Agenda Item: 6.2

Source: TSG RAN WG2

Title: TS RAN S2.01, Radio Interface Protocol Architecture, V0.2.0

Document for: Approval

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This document was approved by TSG RAN WG2 at meeting #3 on 16 April 1999 in Yokohama (issued as Td R2-99337). It is proposed for approval by TSG RAN.

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TS RAN S2.01 V0.2.0 (1999-04)

3rd Generation Partnership Project (3GPP);
Technical Specification Group (TSG) RAN;
Working Group 2 (WG2);

Radio Interface Protocol Architecture

3GPP

Reference

<Workitem> (<Shortfilename>.PDF)

Keywords

Digital cellular telecommunications system,
Universal Mobile Telecommunication System
(UMTS), UTRA, IMT-2000

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Contents

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[Editor's note: This section needs to be reviewed. It is assumed here that a 3GPP IPR report will be available in the near future.]

Foreword

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

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

Version m.t.e

where:

   m   indicates [major version number]

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

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

An assumption made in this document is the support of common and shared transport channels on the Iur interface. If this assumption is reverted some parts of this document will need to be revisited.

1.

2. Scope

The present document shall provide an overview and overall description of the UE-UTRAN radio interface protocol architecture as agreed within the 3GPP TSG RAN working group 2. Details of the radio protocols will be specified in companion documents.

3. References

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

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

[1] ETSI UMTS 23.10: "UMTS Access Stratum Services and Functions"
[2] 3GPP RAN S3.01 RAN Overall Description"
[3] ETSI UMTS 25.XX: "Vocabulary for the UTRAN"
[4] [4] 3GPP RAN S2.02: "Services Provided by the Physical Layer"
[5] [5] 3GPP RAN S2.03: "UE Functions and Inter-Layer Procedures in Connected Mode"
[6] [6] 3GPP RAN S2.04: "UE Procedures in Idle Mode"
[7] [7] 3GPP RAN S2.21: "MAC Protocol Specification"
[8] [8] 3GPP RAN S2.22: "RLC Protocol Specification"
[9] [9] 3GPP RAN S2.31: "RRC Protocol Specification"

4.

5. Definitions and Abbreviations

5.1 Definitions

See [3] for a definition of fundamental concepts and vocabulary.

5.2 Abbreviations

ARQ	Automatic Repeat Request
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
C-	Control-
CC	Call Control
CCCH	Common Control Channel
CCH	Control Channel
CCTrCH	Coded Composite Transport Channel
CN	Core Network
CRC	Cyclic Redundancy Check
CTCH	Common Traffic Channel
DC	Dedicated Control (SAP)
DCA	Dynamic Channel Allocation
DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DL	Downlink
DRNC	Drift Radio Network Controller
DSCH	Downlink Shared Channel
DTCH	Dedicated Traffic Channel
FACH	Forward Link Access Channel
FAUSCH	Fast Uplink Signalling Channel
FCS	Frame Check Sequence
FDD	Frequency Division Duplex
GC	General Control (SAP)
HO	Handover
ITU	International Telecommunication Union
kbps	kilo-bits per second
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
LAC	Link Access Control
LAI	Location Area Identity
MAC	Medium Access Control
MM	Mobility Management
Nt	Notification (SAP)
OCCCH	ODMA Common Control Channel
ODCCH	ODMA Dedicated Control Channel
ODCH	ODMA Dedicated Channel
ODMA	Opportunity Driven Multiple Access
ORACH	ODMA Random Access Channel
ODTCH	ODMA Dedicated Traffic Channel
PCCH	Paging Control Channel
PCH	Paging Channel
PDU	Protocol Data Unit
PU	Payload Unit
PHY	Physical layer
PhyCH	Physical Channels
RAB	Radio Access Bearer
RACH	Random Access Channel
RLC	Radio Link Control
RNC	Radio Network Controller

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RNS   Radio Network Subsystem
RNTI   Radio Network Temporary Identity
RRC   Radio Resource Control
SAP   Service Access Point
SCCH   Synchronization Control Channel
SCH   Synchronization Channel
SDU   Service Data Unit
SRNC   Serving Radio Network Controller
SRNS   Serving Radio Network Subsystem
TCH   Traffic Channel
TDD   Time Division Duplex
TFCI   Transport Format Combination Indicator
TFI   Transport Format Indicator
TMSI   Temporary Mobile Subscriber Identity
TPC   Transmit Power Control
U-   User-
UE   User Equipment
UE_R User Equipment with ODMA relay operation enabled
UL   Uplink
UMTS   Universal Mobile Telecommunications System
URA   UTRAN Registration Area
USCH   Uplink Shared Channel
UTRA   UMTS Terrestrial Radio Access
UTRAN   UMTS Terrestrial Radio Access Network

6.

7. Assumed UMTS Architecture

Error! Unknown switch argument. shows the assumed UMTS architecture as outlined in UMTS 23.10 . The figure shows the UMTS architecture in terms of its entities User Equipment (UE), UTRAN and Core Network. The respective reference points Uu (Radio Interface) and Iu (CN-UTRAN interface) are shown. The figure illustrates furthermore the high-level functional grouping into the Access Stratum and the Non-Access Stratum.

The Access Stratum offers services through the following Service Access Points (SAP) to the Non-Access Stratum:

- General Control (GC) SAPs,

- Notification (Nt) SAPs and

- Dedicated Control (DC) SAPs

The SAPs are marked with circles in Figure 1. The services provided to the non-access stratum by the GC, Nt, and DC SAPs, from a radio interface protocol perspective, are assumed to be provided by the Radio Resource Control (RRC) to the higher protocol layer. It is however assumed that at the network side, the RRC layer terminates in the UTRAN (cf. Sec. 0).
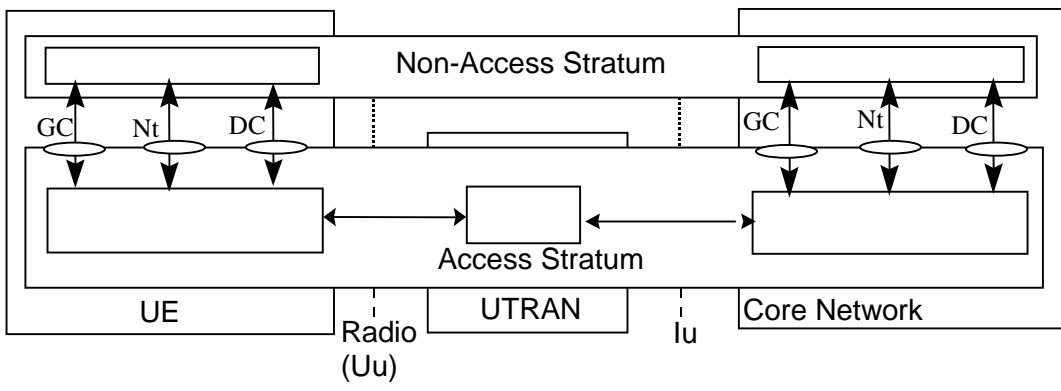
Figure Error! Unknown switch argument.**: Assumed UMTS Architecture**

8. Radio interface protocol architecture

8.1 Overall protocol structure

The radio interface is layered into three protocol layers:

- the physical layer (L1),

- the data link layer (L2),

- network layer (L3).

Layer 2 is split into two sublayers, Radio Link Control (RLC) and Medium Access Control (MAC).

Layer 3 and RLC are divided into Control (C-) and User (U-) planes.

In the C-plane, Layer 3 is partitioned into sublayers where the lowest sublayer, denoted as Radio Resource Control (RRC), interfaces with layer 2. The higher layer signalling such as Mobility Management (MM) and Call Control (CC) are assumed to belong to the non-access stratum, and therefore not in the scope of 3GPP TSG RAN. On the general level, the protocol architecture is similar to the current ITU-R protocol architecture, ITU-R M.1035.

Error! Unknown switch argument. shows the radio interface protocol architecture. Each block in **Error! Unknown switch argument.** represents an instance of the respective protocol. Service Access Points (SAP) for peer-to-peer communication are marked with circles at the interface between sublayers. The SAP between MAC and the physical layer provides the transport channels (cf. Sec. 0). The SAPs between RLC and the MAC sublayer provide the logical

channels (cf. Sec. 0). In the C-plane, the interface between RRC and higher L3 sublayers (CC, MM) is defined by the General Control (GC), Notification (Nt) and Dedicated Control (DC) SAPs.

Also shown in the figure are connections between RRC and MAC as well as RRC and L1 providing local inter-layer control services. An equivalent control interface exists between RRC and the RLC sublayer. These interfaces allow the RRC to control the configuration of the lower layers. For this purpose separate Control SAPs are defined between RRC and each lower layer (RLC, MAC, and L1). It is assumed that for RLC and MAC one Control SAP each is provided per UE.

[Editor´s note: Control of RLC entities in C and U planes needs to be clarified further. Also, the multiplicity of Control SAPs (necessity of one SAP per UE) at the UTRAN side may need to be reconsidered.]

The RLC sublayer provides ARQ functionality closely coupled with the radio transmission technique used. There is no difference between RLC instances in C and U planes.

The UTRAN can be requested by the CN to prevent all loss of data (i.e. independently of the handovers on the radio interface), as long as the Iu connection point is not modified. This is a basic requirement to be fulfilled by the UTRAN retransmission functionality as provided by the RLC sublayer.

However, in case of the Iu connection point is changed (e.g. SRNS relocation, streamlining), the prevention of the loss of data may not be guaranteed autonomously by the UTRAN but would rely on some functions in the CN. In this case, a mechanism to achieve the requested QoS may require support from the CN. Such mechanisms to protect from data loss due to SRNS relocation or streamlining are for further study.

[Editor´s note: Such mechanisms need to be specified jointly with 3GPP TSGs CN and SA. The implied functionality would be applied in the U plane. Applicability in the C plane is for further study.]
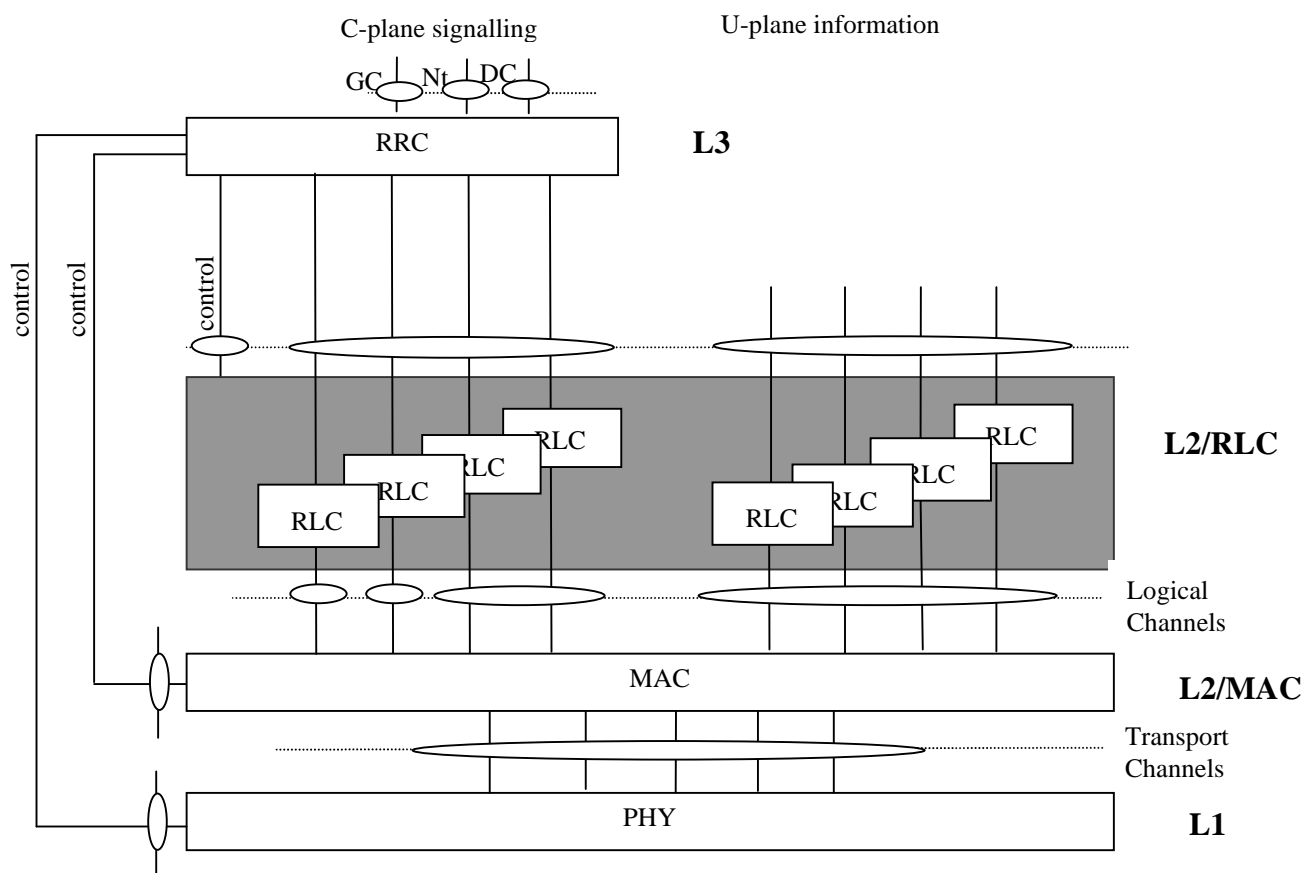
Figure Error! Unknown switch argument.**: Radio Interface protocol architecture (Service Access Points marked by circles)**

8.1.1

8.1.1

8.1.2   Service access points and service primitives

Each layer provides services at Service Access Points (SAPs). A service is defined by a set of service primitives (operations) that a layer provides to upper layer(s).

Control services, allowing the RRC layer to control lower layers locally (i.e. not requiring peer-to-peer communication) are provided at Control SAPs (C-SAP). Note that C-SAP primitives can bypass one or more sublayers, see **Error! Unknown switch argument.**.

In the radio interface protocol specifications, the following naming conventions for primitives shall be applicable:

- Primitives provided by SAPs between adjacent layers shall be prefixed with the name of the service-providing layer, i.e. PHY, MAC or RLC.

- Primitives provided by Control SAPs, in addition to the name of the service-providing layer, shall be prefixed with a "C", i.e. CPHY, CMAC or CRLC.

