description)</b>			
3GPP TS 44.118	Radio Resource Control protocol	3GPP GERAN WG 2	3GPP Rel 5
3GPP TS 25.323	Packet Data Convergence protocol	3GPP RAN WG 2	3GPP Rel 5

# Annex A: RLC protocol alternatives

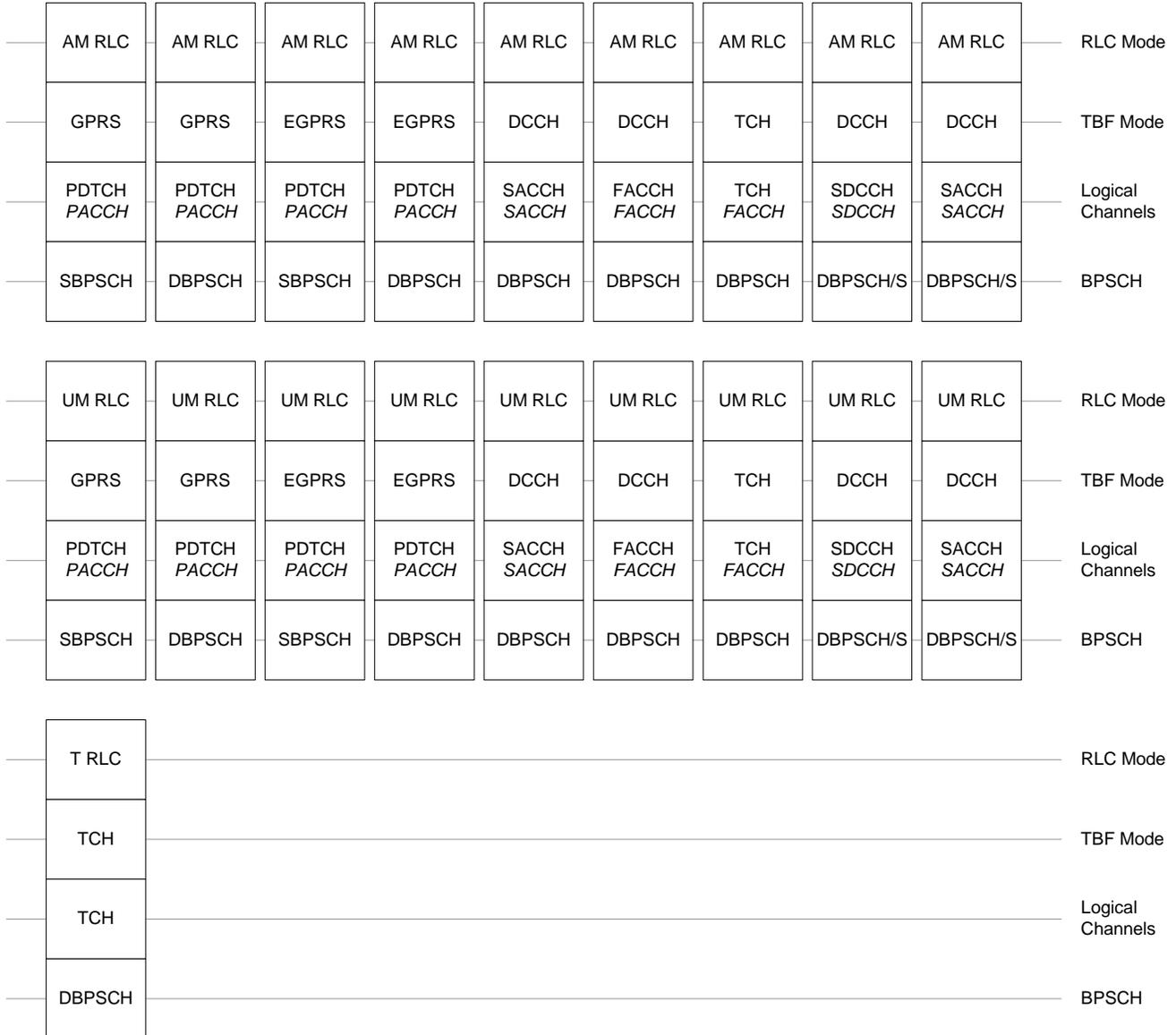


Figure A.1: RLC protocol alternatives