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Evolution der öffentlichen Mobilfunknetze (3G/4G)
Chapter V: Radio Interface Protocols

Universität Hannover
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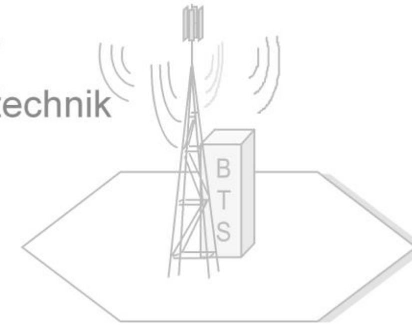

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Evolution of public radio networks

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Outline Part V

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1. Overview
2. Architecture
3. Layer 1 to 3
4. Examples
5. Packet Transmission
6. Traffic Management

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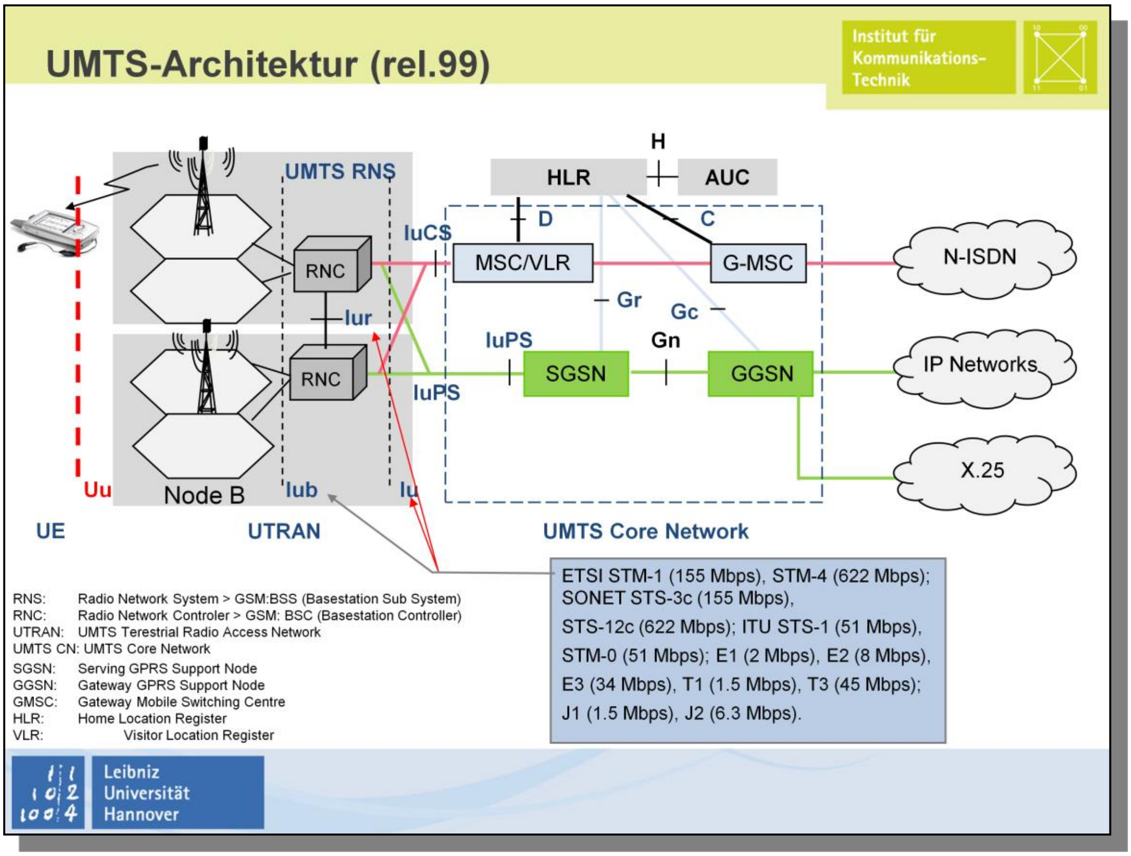

Interfaces:

Iu interface: enables interconnection of Radio Network Controllers (RNCs) with Core Network nodes.