This principle leads to the following notations, where <Type> corresponds to request, indication, response or confirm type of primitives:

Primitives between PHY and MAC:
PHY- <Generic nam>e – <Type>

Primitives between PHY and RRC (over C-SAP):
CPHY- <Generic name> - <Type>

Primitives between MAC and RLC:
MAC- <Generic name> - <Type>

Primitives between MAC and RRC (over C-SAP):
CMAC- <Generic name> - <Type>

Primitives between RLC and non-access stratum, and between RLC and RRC for data transfer:
RLC- <Generic name> - <Type>

Primitives between RLC and RRC for control of RLC (over C-SAP):
CRLC- <Generic name> – <Type>

8.2 Layer 1 Services and Functions

This section shall provide an overview on services and functions provided by the physical layer. A detailed description of Layer 1 general requirements can be found in 3GPP RAN S2.02 [4].

8.2.1   L1 Services

The physical layer offers information transfer services to MAC and higher layers. The physical layer transport services are described by *how* and with what characteristics data are transferred over the radio interface. An adequate term for this is 'Transport Channel'[1].

8.2.1.1 Transport channels

A general classification of transport channels is into two groups:

- common transport channels (where there is a need for inband identification of the UEs when particular UEs are addressed) and

- dedicated transport channels (where the UEs are identified by the physical channel, i.e. code and frequency for FDD and code, time slot and frequency for TDD).

Common transport channel types are (a more detailed description can be found in [4]):

- **Random Access Channel (RACH)**

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1 This should be clearly separated from the classification of *what* is transported, which relates to the concept of logical channels. Thus DCH is used to denote that the physical layer offers the same type of service for both control and traffic.

A contention based uplink channel used for transmission of relatively small amount of data, e.g. for initial access or
    non-realtime dedicated control or traffic data.

- **ODMA Random Access Channel (ORACH)**
A contention based channel used in relaylink.

- **Forward Access Channel (FACH)**
Common downlink channel without closed-loop power control used for transmission of relatively small amount of data.

- **Downlink Shared Channel (DSCH)**
    A downlink channel shared by several UEs carrying dedicated control or traffic data.

- **DSCH Control Channel**
    A downlink channel associated with a DSCH used for signalling of DSCH resource allocation.

    *[Editor' s note: It is for further study whether or not the DSCH Control Channel needs to be regarded as separate
    transport channel type from FACH. Seen from the upper layers, the current requirements are identical to a FACH,
    but some extra L1 information (e.g.TPC bits) may lead to a different physical channel. See Sec. 0 for a description
    of the DSCH concepts currently considered in TSG-RAN WG2. This section also includes further notes on ffs. items
    related to the DSCH.]*

- **Uplink Shared Channel (USCH)**
An uplink channel shared by several UEs carrying dedicated control or traffic data, used in TDD mode only.

- **Broadcast Channel (BCH)**
A downlink channel used for broadcast of system information into an entire cell.

- **Synchronization Channel (SCH)**
A downlink channel used for broadcast of synchronization information into an entire cell in TDD mode.

    Note that the SCH transport channel is defined for the TDD mode only. In the FDD mode, a synchronization channel
    is defined as a physical channel. This channel however should not be confused with the SCH transport channel
    defined above.

- **Paging Channel (PCH)**
A downlink channel used for broadcast of control information into an entire cell allowing efficient UE sleep mode
    procedures. Currently identified information types are paging and notification. Another use could be UTRAN
    notification of change of BCCH information.

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Dedicated transport channel types are:

- **Dedicated Channel (DCH)**
A channel dedicated to one UE used in uplink or downlink.

- **Fast Uplink Signalling Channel (FAUSCH)**
An uplink channel used to allocate dedicated channels in conjunction with FACH.

- **ODMA Dedicated Channel (ODCH)**
A channel dedicated to one UE used in relaylink.

To each transport channel (except for the FAUSCH, since it only conveys a reservation request), there is an associated
Transport Format (for transport channels with a fixed or slow changing rate) or an associated Transport Format Set (for
transport channels with fast changing rate). A Transport Format is defined as a combination of encodings, interleaving,
bit rate and mapping onto physical channels (see 3GPP RAN S2.02 [4] for details). A Transport Format Set is a set of
Transport Formats. E.g., a variable rate DCH has a Transport Format Set (one Transport Format for each rate), whereas
a fixed rate DCH has a single Transport Format.

8.2.2 L1 Functions

The physical layer performs the following main functions:

- Macrodiversity distribution/combining and soft handover execution

- Error detection on transport channels and indication to higher layers

- FEC encoding/decoding and interleaving/deinterleaving of transport channels

- Multiplexing of transport channels and demultiplexing of coded composite transport channels

- Rate matching

- Mapping of coded composite transport channels on physical channels

- Power weighting and combining of physical channels

- Modulation and spreading/demodulation and despreading of physical channels

- Frequency and time (chip, bit, slot, frame) synchronization

- Measurements and indication to higher layers (e.g. FER, SIR, interference power, transmit power, etc.)

- Closed-loop power control

- RF processing

8.3 Layer 2 Services and Functions

8.3.1   MAC Services and Functions

This sections provides an overview on services and functions provided by the MAC sublayer. A detailed description of the MAC protocol is given in 3GPP RAN S2.21 [7].

8.3.1.1 MAC Services to upper layers

- **Data transfer**. This service provides unacknowledged transfer of MAC SDUs between peer MAC entities. This service does not provide any data segmentation. Therefore, segmentation/reassembly function should be achieved by upper layer.

Acknowledged data transfer service by MAC for transmission on RACH/FACH is ffs.

- **Reallocation of radio resources and MAC parameters**. This service performs on request of RRC execution of radio resource reallocation and change of MAC parameters, i.e. reconfiguration of MAC functions such as change of identity of UE, change of transport format (combination) sets, change of transport channel type. In TDD mode, in addition, resource allocation can be handled by the MAC autonomously.

- **Reporting of measurements**. Local measurements such as traffic volume, quality indication, MAC status indication, [other MAC measurements tbd.], are reported to RRC.

The following potential services are regarded as further study items:

- **Allocation/deallocation of radio resources**. Indication to RRC that allocation/deallocation of a MAC bearer is required. In TDD mode, resource allocation can alternatively be performed by the MAC autonomously.

8.3.1.1.1   Logical channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC. Each logical channel type is defined by what type of information is transferred.

A general classification of logical channels is into two groups:

- Control Channels (for the transfer of control plane information)

- Traffic Channels (for the transfer of user plane information)

The configuration of logical channel types is depicted in **Error! Unknown switch argument.**.

Control Channel (CCH) ————————— Synchronisation Control Channel (SCCH)

————— Broadcast Control Channel (BCCH)

————— Paging Control Channel (PCCH)

————— Dedicated Control Channel (DCCH)

————— Common Control Channel (CCCH)

————— ODMA Dedicated Control Channel (ODCCH)

————— ODMA Common Control Channel (OCCCH)

Traffic Channel (TCH) ————————— Dedicated Traffic Channel (DTCH)

————— ODMA Dedicated Traffic Channel (ODTCH)

————— Common Traffic Channel (CTCH)
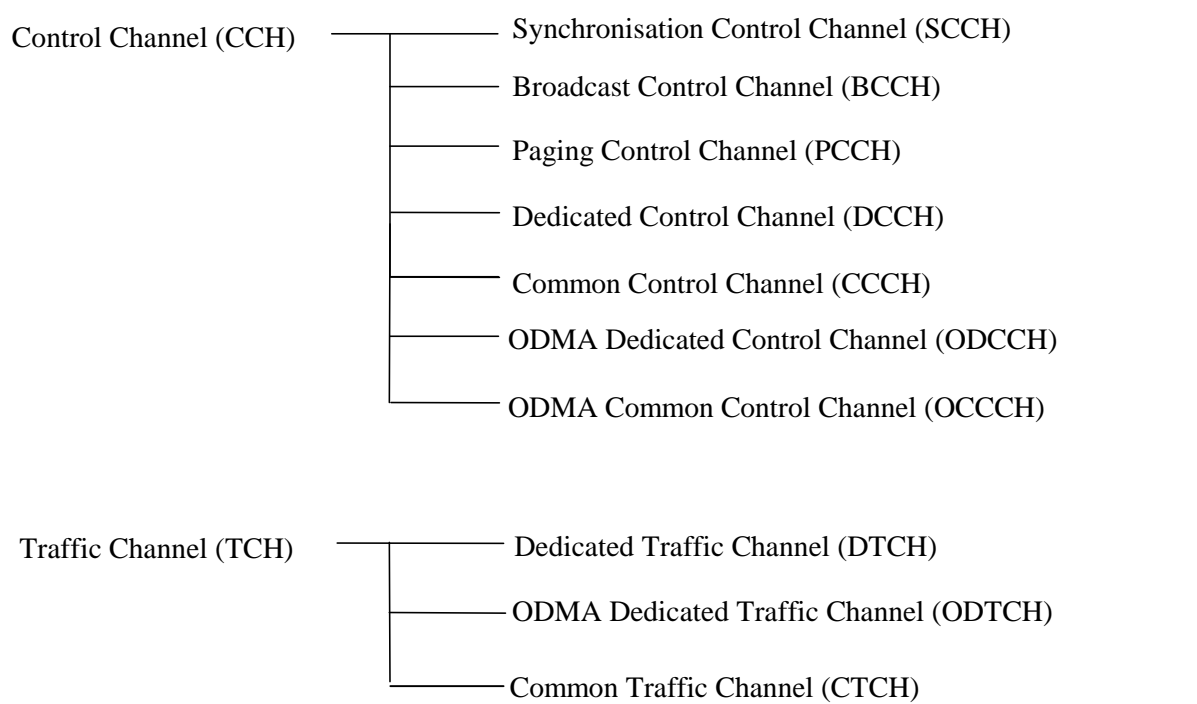
Figure Error! Unknown switch argument.**: Logical channel structure**

8.3.1.1.1.1   Control Channels

Control channels are used for transfer of control plane information only.

Synchronisation Control Channel (SCCH)

A downlink channel for broadcasting synchronisation information (information about the location and structure of the BCCH) in case of TDD operation.

Broadcast Control Channel (BCCH)

A downlink channel for broadcasting system control information. The BCCH may be further devided into two types, BCCH-Constant (BCCH-C) and BCCH-Variable (BCCH-V). BCCH-C would then transmit relatively many layer 3 information elements, which do not change, exept for change of system information. BCCH-V would transmit layer 3 information elements which change frequently and which a UE has to receive in short time (e.g. downlink power level, uplink interference level, etc). The split of BCCH is ffs.

Paging Control Channel (PCCH)

A downlink channel that transfers paging information. This channel is used when the network does not know the location cell of the UE, or, the UE is in the cell connected state (utilizing UE sleep mode procedures).

Common Control Channel (CCCH)

Bi-directional channel for transmitting control information between network and UEs. This channel is commonly used by the UEs having no RRC connection with the network.

Dedicated Control Channel (DCCH)

A point-to-point bi-directional channel that transmits dedicated control information between a UE and the network. This channel is established through RRC connection setup procedure.

ODMA Common Control Channel (OCCCH)

Bi-directional channel for transmitting control information between UEs.

ODMA Dedicated Control Channel (ODCCH)

A point-to-point bi-directional channel that transmits dedicated control information between UEs. This channel is established through RRC connection setup procedure.

8.3.1.1.1.2   Traffic Channels

Traffic channels are used for the transfer of user plane information only.

Dedicated Traffic Channel (DTCH)

A Dedicated Traffic Channel (DTCH) is a point-to-point channel, dedicated to one UE, for the transfer of user information. A DTCH can exist in both uplink and downlink.

ODMA Dedicated Traffic Channel (ODTCH)

A ODMA Dedicated Traffic Channel (ODTCH) is a point-to-point channel, dedicated to one UE, for the transfer of user information between UE's. A ODTCH exists in relaylink.

Common Traffic Channel (CTCH)

A point-to-multipoint unidirectional channel for transfer of dedicated user information for all or a group of specified UEs.

[Editor´s note: This channel type is agreed for support of Short Message Service-Cell Broadcast. Whether or not this logical channel shall also be employed for support of high-rate multicast services is ffs.]

8.3.1.1.2   Mapping between logical channels and transport channels

The following connections between logical channels and transport channels exist:

- SCCH is connected to SCH

- BCCH is connected to BCH

- PCCH is connected to PCH

- CCCH is connected to RACH and FACH

- DTCH can be connected to either RACH and FACH, to RACH and DSCH, to DCH and DSCH, to a DCH, or to USCH (TDD only)

- CTCH can be connected to DSCH, FACH or BCH (ffs.)

    [Editor´s note: Above potential mappings are proposed by the editor. This channel type will be included into the Figures below when the mappings have been agreed.]

- DCCH can be connected to either RACH and FACH, to RACH and DSCH, to DCH and DSCH, to a DCH, to FAUSCH, or to USCH (TDD only).

The mappings as seen from the UE and UTRAN sides are shown in **Error! Unknown switch argument.** and **Error! Unknown switch argument.** respectively. **Error! Unknown switch argument.** illustrates the mapping from the UE in relay operation. Note that ODMA logical channels and transport channels are employed only in relaylink transmissions (i.e. not used for uplink or downlink transmissions on the UE-UTRAN radio interface).
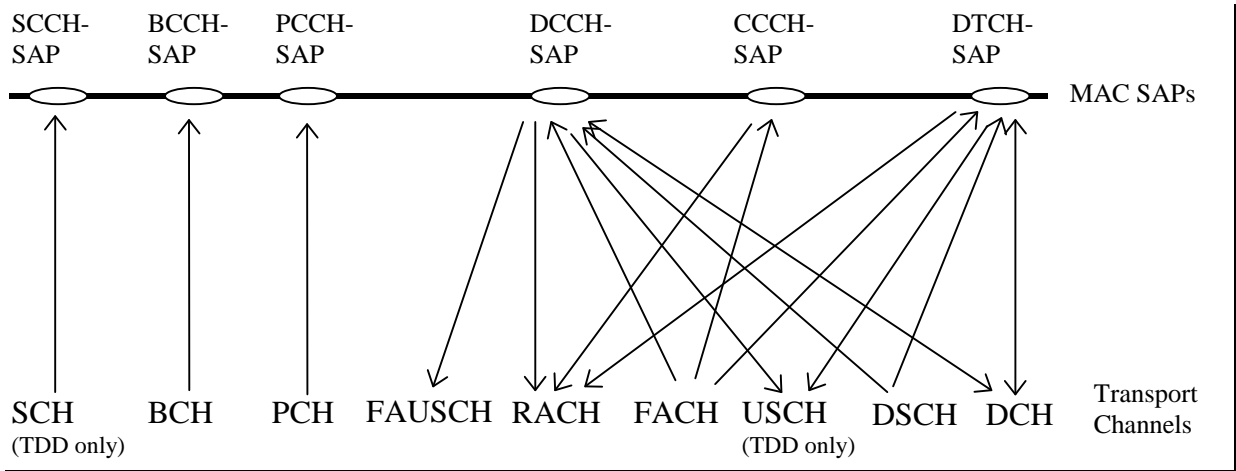
SCCH-   BCCH-   PCCH-   DCCH-   CCCH-   DTCH-
SAP   SAP   SAP   SAP   SAP   SAP

MAC SAPs

SCH   BCH   PCH   FAUSCH   RACH   FACH   USCH   DSCH   DCH   Transport
(TDD only)   (TDD only)   Channels

Figure Error! Unknown switch argument.**: Logical channels mapped onto transport channels, seen from the UE side**

SCCH-   BCCH-   PCCH-   DCCH-   CCCH-   DTCH-
SAP   SAP   SAP   SAP   SAP   SAP

MAC SAPs

SCH   BCH   PCH   FAUSCH   RACH   FACH   USCH   DSCH   DCH   Transport
(TDD only)   (TDD only)   Channels

Figure Error! Unknown switch argument.**: Logical channels mapped onto transport channels, seen from the UTRAN side**

ODCCH-   OCCCH-   ODTCH-
SAP   SAP   SAP

MAC SAPs

ORACH   ODCH   Transport
                                               Channels

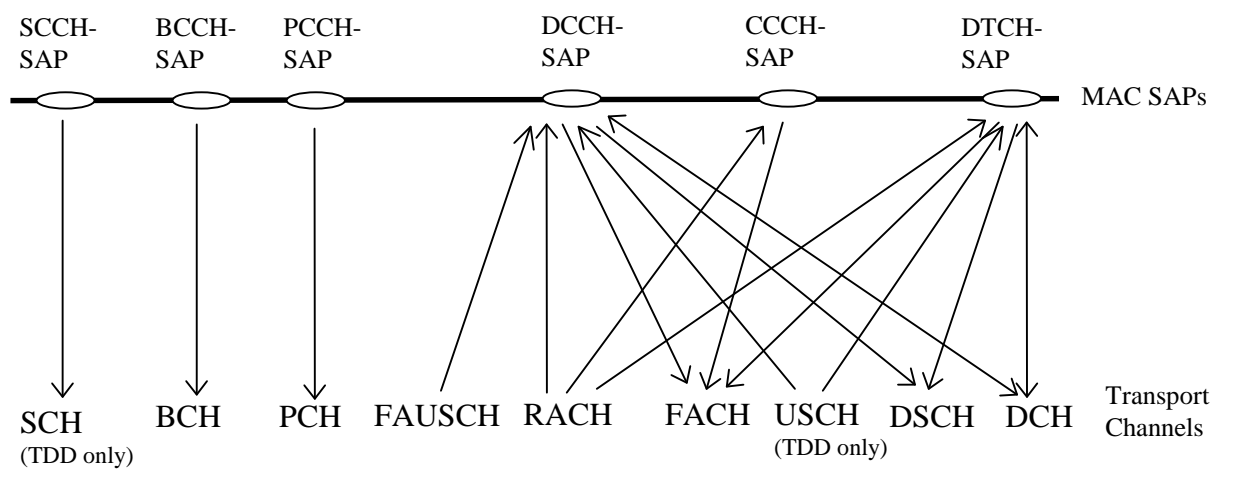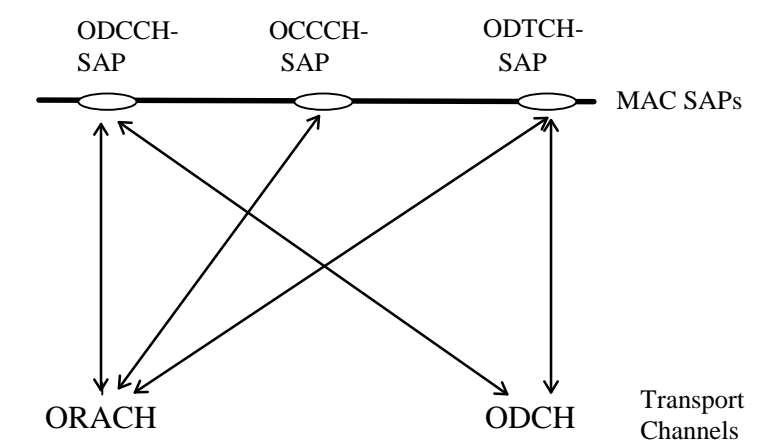**Figure** Error! Unknown switch argument.**: Logical channels mapped onto transport channels, seen from the UE side (relay only)**

8.3.1.2 MAC functions

The functions of MAC include:

- **Mapping between logical channels and transport channels.** The MAC is responsible for mapping of logical channel(s) onto the appropriate transport channel(s).

- **Selection of appropriate Transport Format for each Transport Channel depending on instantaneous source rate**. Given the Transport Format Combination Set assigned by RRC, MAC selects the appropriate transport format within an assigned transport format set for each active transport channel depending on source rate. The control of transport formats ensures efficient use of transport channels.

- **Priority handling between data flows of one UE**. When selecting between the Transport Format Combinations in the given Transport Format Combination Set, priorities of the data flows to be mapped onto the corresponding Transport Channels can be taken into account. Priorities are e.g. given by attributes of radio access bearer services and RLC buffer status. The priority handling is achieved by selecting a Transport Format Combination for which high priority data is mapped onto L1 with a "high bit rate" Transport Format, at the same time letting lower priority data be mapped with a "low bit rate" (could be zero bit rate) Transport Format. Transport format selection may also take into account transmit power indication from Layer 1.

- **Priority handling between UEs by means of dynamic scheduling**. In order to utilize the spectrum resources efficiently for bursty transfer, a dynamic scheduling function may be applied. Priority handling on common and shared transport channels is realized by MAC. Note that for dedicated transport channels, the equivalent of the dynamic scheduling function is implicitly included as part of the reconfiguration function of the RRC sublayer. For TDD it is regarded as further study item.

Note that in the TDD mode the data to be transported are represented in terms of sets of resource units.

- **Scheduling of broadcast, paging and notification messages**. This function provides mechanisms for efficient transfer of broadcast, paging and notification messages by means of appropriate scheduling and repetition of the messages.

- **Identification of UEs on common transport channels**. When a particular UE is addressed on a common downlink channel, or when a UE is using the RACH, there is a need for inband identification of the UE. Since the MAC layer handles the access to, and multiplexing onto, the transport channels, the identification functionality is naturally also placed in MAC.

- **Multiplexing/demultiplexing of higher layer PDUs into/from transport blocks delivered to/from the physical layer on common transport channels**. MAC should support service multiplexing for common transport channels, since the physical layer does not support multiplexing of these channels.

- **Multiplexing/demultiplexing of higher layer PDUs into/from transport block sets delivered to/from the physical layer on dedicated transport channels**. The MAC allows service multiplexing for dedicated transport channels. This function can be utilized when several upper layer services (e.g. RLC instances) can be mapped efficiently on the same transport channel. In this case the identification of multiplexing is contained in the MAC protocol control information.

- **Traffic volume monitoring**. Measurement of traffic volume on logical channels and reporting to RRC. Based on the reported traffic volume information, RRC performs transport channel switching decisions.

- **Routing of higher layer signalling**. This function performs the mapping of higher layer signalling messages to the appropriate transport channel. This function is required in TDD mode, where resource allocation is performed by the MAC autonomously.

- **Maintenance of a MAC signalling connection between peer MAC entities**. This function supports unacknowledged transfer of MAC-internal messages between peer MAC entities. A MAC signalling connection is required in the TDD mode.

- **Monitoring the links of the assigned resources**. This function provides means for monitoring link quality in TDD mode (used by MAC for fast DCA).

- **Dynamic Transport Channel type switching.** Execution of the switching between common and dedicated transport channels based on a switching decision derived by RRC.

The following potential functions are regarded as further study items:

- **Constrained execution of open loop power control algorithms**. This function establishes layer 1 power levels within the constraints of open loop power control set by RRC.

[Editor's note: Details of this function need to be clarified.]

- **Processing of messages received at common control channels**. This function is applied in TDD mode to support a data transfer on common control channels to support MAC operation (needed for fast DCA details are ffs.).

- **Successive Transmission on RACH.** When the mobile station continues to transmit the succeeding (second or more) radio frames because the message length is longer than a radio frame, the transmission timing offset, the RACH spreading code and signature shall be determined as follows: The transmission timing offset (frame and/or slot) shall be determined pseudo-randomly. The RACH spreading code and the signature of the succeeding radio frame can be determined pseudo-randomly. The same RNTI shall be used as in the previous radio frame (for the radio frames belonging to the same higher layer PDU).

· *[Editor's note: This function requires further clarification. Contributions are invited.]*

- **Ciphering**. This function prevents unauthorised acquisition of data.

· *[Editor's note: Ciphering is considered as further study item. This includes consideration where it is applied, for instance on MAC, RLC, or elsewhere, cf. Sec. 0.]*
·

- **Access Service Class selection for RACH transmission**. The RACH resources (i.e. access slots and preamble signatures) may be divided between different Access Service Classes in order to provide different priorities of RACH usage. This function selects, based upon the type of data to be transmitted, the RACH parameters in accordance with the Service Access Class assignment.

· *[Editor's note: This function may support admission control. Its impact on BCCH capacity and its effects on RACH interference, retransmission and back-off time remains ffs.]*

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8.3.2   RLC Services and Functions

This sections provides an overview on services and functions provided by the RLC sublayer. A detailed description of the RLC protocol is given in 3GPP RAN S2.22 [8].

8.3.2.1 Services provided to the upper layer

- **RLC connection establishment/release**. This service performs establishment/release of RLC connections.

- **Transparent data transfer**. This service transmits higher layer PDUs without adding any protocol information, possibly including segmentation/reassembly functionality.

- **Unacknowledged data transfer**. This service transmits higher layer PDUs without guaranteeing delivery to the peer entity. The unacknowledged data transfer mode has the following characteristics:

    - Detection of erroneous data: The RLC sublayer shall deliver only those SDUs to the receiving higher layer that are free of transmission errors by using the sequence-number check function.

    - Unique delivery: The RLC sublayer shall deliver each SDU only once to the receiving upper layer using duplication detection function.

    - Immediate delivery: The receiving RLC sublayer entity shall deliver a SDU to the higher layer receiving entity as soon as it arrives at the receiver.

- **Acknowledged data transfer**. This service transmits higher layer PDUs and guarantees delivery to the peer entity. In case RLC is unable to deliver the data correctly, the user of RLC at the transmitting side is notified. For this service, both in-sequence and out-of-sequence delivery are supported. In many cases a higher layer protocol can restore the order of its PDUs. As long as the out-of-sequence properties of the lower layer are known and controlled (i.e. the higher layer protocol will not immediately request retransmission of a missing PDU) allowing out-of-sequence delivery can save memory space in the receiving RLC. The acknowledged data transfer mode has the following characteristics:

- Error-free delivery: Error-free delivery is ensured by means of retransmission. The receiving RLC entity delivers only error-free SDUs to the higher layer.

- Unique delivery: The RLC sublayer shall deliver each SDU only once to the receiving upper layer using duplication detection function.

- In-sequence delivery: RLC sublayer shall provide support for in-order delivery of SDUs, i.e., RLC sublayer should deliver SDUs to the receiving higher layer entity in the same order as the transmitting higher layer entity submits them to the RLC sublayer.

- Out-of-sequence delivery: Alternatively to in-sequence delivery, it shall also be possible to allow that the receiving RLC entity delivers SDUs to higher layer in different order than submitted to RLC sublayer at the transmitting side.

- **QoS setting.** The retransmission protocol shall be configurable by layer 3 to provide different levels of QoS. This can be controlled.

- **Notification of unrecoverable errors**. RLC notifies the upper layer of errors which cannot be resolved by RLC itself by normal exception handling procedures. e.g. by adjusting the maximum number of retransmissions according to delay requirements

The following service is regarded as further study item:

- **Multicast delivery of higher layer messages**. It is left for further study whether or not special functionality on RLC is needed for support of acknowledged transfer of user data to a specified group of UEs.

  [Editor´s note: Contributions on this issue are invited.]

The length of a higher layer PDU (RLC SDU) can be variable up to the maximum length specified for each data transfer service [ffs.]. There is only a single RLC connection per Radio Access Bearer.

8.3.2.2 RLC Functions

- **Connection Control.** This function performs establishment, release, and maintenance of a RLC connection.

- **Segmentation and reassembly.** This function performs segmentation/reassembly of variable-length higher layer PDUs into/from smaller RLC Payload Units (PUs). One RLC PDU carries one PU or, in case header compression is applied several RLC PUs. The size oft the smallest retransmission unit shall be determined by the smallest possible bit rate. The RLC PDU size is adjustable to the actual set of transport formats.

- **Header compression**. The feature to include several Payload Units into one RLC PDU is referred to as RLC header compression. RLC header compression can be applied for acknowledged data transfer service. Its applicability shall be negotiable between network and UE. Application of RLC header compression is optional for the network but it shall be supported by the UE mandatory.

- **Concatenation.** If the contents of an RLC SDU does not fill an integer number of RLC PUs, the first segment of the next RLC SDU may be put into the RLC PU in concatenation with the last segment of the previous RLC SDU.

- **Padding.** When concatenation is not applicable and the remaining data to be transmitted does not fill an entire RLC PDU of given size, the remainder of the data field shall be filled with padding bits.

- **Transfer of user data.** This function is used for conveyance of data between users of RLC services. RLC supports acknowledged, unacknowledged and transparent data transfer. Transfer of user data is controlled by QoS setting.

- **Error correction.** This function provides error correction by retransmission (e.g. Selective Repeat, Go Back N, or a Stop-and-Wait ARQ) in acknowledged data transfer mode.

- **In-sequence delivery of higher layer PDUs**. This function preserves the order of higher layer PDUs that were submitted for transfer by RLC using the acknowledged data transfer service. If this function is not used, out-of-sequence delivery is provided.