The Iu (IuPS and IuCS) interface is available in two separate packages IuPS and IuCS for Packet Switched and Circuit Switched domains respectively. The IuCS interface interconnects the MSC/ VLR and the RNC network nodes while the IuPS interface provides interconnection between the SGSN and the RNC network nodes in UMTS/3G networks

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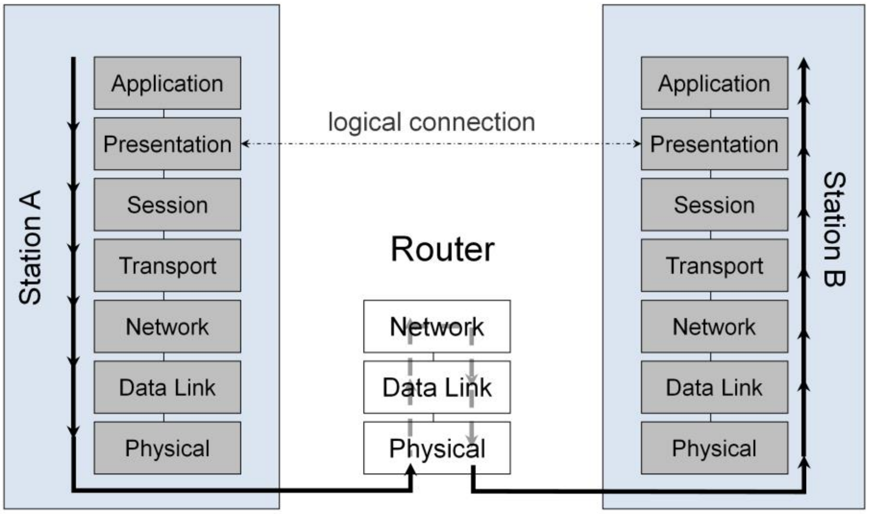
Iu, Iur, Iub: The Physical Layers [3G TS 25.411]

The physical layer defines the access to the transmission media, the physical and electrical properties and how to activate and de-activate a connection. It offers to the higher layer physical service access points to support the transmission of a uniform bit stream. A huge set of physical layer solutions is allowed in UTRAN, including: ETSI STM-1 (155 Mbps), STM-4 (622 Mbps); SONET STS-3c (155 Mbps), STS-12c (622 Mbps); ITU STS-1 (51 Mbps), STM-0 (51 Mbps); E1 (2 Mbps), E2 (8 Mbps), E3 (34 Mbps), T1 (1.5 Mbps), T3 (45 Mbps); J1 (1.5 Mbps), J2 (6.3 Mbps).

With the above protocol layers, the interfaces Iu, Iur, and Iub are fully described.

ISO/ OSI reference model



Protocol Stack Architecture (I)

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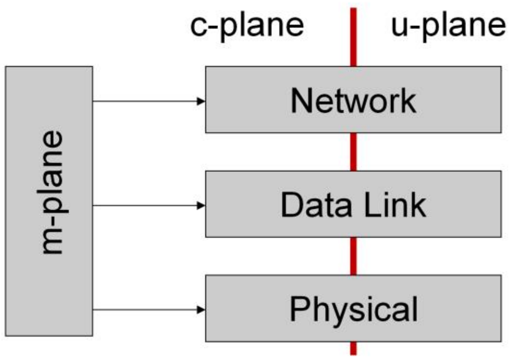

C-plane:

transport of control-data

U-plane:

transport of user data

M-plane:

protocol stack layer configuration

The UTRA protocol stack at the Uu-Interface comprises layers 1 to 3.