- **Duplicate Detection.** This function detects duplicated received RLC PDUs and ensures that the resultant higher Layer PDU is delivered only once to the upper layer.

- **Flow control**. This function allows an RLC receiver to control the rate at which the peer RLC transmitting entity may send information.

- **Sequence number check (Unacknowledged data transfer mode).** This function guarantees the integrity of reassembled PDUs and provides a mechanism for the detection of corrupted RLC SDUs through checking sequence number in RLC PDUs when they are reassembled into a RLC SDU. A corrupted RLC SDU will be discarded.

- **Protocol error detection and recovery**. This function detects and recovers from errors in the operation of the RLC protocol.

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· The following potential function(s) are regarded as further study items:

- **Suspend/resume function**. Suspension and resumption of data transfer as in e.g. LAPDm (cf. GSM 04.05).

- **Ciphering**. This function prevents unauthorised acquisition of data.

- **Quick repeat (C plane only).** This function provides mechanisms to transmit unacknowledged mode data PDUs several times.

[Editor´s note: Whether quick repeat function is performed by layer 3 or by RLC sublayer is FFS..]

8.3.3 Data flows through Layer 2

Data flows through layer 2 are characterized by the applied data transfer modes on RLC (acknowledged, unacknowledged and transparent transmission) in combination with the data transfer type on MAC, i.e. whether or not a MAC header is required. The case where no MAC header is required is referred to as "transparent" MAC transmission. Acknowledged and unacknowledged RLC transmissions both require a RLC header. In unacknowledged transmission, only one type of unacknowledged data PDU is exchanged between peer RLC entities In acknowledged transmission, both (acknowledged) data PDUs and control PDUs are exchanged between peer RLC entities.

The resulting different data flow cases are illustrated in Figures 7 - 10. On the level of detail presented here, differences between acknowledged and unacknowledged RLC transmission are not visible. Acknowledged and unacknowledged RLC transmission is shown as one case, referred to as non-transparent RLC.

[Editor's note: The term "transparent transmission" is used here to characterize the case where a protocol, MAC or RLC, does not require any protocol control information (e.g. header). In transparent transmission mode, however, some protocol functions may still be applied. In this case an entity of the respective protocol must be present even when the protocol is transparent. For the RLC protocol the segmentation/reassembly function may be applied. This can be performed without segmentation header when a given higher layer PDU fits into a fixed number of RLC PDUs to be transferred in a given transmission time interval. In this case segmentation/reassembly follows predefined rules known to sending and receiving RLC entities. For instance in the user plane, the segmentation/reassembly function is needed for the case of real-time services using high and possibly variable bit rates. For such services higher layer PDUs shall be segmented into reasonably sized RLC PDUs of fixed length allowing efficient FCS error detection on the physical layer. The higher layer PDU can be reassembled by simply concatenating all RLC PDUs included in a transport block set as implied by the used transport format.]
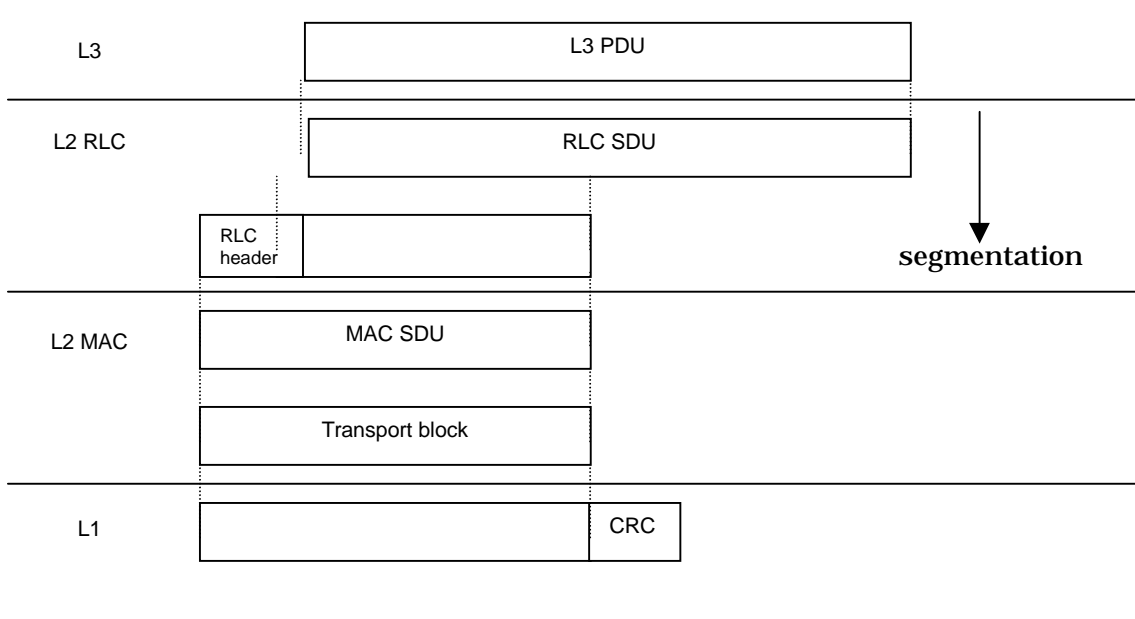
Error! Unknown switch argument. and **Error! Unknown switch argument.** illustrate the data flows for transparent RLC with transparent and non-transparent MAC transmission, respectively.

Error! Unknown switch argument. and **Error! Unknown switch argument.** illustrate the data flows for non-transparent RLC with transparent and non-transparent MAC transmission, respectively.

For acknowledged RLC transmission mode, a single RLC PDU may include more than one segment (referred to as Payload Unit, cf. S2.22 [8]) of RLC SDU. This feature, referred to as RLC header compression, is not shown here in the data flow.

A number of MAC PDUs shown in the figures shall comprise a transport block set. Note, however, that in all cases a transport block set must not necessarily match with a RLC SDU. The span of a transport block set can be smaller or larger than a RLC SDU.

Each mapping between a logical channel and a transport channel as defined in **Error! Unknown switch argument.** and **Error! Unknown switch argument.** in combination with the respective RLC transmission mode implies a certain data flow which is specified on a general level in the following.
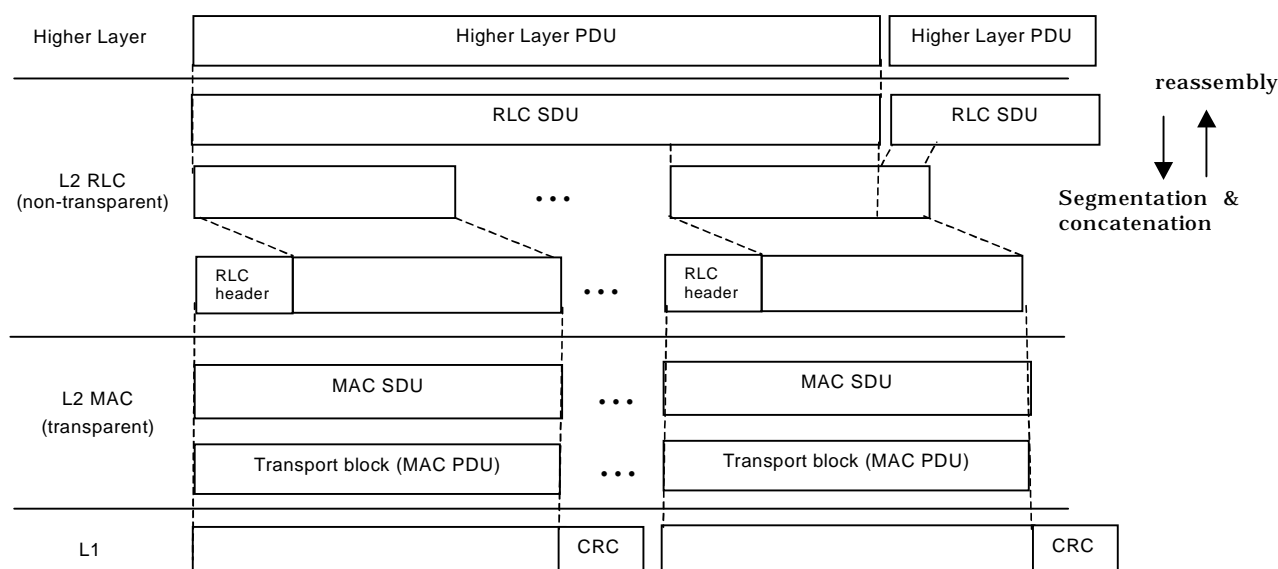
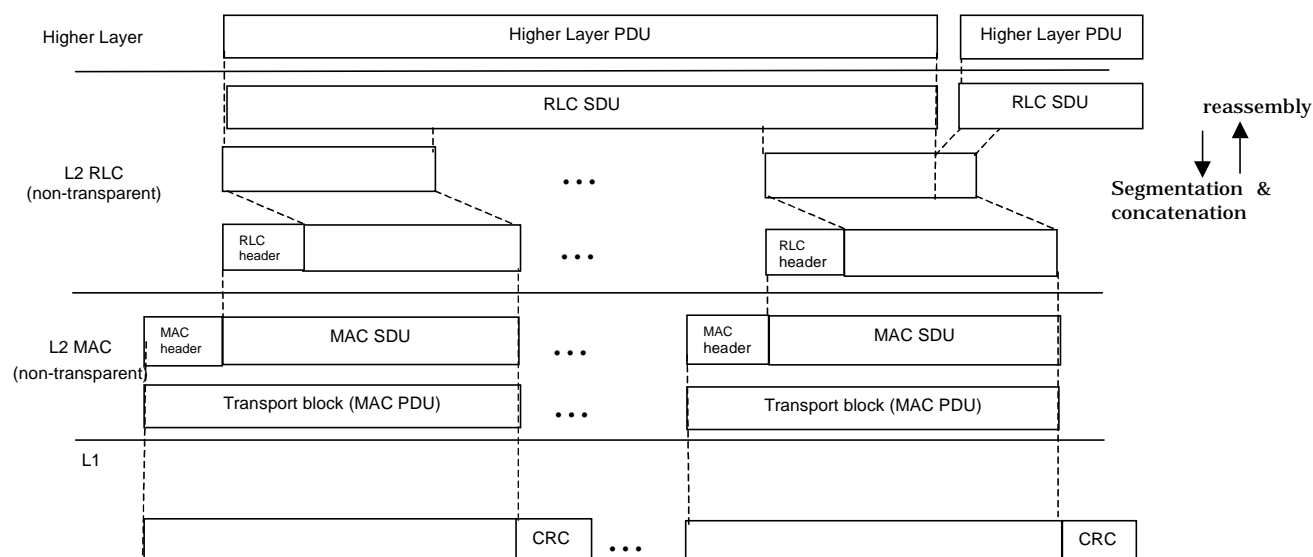**Figure** Error! Unknown switch argument.**: Data flow for transparent RLC and MAC**
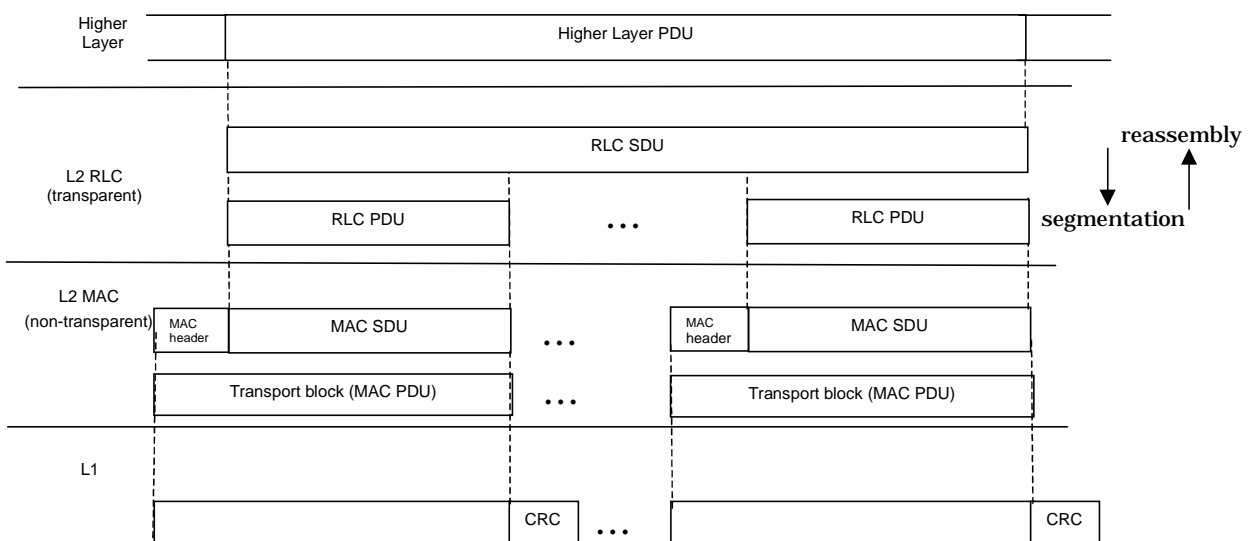
Figure Error! Unknown switch argument.**: Data flow for transparent RLC and non-transparent MAC**

Figure Error! Unknown switch argument.**: Data flow for non-transparent RLC and transparent MAC**

Figure Error! Unknown switch argument.**: Data flow for non-transparent RLC and MAC**

8.3.3.1 Data flow for BCCH mapped to BCH (ffs.)

Regarding the mapping of RRC PDUs into RLC PDUs two alternatives can be considered:

(i)   All RRC PDUs transmitted on BCCH have a fixed length and fit into one (or a fixed number) of RLC PDUs
         (and, equivalently, MAC PDUs, as defined by the transport format). For this type of segmentation no RLC
         header is needed, i.e. the transparent data transfer mode of RLC is applied.

(ii)   RRC PDUs do not fit to the size of a fixed number of RLC PDUs. In this case the unacknowledged RLC
         transfer mode must be applied, since segmentation/reassembly requires a RLC header for segmentation
         sequence control.

A MAC header is needed only if multiple BCCH logical channels are mapped onto a BCH.

If the transparent RLC transfer mode is applied (above option (i)), depending on whether the MAC header is needed or
not, either the data flow **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** is
applicable. If the unacknowledged RLC transfer mode is applied (above option (ii)), depending on whether the MAC
header is needed or not, either the data flow Figure **Error! Unknown switch argument.** or Figure **Error! Unknown
switch argument.** is applicable.

[Editor´s note: It is expected that some of the above mentioned options can be removed when details of the BCCH have been specified.]

8.3.3.2 Data flow for PCCH mapped to PCH (ffs.)

Same data flow is applicable as for BCCH mapped to BCH. A MAC header is needed only if multiple PCCH logical channels are mapped onto a single PCH.

8.3.3.3 Data flow for SCCH mapped to SCH (ffs.)

Same data flow is applicable as for BCCH mapped to BCH. Applied in TDD mode only. A MAC header is not needed. The data flow shown in **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** applies, depending on applied RLC transmission mode.

8.3.3.4 Data flow for CCCH mapped to FACH/RACH (ffs)

For CCCH, transparent or unacknowledged transmission mode on RLC is employed. A MAC header may be used for logical channel identification (CCCH, DCCH, DTCH). When no MAC header is used, CCCH must be the only channel mapped to RACH/FACH. If the transparent RLC transfer mode is applied, depending on whether the MAC header is needed or not, either the data flow **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** is applicable. If the unacknowledged RLC transfer mode is applied, depending on whether the MAC header is needed or not, either the data flow Figure **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** is applicable.

[Editor´s note: It might be possible that some of the above mentioned options can be removed when all messages carried on CCCH have been specified in detail.]

8.3.3.5 Data flow for DCCH mapped to FACH/RACH

For DCCH, both unacknowledged and acknowledged transmission mode on RLC is employed. A MAC header is mandatory for FACH/RACH carrying DCCH. The data flow shown in Figure **Error! Unknown switch argument.** is applicable.

8.3.3.6 Data flow for DCCH mapped to DSCH

For DCCH, both unacknowledged and acknowledged transmission mode on RLC is employed. Whether or not a MAC header is needed for UE identification when DCCH is mapped to a DSCH is ffs., i.e. either the data flow in Figure **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** is applicable.

8.3.3.7 Data flow for DTCH (non-transparent RLC) mapped to FACH/RACH

Mapping to FACH/RACH implies a DTCH with acknowledged (possibly also unacknowledged, ffs.) transmission on RLC. A MAC header is mandatory for FACH/RACH when carrying DTCH. The data flow shown in Figure **Error! Unknown switch argument.** is applicable.

8.3.3.8 Data flow for DTCH (non-transparent RLC) mapped to DSCH

Mapping to DSCH implies a DTCH with acknowledged (possibly also unacknowledged, ffs.) transmission on RLC. Whether or not a MAC header is needed for UE identification when DTCH is mapped to a DSCH is ffs., i.e. either the data flow in Figure **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** is applicable.

8.3.3.9 Data flow for DTCH (transparent RLC) mapped to DCH

Continuous DTCH data stream is segmented into transport blocks on RLC and mapped on a DCH transport channel on MAC. The transport block size is naturally implied by the data rate. Both RLC and MAC sublayers are transparent, i.e. no protocol control information is added, when no multiplexing of DTCH on MAC is applied. The data flow shown in **Error! Unknown switch argument.** is applicable. If multiplexing on MAC is performed, a MAC header is needed, and Figure **Error! Unknown switch argument.** applies.

8.3.3.10   Data flow for DTCH (non-transparent RLC) mapped to DCH

In this case acknowledged or unacknowledged transmission on RLC is applied. A MAC header is needed only if multiple DTCH logical channels are multiplexed in MAC before mapping to a DCH, i.e. either the data flow in Figure **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** is applicable.

8.3.3.11 Data flow for DCCH mapped to DCH

In this case non-transparent transmission mode on RLC is applied. A MAC header is needed only if DCCH and DTCH logical channels are multiplexed in MAC before mapping to a DCH, i.e. either the data flow in Figure **Error! Unknown switch argument.** or Figure **Error! Unknown switch argument.** is applicable.

8.4 Layer 3 - RRC Services and Functions

This sections provides an overview on services and functions provided by the RRC layer. A detailed description of the RRC protocol is given in 3GPP RAN S2.31 [9]. Examples of structured procedures involving RRC in Idle Mode and Connected Mode are described in 3GPP RAN S2.03 [5] and 3GPP RAN S2.04 [6], respectively.

8.4.1 RRC services

8.4.1.1 General Control

The GC SAP provides an information broadcast service. This service broadcasts information to all UEs in a certain geographical area. The basic requirements from such service are:

- It should be possible to broadcast non-access stratum information in a certain geographical area.

- The information is transferred on an unacknowledged mode link. Unacknowledged mode means that the delivery of the broadcast information can not be guaranteed (typically no retransmission scheme is used). It seems reasonable to use an unacknowledged mode link since the information is broadcast to a lot of UEs and since broadcast information often is repeated periodically.

- It should be possible to do repeated transmissions of the broadcast information (how it is repeated is controlled by the non-access stratum).

- The point where the UE received the broadcast information should be included, when the access stratum delivers broadcast information to the non-access stratum.

8.4.1.2 Notification

The Nt SAP provides paging and notification broadcast services. The paging service sends information to a specific UE(s). The information is broadcast in a certain geographical area but addressed to a specific UE(s). The basic requirements from such service are:

- It should be possible to broadcast paging information to a number of UEs in a certain geographical area.

- The information is transferred on an unacknowledged mode link. It is assumed that the protocol entities in non-access stratum handle any kind of retransmission of paging information.

The notification broadcast service broadcasts information to all UEs in a certain geographical. The basic requirements from this service are typically the same as for the information broadcast service of the GC SAP:

- It should be possible to broadcast notification information in a certain geographical area.

- The information is transferred on an unacknowledged mode link.

8.4.1.3 Dedicated Control

The DC SAP provides services for establishment/release of a connection and transfer of messages using this connection. It should also be possible to transfer a message during the establishment phase. The basic requirements from the establishment/release services are:

- It should be possible to establish connections (both point and group connections).

- It should be possible to transfer an initial message during the connection establishment phase. This message transfer has the same requirements as the information transfer service.

- It should be possible to release connections.

The information transfer service sends a message using the earlier established connection. According to [1] it is possible to specify the quality of service requirements for each message. A finite number of quality of service classes will be specified in [1], but currently no class has been specified. In order to get an idea of the basic requirements, the CC and MM protocols in GSM are used as a reference. A GSM based core network is chosen since it is one main option for

UMTS. Considering the existing GSM specification of CC and MM the basic requirements from the information transfer service are (these are some the services provided by RR and the data link layer in GSM):

- Acknowledged mode link for transfer of messages
  This acknowledged mode link guarantees that the CC and MM messages are transferred to the corresponding side. Acknowledged mode means that the delivery of upper layer information can be guaranteed (some kind of retransmission scheme is used). A connection between two DC SAPs using an acknowledged mode link is called *signalling connection*. This link should also guarantee that no messages are lost or duplicated during handover.

- Preserved message order
  The order of the transferred messages is preserved.

- Priority handling
  If SMS messages should be transported through the control plane it should be possible to give higher priority to signalling messages.

The CC and MM protocols also expect other services, which can not be supported by the current primitives of the DC SAP, e.g. indication of radio link failure.

8.4.2 RRC functions

The Radio Resource Control (RRC) layer handles the control plane signalling of Layer 3 between the UEs and UTRAN. The RRC performs the following functions:

- **Broadcast of information provided by the non-access stratum (Core Network).** The RRC layer performs system information broadcasting from the network to all UEs. The system information is normally repeated on a regular basis. This function supports broadcast of higher layer (above RRC) information. This information may be cell specific or not. As an example RRC may broadcast Core Network location service area information related to some specific cells.

- **Broadcast of information related to the access stratum.** The RRC layer performs system information broadcasting from the network to all Ues This function supports broadcast of   typically cell-specific information.

- **Broadcast of ODMA relay node neighbour information.** The RRC layer performs probe information broadcasting to allow ODMA routeing information to be collected.

- **Establishment, maintenance and release of an RRC connection between the UE and UTRAN.** The establishment of an RRC connection is initiated by a request from higher layers at the UE side to establish the first Signalling Connection for the UE. The establishment of an RRC connection includes an optional cell re-selection, an admission control, and a layer 2 signalling link establishment. The release of an RRC connection can be initiated by a request from higher layers to release the last Signalling Connection for the UE or by the RRC layer itself in case of RRC connection failure. The RRC layer detects loss of RRC connection and releases resources assigned for the RRC connection in case of connection failure.

- **Collating ODMA neighbour list and gradient information.** The ODMA relay node neighbour lists and their respective gradient information will be maintaining by the RRC.

- **Maintenance of number of ODMA relay node neighbours.** The RRC will adjust the broadcast powers used for probing messages to maintain the desired number of neighbours.

- **Establishment, maintenance and release of a route between ODMA relay nodes.** The establishment of an ODMA route and RRC connection based upon the routeing algorithm.

- **Interworking between the Gateway ODMA relay node and the UTRAN.** The RRC layer will control the interworking with the standard TDD or FDD communication link between the Gateway ODMA relay node and the UTRAN.

- **Establishment, reconfiguration and release of Radio Access Bearers.** The RRC layer can, on request from higher layers, perform the establishment, reconfiguration and release of radio access bearers in the user plane. A number of radio access bearers can be established to an UE at the same time. At establishment and reconfiguration, the RRC layer performs admission control and selects parameters describing the radio access bearer processing in layer 2 and layer 1, based on information from higher layers.

- **Assignment, reconfiguration and release of radio resources for the RRC connection.** The RRC layer handles the assignment of radio resources (e.g. codes) needed for the RRC connection including needs from both the control and

user plane. The RRC layer may reconfigure radio resources during an established RRC connection. This function includes coordination of the radio resource allocation between multiple radio bearers related to the same RRC connection. RRC controls the radio resources in the uplink and downlink such that UE and UTRAN can communicate using unbalanced radio resources (asymmetric uplink and downlink). RRC signals to the UE to indicate resource allocations for purposes of handover to GSM or other radio systems.

- **RRC connection mobility functions.** The RRC layer performs evaluation, decision and execution related to RRC connection mobility during an established RRC connection, such as handover, preparation of handover to GSM or other systems, cell re-selection and cell/paging area update procedures, based on e.g. measurements done by the UE.

- **Paging/notification.** The RRC layer can broadcast paging information from the network to selected UEs. Paging and notification can be requested by higher layers on the network side. The RRC layer can also initiate paging during an established RRC connection.

- **Routing of higher layer PDUs.** This function performs at the UE side routing of higher layer PDUs to the correct higher layer entity, at the UTRAN side to the correct RANAP entity.

- **Control of requested QoS**. This function shall ensure that the QoS requested for the radio access bearers can be met. This includes the allocation of a sufficient number of radio resources. The exact requirements on RRC to support this function are ffs.

- **UE measurement reporting and control of the reporting.** The measurements performed by the UE are controlled by the RRC layer, in terms of what to measure, when to measure and how to report, including both UMTS air interface and other systems. The RRC layer also performs the reporting of the measurements from the UE to the network.

- **Outer loop power control.** The RRC layer controls setting of the target of the closed loop power control.

- **Control of ciphering.** The RRC layer provides procedures for setting of ciphering (on/off) between the UE and UTRAN.

- **Slow DCA**. Allocation of preferred radio resources based on long-term decision criteria. It is applicable only in TDD mode.

- **Contention resolution**. The RRC handles reallocations and releases of radio resources in case of collisions indicated by lower layers in TDD mode. Applicability of contention resolution in FDD mode is ffs.

- **Arbitration of radio resources on uplink DCH**. This function controls the allocation of radio resources on uplink DCH on a fast basis, using a broadcast channel to send control information to all involved users. *[Note: This function is implemented in the CRNC. Details are ffs.]*

- **Initial cell selection and re-selection in idle mode.** Selection of the most suitable cell based on idle mode measurements and cell selection criteria.

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· The following functions are regarded as further study items:

- **Arbitration of the radio resource allocation between the cells**. This function shall ensure optimal performance of the overall UTRAN capacity.

· *[Editor's note: Some clarification should be provided what exact requirements this function implies on the RRC protocol, beyond general radio resource optimization.]*

- **Congestion control.** Further study item.

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8.5 Interactions between RRC and lower layers in the C plane