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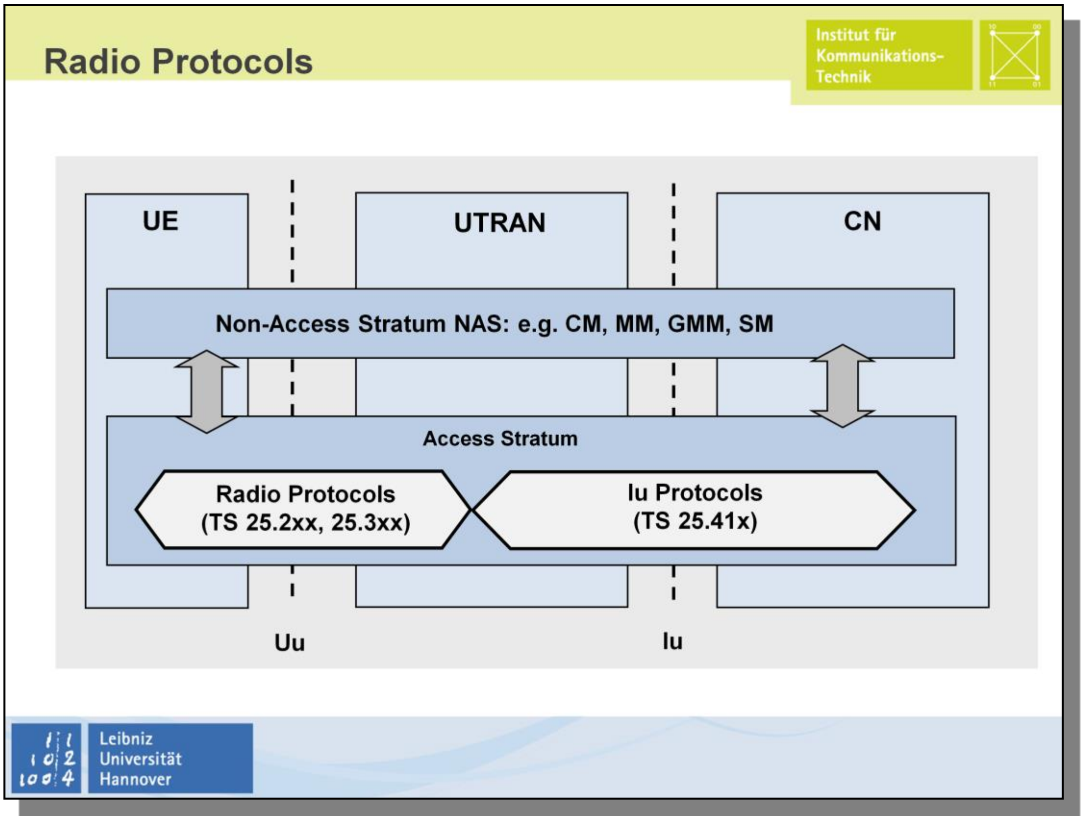

CM Call Management

MM Mobility Management

GMM GPRS Mobility Management

SM Session Management

Radio Interface Protocols

The Radio Interface Protocols (TS 25.301) are used for the transfer of user and control data between the UE and UTRAN. Similar to the UTRAN interfaces protocol structure, the radio interface protocol structure is designed in horizontal layers and vertical planes.

The Radio Interface protocol architecture consists of two vertical planes – the Control Plane and the User Plane.

The User Plane is used to transport all user data, e.g. speech data or packet data.

The Control Plane is used for all UMTS-specific control signaling.

Three horizontal layer have been defined on the radio interface:

• Layer 1: the physical layer (TS 25.2xx)

• Layer 2: the data link layer

• Layer 3: the network layer

Layer 2 is sub-divided into the following sub-layers: Medium Access Control MAC, Radio Link Control RLC, Packet Data Convergence Protocol PDCP and Broadcast/Multicast Control BMC. MAC and RLC are used for on the User and Control Plane. PDCP and BMC are only defined for the User Plane.

Only one protocol is defined in Layer 3: Radio Resource Control RRC. RRC belongs to the Control Plane. The RRC is not only responsible for the transmission of control information between UTRAN and UE. It is also interfaced to RLC, MAC, PDCP, BMC and L1 to provide local inter-layer control services. The configuration of the lower layer is controlled by the RRC.

The higher layer signaling such as Connection Management CM, (GPRS) Mobility Management (G)MM, Session Management SM or Short Message Service SMS belong to the Non-Access Stratum NAS. The are transparently transmitted between UE and CN. Therefore, they are not in the scope of the Radio Interface protocol architecture.