The RRC protocol controls and signals the allocation of radio resources to the UE. RRC allows MAC to arbitrate between users and radio access bearers within the radio resource allocation. The RRC uses the measurements done by the lower layers to determine which radio resources that are available. Therefore it is a need for a measurement report from the UE RRC to the UTRAN RRC. **Error! Unknown switch argument.** illustrates the principle. The local control and local measurements reporting is handled through the control SAPs between RRC and the lower layers.
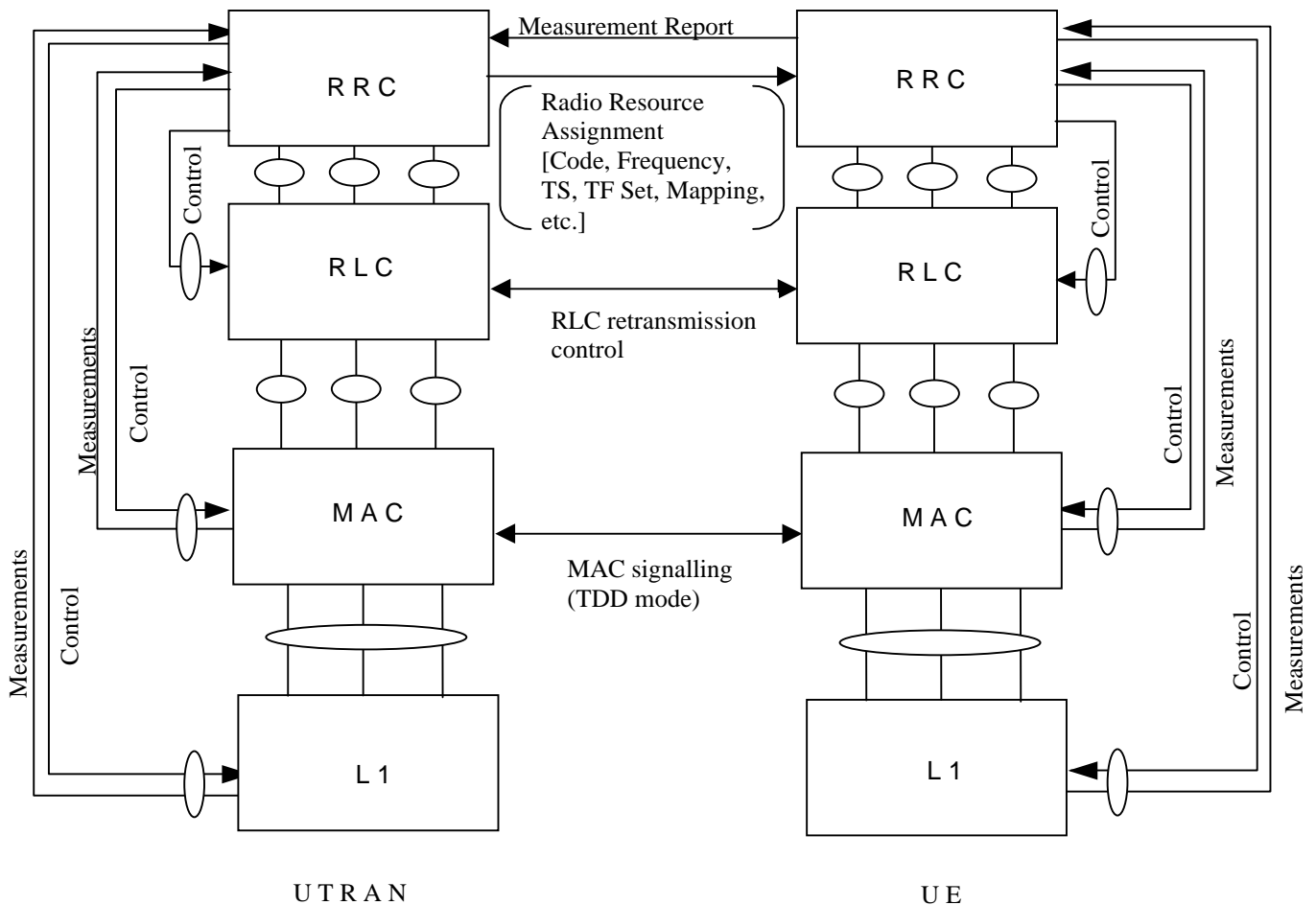
Figure Error! Unknown switch argument.**: Interactions between RRC and lower layers**
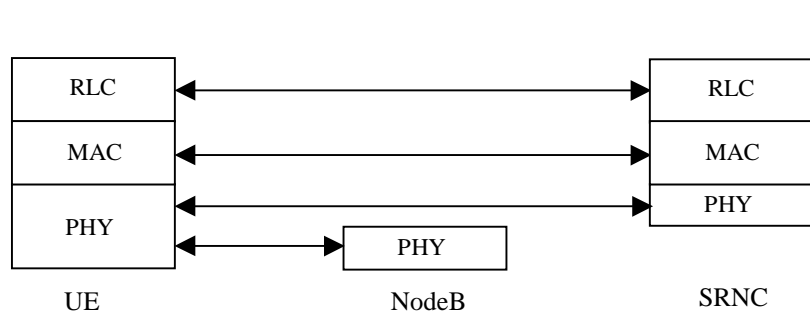
8.6 Protocol termination

This section specifies in which node of the UTRAN the radio interface protocols are terminated, i.e. where within UTRAN the respective protocol services are accessible.

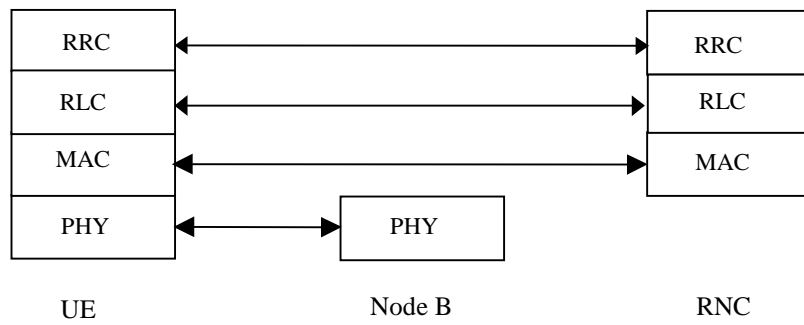## 8.6.1 Protocol termination for DCH

Error! Unknown switch argument. and **Error! Unknown switch argument.** show the protocol termination for DCH for the control and user planes, respectively. The part of physical layer terminating in the Serving RNC is the topmost macro-diversity combining and splitting function for the FDD mode. If no macrodiversity applies, the physical layer is terminated in Node B.
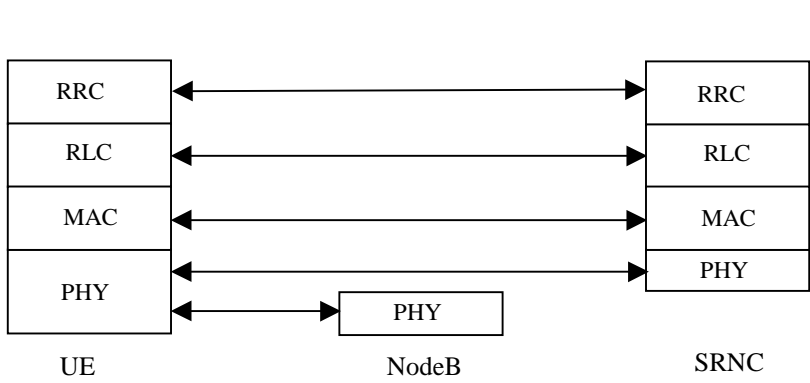
Figure Error! Unknown switch argument.**: Protocol Termination for DCH, control plane**

Figure Error! Unknown switch argument.**: Protocol Termination for DCH, user plane**
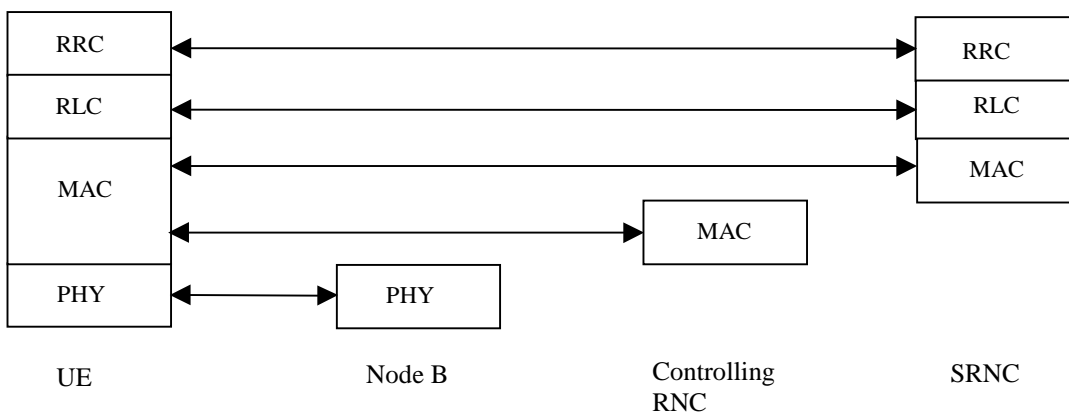
8.6.2   Protocol termination for RACH/FACH

Error! Unknown switch argument. and **Error! Unknown switch argument.** show the protocol termination for RACH/FACH for the control and user planes, respectively. Control plane termination refers to the case where RACH/FACH carry dedicated or common control information (i.e. CCCH or DCCH). User plane termination refers to the case where RACH/FACH carry user data (DTCH) (two alternatives cases, referred to as case B and C, are described in the Annex).

It is assumed that macrodiversity/soft handover is not applied for RACH/FACH. Therefore, the physical layer terminates in Node B. For RACH/FACH carrying DCCH, MAC is split between Controlling and Serving RNC. RLC, and in the C plane also RRC terminate in the Serving RNC. Since Iur can support common channel data streams, the users of that common channel can depend on different SRNCs. However, they depend on the same Controlling RNC. Therefore, for a given user, the Controlling RNC and the Serving RNC can be separate RNCs.

For RACH/FACH carrying CCCH, MAC, RLC and RRC are terminated in the RNC.

[Editor's note: It is currently an open issue whether or not there are CCCH messages that need to be routed between Controlling and Serving RNC over Iur. If it is only the initial access message that is defined for CCCH, C-RNC and S-RNC are always identical and no routing would be needed. If messages such as "URA update", "Cell update" and "RRC connection re-establishment" would be signalled on CCCH, routing of these messages on RRC level would need to be performed]

CCCH:

DCCH:

Figure Error! Unknown switch argument.**: Protocol Termination for RACH/FACH, control plane**
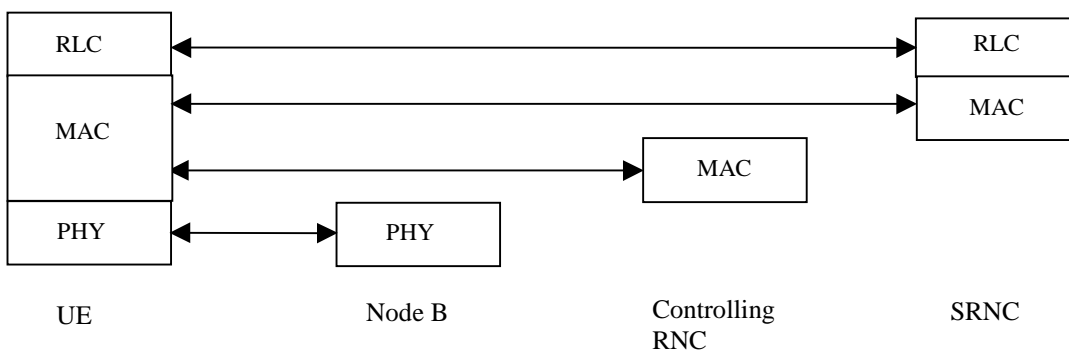
Figure Error! Unknown switch argument.**: Protocol Termination for RACH/FACH, user plane**

8.6.3 Protocol termination for FAUSCH

Protocol termination for the FAUSCH is the same as for the RACH in the control plane (see **Error! Unknown switch argument.**), since FAUSCH is for control purposes only.

8.6.4

8.6.5   Protocol termination for DSCH

8.6.5.1 DSCH definition

The DSCH is a resource that exists in downlink only. It has only impact on the physical and transport channel levels, so there is no definition of shared channel in the logical channels provided by MAC.

The DSCH is a transport channel shared dynamically between several UEs. The DSCH is mapped to one or several physical channels such that a specified part of the downlink code tree is employed. For the DSCH no macrodiversity is applied, i.e. a specific DSCH is transmitted in a single cell only.

The following two DSCH cases are presently considered, in the following denoted as cases A and B:

Case A: The DSCH is defined is an extension to DCH transmission. DSCH related resource allocation is signalled utilizing the transport format indication field (TFI) that will be mapped to the TFCI of the associated DCH.

Case B: The DSCH is defined as a shared downlink channel for which resource allocation, including UE identification, is signalled on another common downlink channel, referred to as DSCH Control Channel.

> *[Editor's note: It is considered ffs. whether the DSCH Control Channel requires a new type of transport channel or whether a specific FACH transport channel can be used for this purpose. It is assumed that the DSCH control channel is supported on the PSCCCH (Physical Shared Common Control Channel) if it carries TPC information. It needs to be confirmed by TSG RAN WG1 that this channel will be specified.]*

> Note: For case B it is assumed that DSCH and DSCH Control Channel employ individual channelization codes each. Time multiplexing of user data (DSCH) and control information (DSCH Control Channel) is not considered.

> Note also that a third case of DSCH definition, where the DSCH was defined as a stand-alone channel providing in-band UE identification is not considered any more. This case has been identified as being equivalent to a FACH and is as such already included in the radio interface specification.

Interleaving for the DSCH may be applied over a multiplicity of radio frames. Nevertheless, here the basic case is considered where the interleaving is rectangular for a given MAC PDU, and equal to one radio frame (10 ms). The framing is synchronised on the SCH.

In every radio frame, one or several codes can be used in the downlink. Therefore, the DSCH supports code multiplexing. MAC multiplexing shall not be applied within a radio frame, i.e. the whole radio frame for one code is assigned to a single UE. However, MAC multiplexing is allowed on a frame by frame basis, i.e. one code may be allocated to different UEs at each frame.

Transport blocks on the DSCH may be of constant size, so that the Transport Block Set may be derived from the code allocated to each UE on the DSCH.

8.6.5.2 Resource allocation and UE identification on DSCH

The principles of capacity allocation and UE identification on the DSCH are described in more detail below.

[Editor's note: The two resource allocation methods of the cases A and B might be used simultaneously for one DSCH, i.e. some UEs may use an associated DSCH Control Channel and some UEs may use an associated DCH for resource allocation while transmitting data on the same DSCH. This option is ffs.]

8.6.5.2.1   Case A (UE requires a downlink TFCI on a DPCCH)

The TFCI of the dedicated physical channel may carry the information that a given code of the DSCH must be listened to by the UE. Fast power control can be applied per code based on the dedicated physical control channel, DPCCH.

Alternatively, a UE may be requested on the DCH to listen to a DSCH for a given period of time, and to decode the data so that the address of the destination UE can be decoded. This does not require more TFCI values because signalling is done in layers 2 and 3.

8.6.5.2.2   Case B (UE requires a downlink DSCH Control Channel)

The information which DSCH code to listen to and when is sent on an additional downlink channel to the UE (essentially a broadcast channel). This channel, is referred to as *DSCH Control Channel*. It is code multiplexed on the downlink and should convey the following information, which is modified every radio frame:

- Layer 1 information

- • TPC bits for each UE which would have an uplink DCH without downlink DCH. The location of TPC bits on the PSCCCH of each cell is allocated to each UE when a RAB is mapped onto a DSCH.
    - • Channelisation code allocated to each UE indicated relatively to the DSCH code entry point
- • Layer 2 information
    - • Identity of the UEs who should receive information on the DSCH. The UE ID is allocated when a RAB is mapped onto a DSCH. Which UE ID is used to identify UE on the DSCH of each cell is ffs.

This concept allows to perform power control on the DSCH, whereas the DSCH Control Channel would be less efficient in terms of power control efficiency (need to power control on the farthest UE).

8.6.5.3 Model of DSCH in UTRAN

Error! Unknown switch argument. captures the working assumption on the Downlink Shared Channel (DSCH). The two RLCs point to logical channel (DTCH) specific RLC-entities of specific users while MAC refers to the provision of MAC sublayer functions for all users.