Simplified Uu-Interface and protocol stacks of UE and UTRAN

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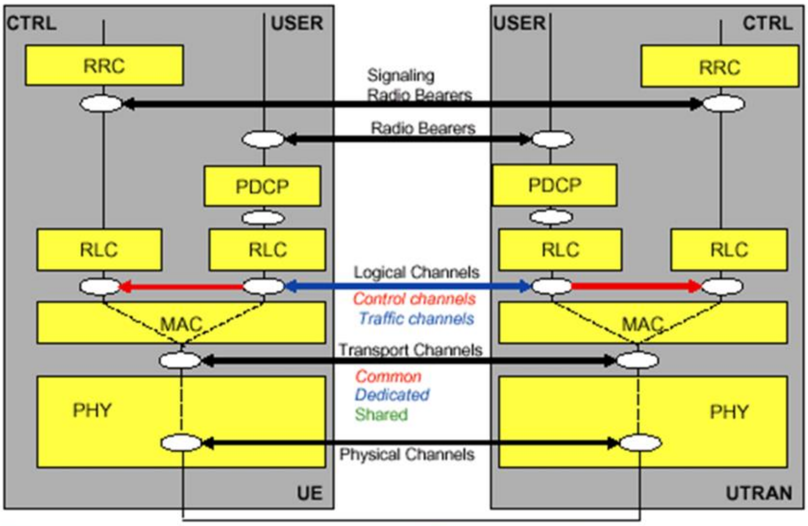

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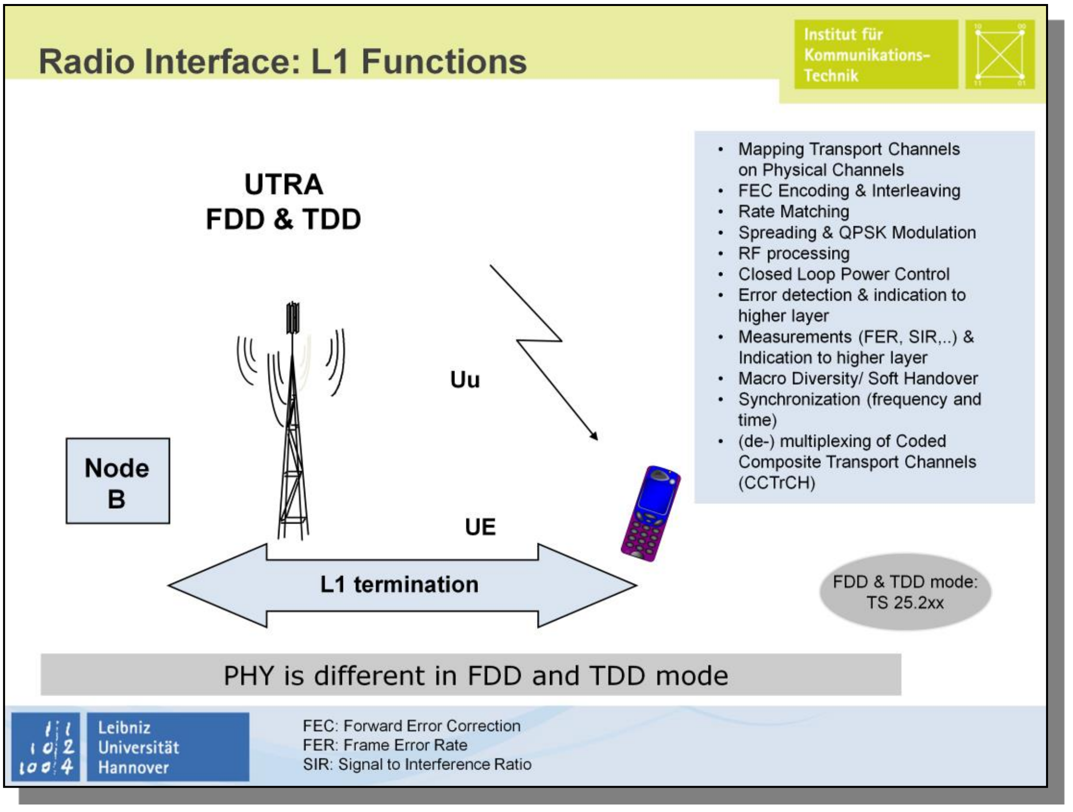


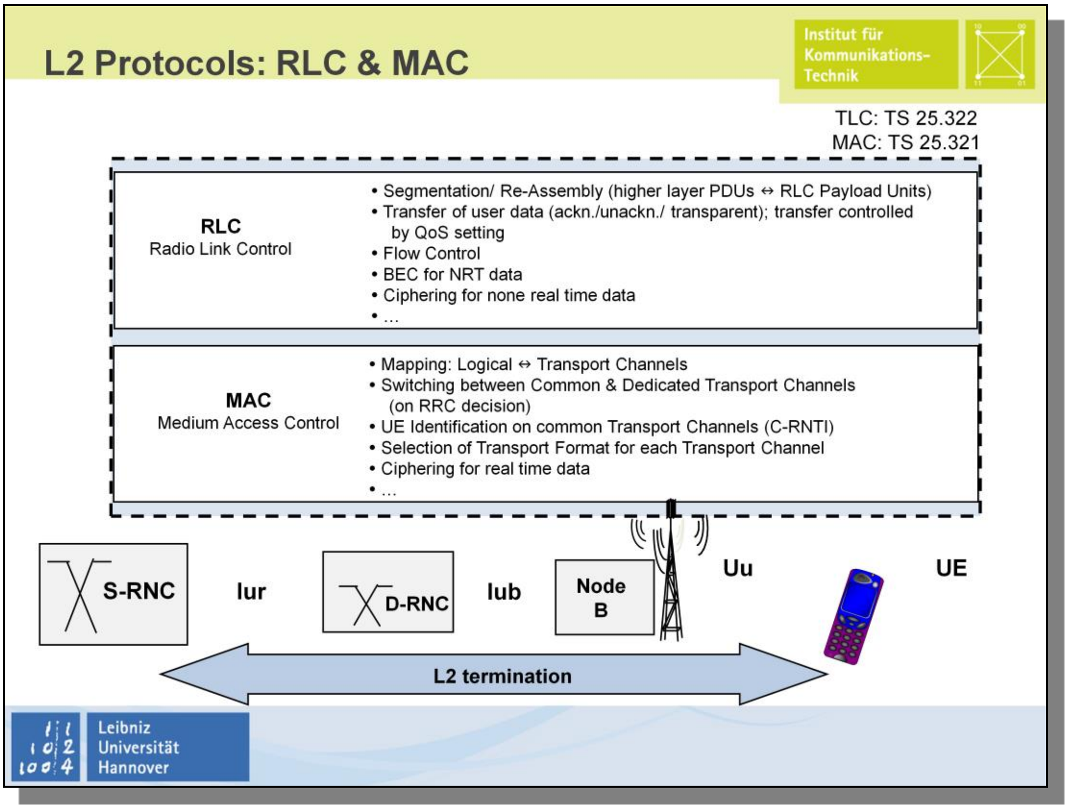
Radio Interface: Layer 1 functions

Layer 1 of the radio interface is described in the TS 25.2xx series. UTRA FDD and TDD mode are used for the physical transmission of the information over Uu.

The physical layer offers information transfer to MAC and higher layers via Transport Channels. Transport Channels are defined by „how and with what characteristics data are transferred over the radion interface". The UMTS Transport Channels (e.g. Random Access Channel RACH, Forward Access Channel FACH, Broadcast Channel BCH, Paging Channel PCH, Dedicated Channel DCH) are mapped on Physical Channel (e.g. Physical Random Access Channel PRACH, Primary/Secondary Common Control Physical Channel P-/S-CCPCH, Dedicated Physical Channel DPCH). The Physical Channel of UTRA FDD mode are characterized by frequency and code, of UTRAN TDD mode by frequency, code and time slot TS.

Other important Layer 1 functions are:

- Forward Error Correction FEC encoding/decoding and (de-)interleaving
- Rate matching
- (De-) Spreading and QPSK (De-) Modulation
- RF Processing
- Closed Loop Power Control
- Error Detection on transport channels and indication to higher layer
- Measurement of the Frame Error Rate FER, Signal-to-Interference Ratio SIR, interference & transmit power, etc. and indication to higher layer.



RLC

RLC Connection Management

Transparent-, unacknowledged-, acknowledged data transfer

QoS settings

Notification of unrecoverable errors

Monitoring of QoS, defined by higher layers

Segmentation and reassembly, concatenation, padding

Error correction, In-sequence delivery, Duplicate Detection

Flow control

Ciphering for non-transparent modes

Layer 2 protocols: RLC & MAC

Medium Access Control MAC

The MAC protocol is described in TS 25.321. It fulfils many different functions. Some important functions are:

The MAC protocol offers mapping of Logical Channel to Transport Channel. The Logical Channel are defined by the type of transferred data.