The MAC sublayer of a DSCH is split between the Controlling RNC and SRNC. For a given user, the RLC sublayer is terminated in its SRNC. Since Iur can support DSCH data streams, the users on that DSCH can depend on different SRNCs. For a given user, the Controlling RNC and the Serving RNC can be separate RNCs. The MAC in the network takes care of mapping downlink data either to a common channel (FACH, not shown in this figure), DCH or the DSCH.

Error! Unknown switch argument. also includes the DSCH Control Channel, needed for case B of DSCH definition only. See 3GPP RAN S2.21 [8] for details on MAC architecture. In this example, the resource allocation on the DSCH is signalled on the DSCH control channel for UE 1 and on the associated DCH for UE 2.
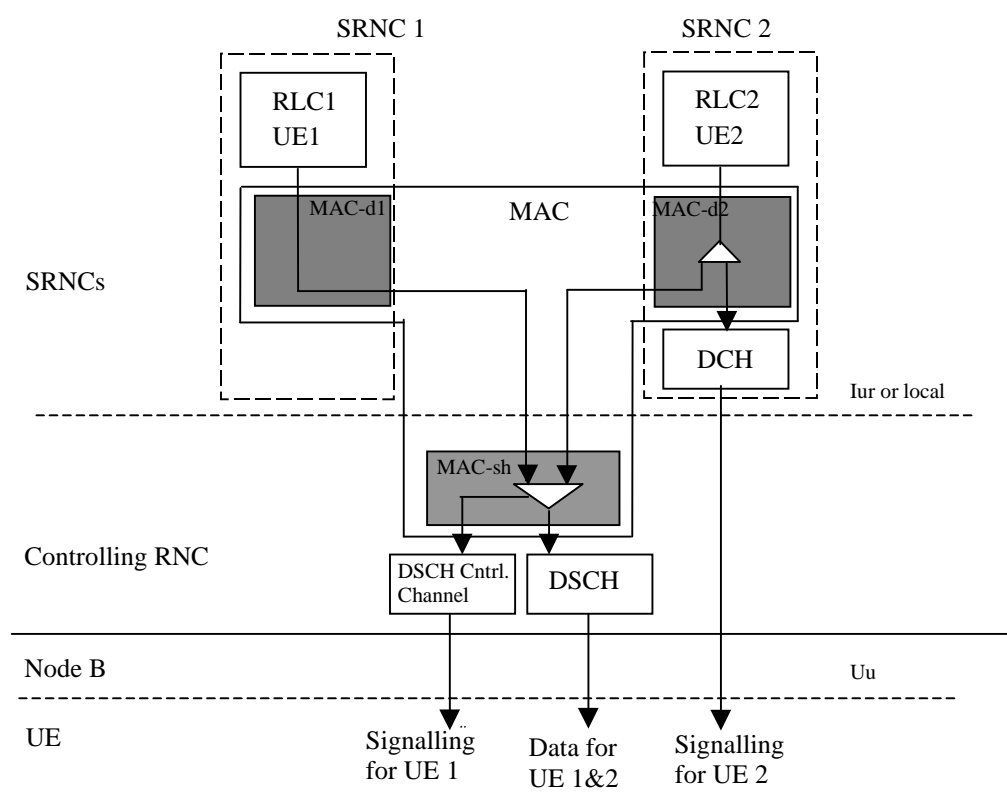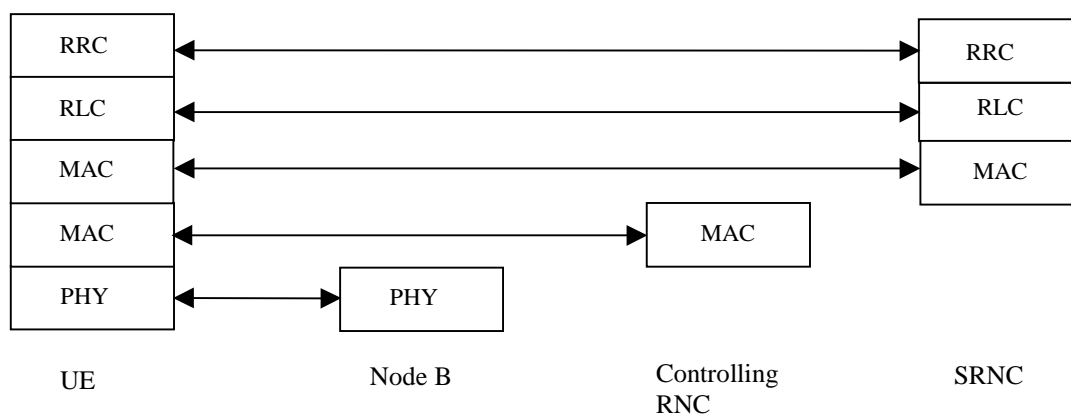

Figure Error! Unknown switch argument.**: Model of downlink shared channel (DSCH) in UTRAN**

8.6.5.4 Protocol termination

The protocol termination points for DSCH in control and user planes are presented in **Error! Unknown switch argument.** and **Error! Unknown switch argument.**, respectively.
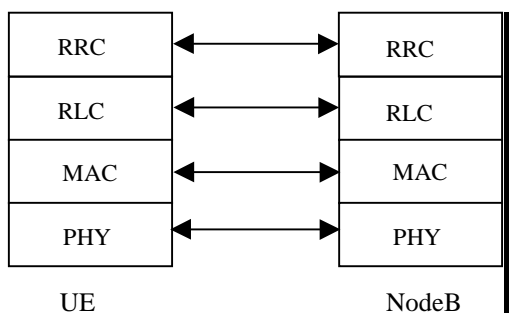
Figure Error! Unknown switch argument.**: Protocol termination points for DSCH, control plane.**

Figure Error! Unknown switch argument.**: Protocol termination points for DSCH, user plane.**

8.6.6   Protocol termination for transport channel of type BCH

System information on BCH can include information which is available only in Node B, and need to be updated very frequently (each 10-100 ms), such as uplink interference in the cell. Also, for the system information originating from the RNC, it is assumed that the updating of system information is at least one magnitude less (minutes) than the repetition frequency on the BCH (in the order of 1s). Protocol termination for the BCH shall therefore reside in the Node B, resulting in less signalling on Iub and lower processor load. Note that the RLC sublayer is transparent for this transport channel type.

Figure Error! Unknown switch argument.**: Protocol termination for BCH.**

8.6.7   Protocol termination for transport channel of type PCH

In order to enable coordinated scheduling between PCH and FACH/DSCH the corresponding MAC scheduling functions shall be allocated in the same node (co-location of MAC-p, MAC-c and MAC-sh entities) Both MAC-sh and MAC-c are terminated in CRNC. Consequently, the MAC termination of PCH shall also be in CRNC. A natural implication is that RLC and RRC also are terminated in CRNC.
Note that the RLC sublayer is transparent for this channel.

[Editor's note: Above termination of PCH has been agreed as working assumption. Some WG2 members however requested some more time for further consideration. The above assumption shall be confirmed before or at the next WG2 meeting. The previous solution is kept in the Annex as alternative PCH termination option.]
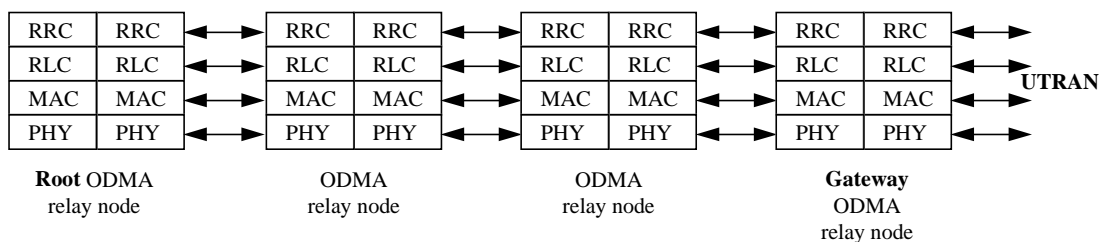
Figure Error! Unknown switch argument.**: Protocol termination for PCH**

## 8.6.8   Protocol termination for transport channel of type SCH

The SCH transport channel is used in TDD mode only. Protocol termination for SCH is the same as for BCH as shown in **Error! Unknown switch argument.**.

8.6.9   Protocol termination for ODCH

Error! Unknown switch argument. and **Error! Unknown switch argument.** show the protocol termination for ODCH in the control and user planes, respectively.

Figure Error! Unknown switch argument.**: Protocol Termination for the ODCH in the Control Plane**
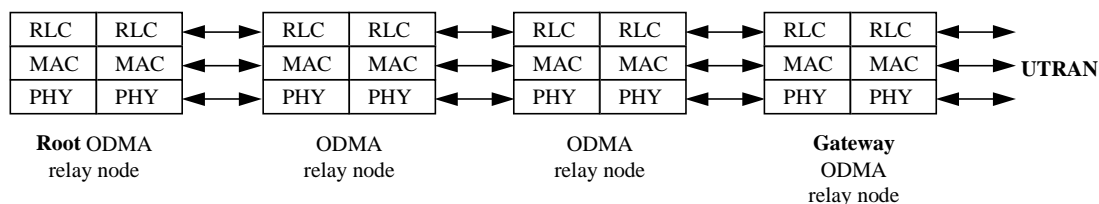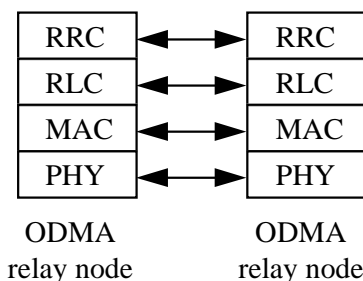

Figure Error! Unknown switch argument.**: Protocol Termination for the ODCH in the User Plane**

Note: The current mechanisms and procedures carried out by the RLC and the MAC for the DCH will require minor, subtle modifications to enable them to handle the ODCH.

8.6.10 Protocol termination for ORACH

The protocol termination for ORACH for the control and user planes are illustrated in **Error! Unknown switch argument.** and **Error! Unknown switch argument.**, respectively. The shown ODMA relay nodes may be either UE_R, Seed, Root, or Gateway.

Figure Error! Unknown switch argument.**: Protocol Termination for ORACH control plane**

RLC	RLC
MAC	MAC
PHY	PHY

ODMA   ODMA
relay node   relay node
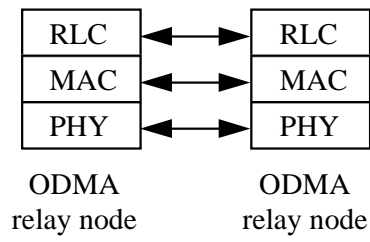
Figure Error! Unknown switch argument.**: Protocol Termination for ORACH user plane**

9.

10. User Identification and RRC Connection Mobility

10.1 UE identification within UTRAN

A Radio Network Temporary Identity (RNTI) is used as an UE identifier on RACH/FACH by the MAC protocol, or on PCH by the RRC, when a RRC connection exists.

Definition of UE identifiers

Two types of RNTI exist. One is used within the Serving RNC and it is denoted by Serving RNC RNTI (s-RNTI), the other is used within C-RNC, when applicable, and it is denoted by Controlling RNC RNTI (c-RNTI).

s-RNTI is allocated for all UEs having a RRC connection. It is allocated by the Serving RNC and it is unique within the Serving RNC. s-RNTI is reallocated always when the Serving RNC for the RRC connection is changed and deallocated when the RRC connection is released.

In addition for each UE having an RRC connection, there is an identifier of its current serving RNC, which is denoted as S-RNC identifier. The S-RNC identifier together with s-RNTI is a unique identifier of the RRC connection within PLMN.

 c-RNTI for an UE is allocated by each controlling RNC through which UE is able to communicate on DCCH. c-RNTI is unique within the allocating C-RNC. c-RNTI is always allocated when a new UE context is created to a RNC. Serving RNC is always aware of all c-RNTIs allocated for the UE.

Usage of UE identifiers

s-RNTI together with the S-RNC identifier is used as a UE identifier in cell update, URA update, RRC connection reestablishment and (UTRAN originated) paging messages and associated responses on the air interface. S-RNC identifier is used by Controlling RNC to route the received uplink messages towards the Serving RNC. For the initial access two different methods of identification, a random number and a unique core network identifier are under consideration.

c-RNTI is used as a UE identifier in all other DCCH/DTCH common channel messages on the air interface.

[Editors note: Initial access, when no RRC connection exists, needs further study. The following two methods could be applied: (i) The initial access message carried on RACH/FACH transport channels and CCCH logical channel includes a unique UE identity (e.g. TMSI + LAI). (ii) The initial access message includes a random number as temporary identity. The unique UE identity is then exchanged in a second phase after establishment of DCH transport channels on DCCH. In TDD mode, the first approach may imply initial access message length too large to be carried on RACH. Therefore the above second approach is preferred for TDD. In FDD mode, the first approach would be preferable. It is thus currently not decided whether the same or different initial access methods will need to be applied in FDD and TDD modes. Further contributions on this issue are invited. Also, it is ffs. whether messages with s-RNTI and RNC-ID will use the CCCH or the DCCH logical channel and whether the protocol layer providing the address field (and C-RNC routing) is MAC or RRC.]

A specific s-RNTI or c-RNTI (ffs.) is valid in several cells, thus decreasing the RNTI reallocation signalling for moving inactive packet data UE's.

10.2

10.3 UE connection to UTRAN

The different levels of UE connection to UTRAN are listed below:

- No signalling connection exist
  The UE has no relation to UTRAN, only to CN. For data transfer, a signalling connection has to be established.

- Signalling connection exist
  There is a RRC connection between UE and UTRAN. The UE position can be known on different levels:

  - UTRAN Registration Area (URA) level
    The UE position is known on UTRAN registration area level. URA is a specified set of cell which can be identified on the BCCH.

  - Cell level
    The UE position is known on cell level. Different channel types can be used for data transfer:

    - Common transport channels (RACH/FACH),
    - Dedicated transport channels (DCH); note that FAUSCH can be used to allocate a dedicated channel for data transmission.

11. UE modes

Two modes of operation are defined for the UE, idle mode and connected mode [5, 6].

After power on, the UE stays in idle mode until it transmits a request to establish an RRC connection. In idle mode the UE is identified by non-access stratum identities such as IMSI, TMSI and TLLI. In addition, the UTRAN has no own information about the individual idle mode UEs, and can only address e.g. all UEs in a cell or all UEs in a paging group.

The connected mode is entered when the RRC connection is established. The UE is assigned a radio network temporary identity (s-RNTI + S-RNC ID and possibly in addition c-RNTI) to be used as UE identity on common transport channels. *[Note: The exact definition of RRC connection needs further refinement.]*

The UE leaves the connected mode and returns to idle mode when the RRC connection is released or at RRC connection failure. *[Note: whether UE power off causes RRC connection release and/or RRC connection failure is FFS.]*

[Note: Other modes than idle mode and connected mode, such as separate mode(s) for the reception of point-to-multipoint information, are FFS.]

12.

13. Ciphering

[Editor's note: This section describes preliminary assumptions on ciphering and a proposed solution to the frame number initialization problem. This text may be moved to other parts of this document or to other specifications (S2.21, S2.22) after decisions have been taken. The proposed scheme is not approved yet by WG2.]

Presently two solutions for the ciphering execution exist. Ciphering is performed either *(a)* always on MAC layer or *(b)* depending on RLC type (transparent vs. non-transparent) either on MAC or on RLC layer. In addition, integrity control on Common Control Channels is considered. (Introduction of a separate ciphering sublayer may be considered in case there are severe problems with these assumptions).

Any ciphering algorithm requires a sequence number as an input parameter. As sequence number, a UE frame number (UE FN) as defined in S3.01 [2] may be used when ciphering is performed in MAC layer. The UE FN is composed at least of a Connection Frame Number (CFN). The sequence number is composed at least of the RLC PDU sequence number when ciphering is performed in RLC. To meet the requirements for the length of frame number used for ciphering, a Hyper Frame Number (HFN), incremented at every completed cycle of the CFN, is added to the UE FN. With this solution, the length of the frame number broadcast in BCCH need not be as long as the length of frame number used for ciphering (which should be at least 32 bits).

A problem with regard to security risk, common for all proposed ciphering methods, is how to initialize the HFN. In case of MAC ciphering, only one HFN is needed. In case of MAC and RLC ciphering, at least two HFNs (or equivalent counters) are needed.

Following requirements exists:
- Initialise the HFN before the ciphering is activated.
- Avoid to reuse the same SN value in input of the ciphering algorithm twice or more in a "short" time (especially with the same ciphering key, Kc). This reduces the security of the system.

A problem exists when a UE uses the same Kc (ciphering key) in two subsequent RRC connections. If in both connections the HFN is initialised to zero, the same inputs to the ciphering algorithm (FN and Kc) are used twice and the same ciphering mask may be reused in a relatively short period of time. This may occur also with a random initialisation of HFN. This is not 'secure' and should be avoided.

One possible solution to this is that when the RRC connection is released, the terminal (SIM card) stores the last HFN(s) used.

At a new RRC connection setup or at RRC connection re-establishment, UE initialises the HFN(s) to a value higher than the last used HFN(s) value, and transmits this/these to the SRNC, either in the RRC Connection Request message or in the first message after the RRC connection is established.

Depending on the requirements (e.g. how many successive RRC Connections can use the same ciphering key), it may be sufficient to use only the most significant bits of HFN in the re-initialization (and set LSBs implicitly to zero). This may be necessary at least if the HFN value needs to be included in the RRC Connection Request message.

Appendices

Annex A (informative): Protocol termination

This Annex describes protocol termination cases which have been excluded from the initial UMTS release. These cases are captured here for information. They potentially may be considered for future releases.
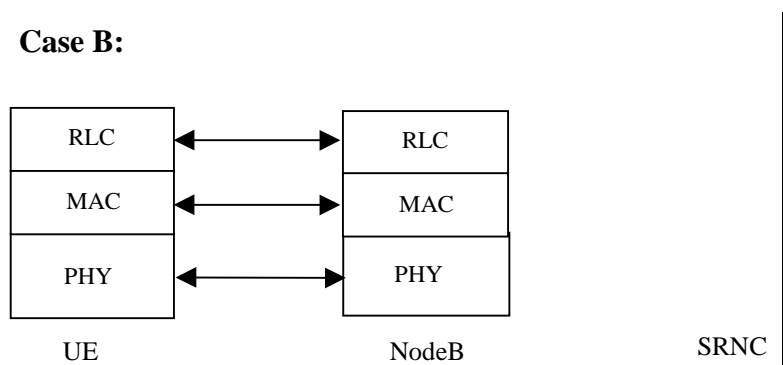
A.1 Alternative protocol termination for DCH

Error! Unknown switch argument. and **Error! Unknown switch argument.** show an alternative protocol termination case for DCH for the control and user planes, respectively, referred to as Case B. This case would be applicable when macrodiversity at RNC level is not applied, i.e. especially for DCH in the TDD mode.

Case B:
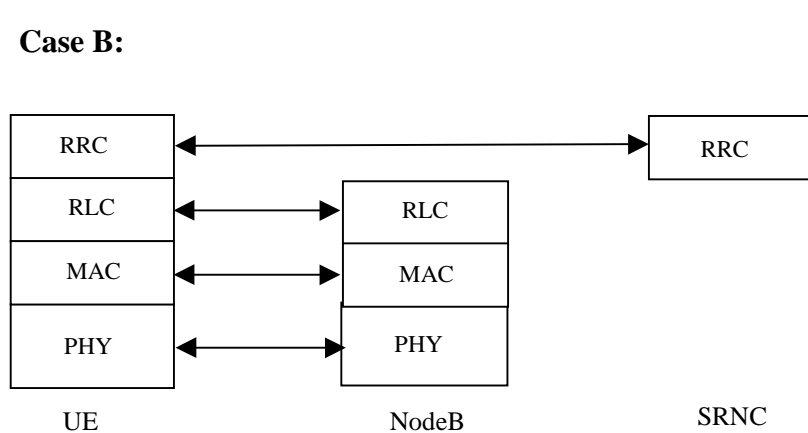
Figure Error! Unknown switch argument.**: Protocol Termination for DCH, control plane**

Case B:

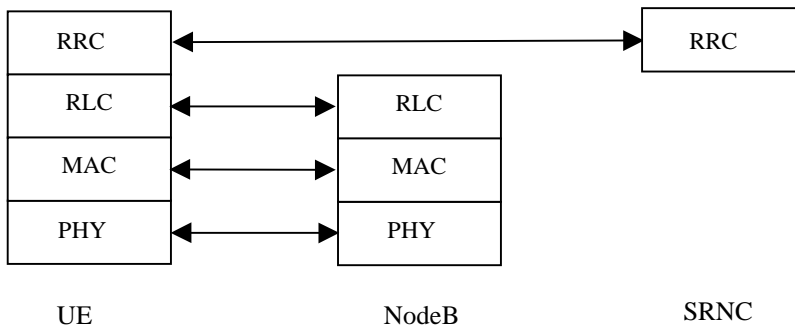**Figure** Error! Unknown switch argument.**: Protocol Termination for DCH, user plane**

A.2 Protocol termination for RACH/FACH

Error! Unknown switch argument. and **Error! Unknown switch argument.** show two alternative protocol termination cases for RACH/FACH for the control and user planes, respectively, referred to as Case B and Case C.
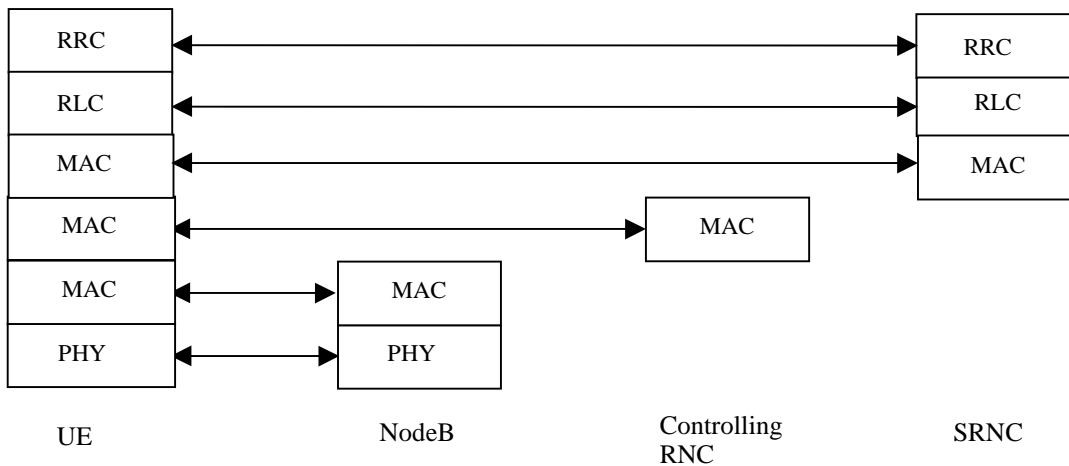
In case B, the physical layer, MAC and RLC terminate in Node B.

In case C, the MAC sublayer is split between Node B, Controlling and Serving RNC. This would be the preferred solution when MAC in Node B shall provide acknowledgements to RACH messages and perform scheduling of FACH transmissions.
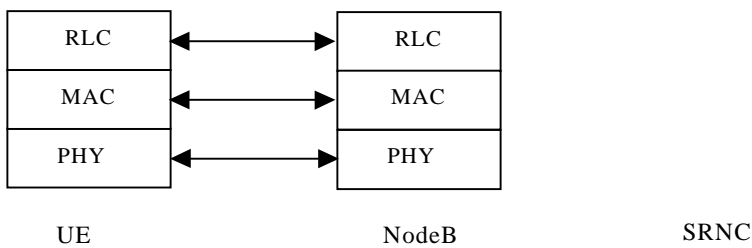
Case B:

UE   NodeB   SRNC

Case C:

UE   NodeB   Controlling   SRNC
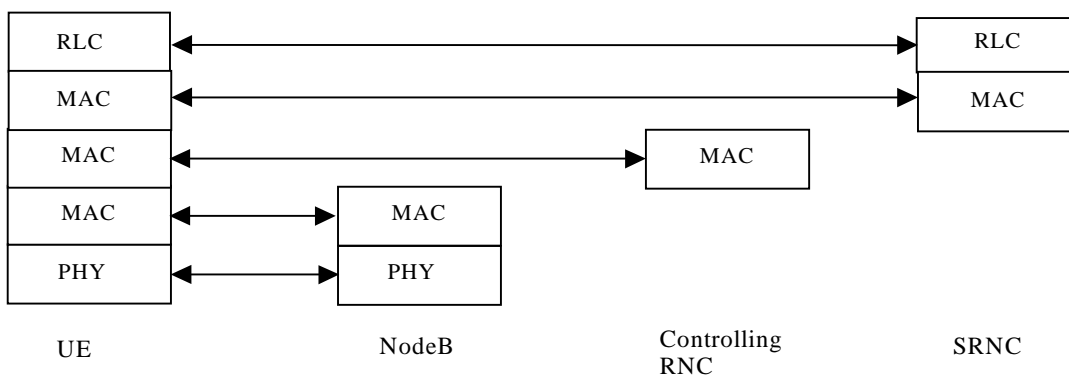   RNC

Figure Error! Unknown switch argument.**: Protocol Termination for RACH/FACH, control plane**

Case B:

UE   NodeB   SRNC

Case C:

UE   NodeB   Controlling   SRNC
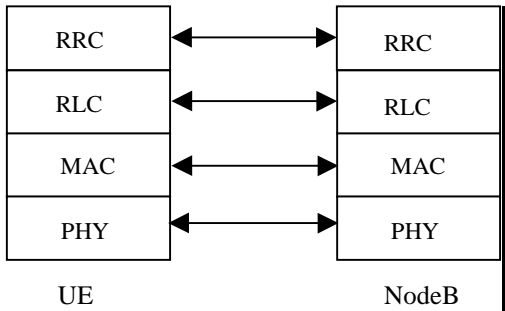   RNC

Figure Error! Unknown switch argument.**: Protocol Termination for RACH/FACH, user plan**

A.3 Alternative Protocol termination for transport channel of type PCH

[Editor's note: This section captures the initially assumed PCH termination option before it has been changed.]

Since a Node B possibly can control several cells, the paging distribution signalling can be reduced if the Node B handles the distribution to each cell it controls. This results in less paging signalling on the Iub interface and thus lower processor load for distribution of paging. Protocol termination for the PCH shall therefore reside in the Node B. Note that the RLC sublayer is transparent for this transport channel type.

```
  ┌──────────┐          ┌──────────┐ ┃
  │   RRC    │ ◄──────► │   RRC    │ ┃
  ├──────────┤          ├──────────┤ ┃
  │   RLC    │ ◄──────► │   RLC    │ ┃
  ├──────────┤          ├──────────┤ ┃
  │   MAC    │ ◄──────► │   MAC    │ ┃
  ├──────────┤          ├──────────┤ ┃
  │   PHY    │ ◄──────► │   PHY    │ ┃
  └──────────┘          └──────────┘ ┃
      UE                   NodeB
```

Figure Error! Unknown switch argument.**: Protocol termination for PCH**

History

Document history		
Date	**Version**	**Comment**
January 1999	0.0.1	Initial version based on ARIB Radio Interface Protocol Architecture, V1.0.0 (Tdoc TSG-RAN WG2 008/99) and ETSI UMTS YY.01, V1.0.3 (Tdoc TSG-RAN WG2 011/99) as agreed at the 3GPP TSG RAN WG2 meeting #1, Helsinki, Jan. 20-22, 1999. Revision markers with respect to YY.01.
February 1999	0.0.2	Document layout updated according to 3GPP template. All revisions shown in V0.0.1 accepted.. Some editorial corrections/updates. Incorporation of changes agreed in e-mail discussions regarding padding and dynamic scheduling functions of MAC and regarding DSCH.
February 1999	0.1.0	Approved by TSG RAN WG2. Document presented to 3GPP TSG RAN #2, Fort Lauderdale, March 2-4, 1999.
March 1999	0.1.1	Updated according to decisions agreed at 3GPP TSG RAN WG2 meeting #2, Stockholm, March 8-12.
April 1999	0.1.2	Updated according to e-mail comments. Document presented at 3GPP TSG RAN WG2 meeting #3, Yokohama, April 13-16.
April 1999	0.1.3	Updated according to decisions agreed at 3GPP TSG RAN WG2 meeting #3, Yokohama, April 13-16.
April 1999	0.2.0	Approved by TSG RAN WG2. Document presented to 3GPP TSG RAN #3 for approval, Yokohama, April 21-23, 1999.

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This document is written in Microsoft Word version 6.0/95.

3GPP