The user data are transmitted on the radio interface via Dedicated Transport Channel (i.e. via resources dedicated to only one UE) or via Common Transport Channel (i.e. via common resources, which can be used for different UEs). The MAC protocol switches between Common and Dedicated Transport Channel on RRC decision.

When using Common Transport Channels, MAC selects the C-RNTI as in-band identification for the UE.

The MAC protocol is responsible for the selection of appropriate Transport Format for each Transport Channel depending on the instantaneous source rate. This ensures efficient use of Transport Channels.

Ciphering of RT data, which are transparently transmitted through the RLC, is performed by the MAC protocol. UMTS ciphering is described in TS 33.102.

Radio Link Control RLC

The RLC protocol is described in detail in TS 25.322. It is responsible for e.g.:

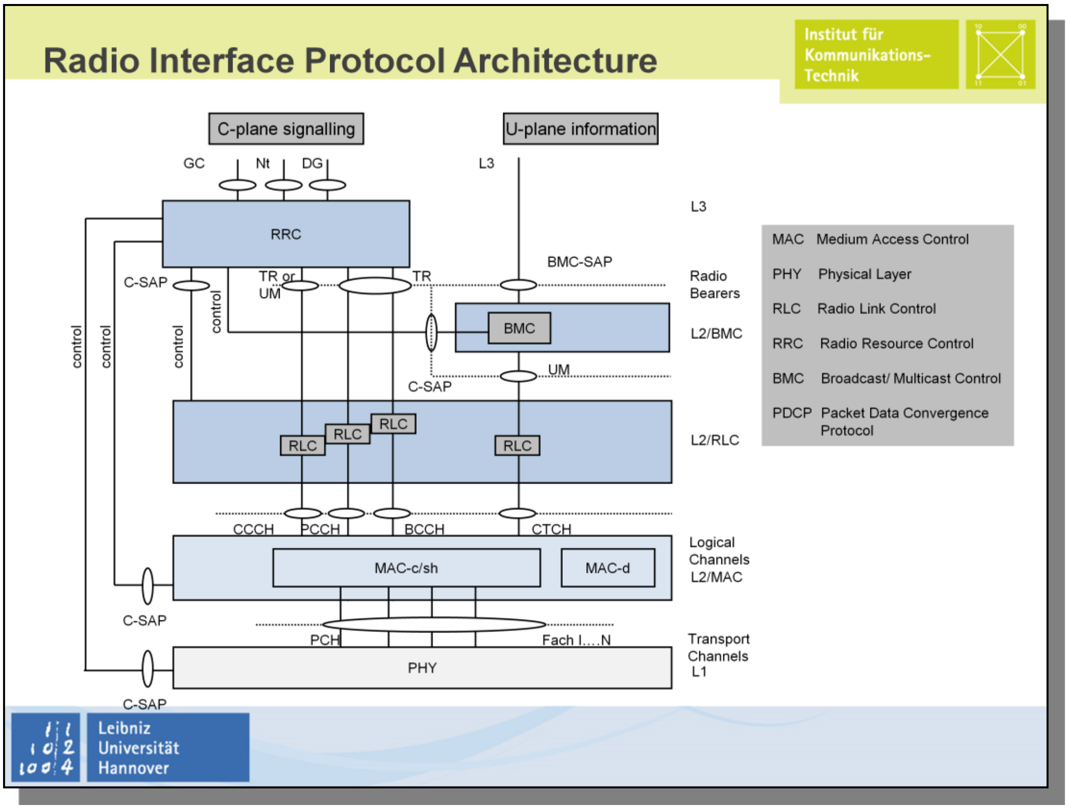
Segmentation & Re-assembly of higher layer Packet Data Units PDU into/from smaller RLC Payload Units PU. The higher layer PDUs are of varialbe length. The RLC PDUs (carrying one RLC PU) are adjustable to the actual transport rate.

The RLC offers transport (without adding any protocol information), unacknowledged (without guaranteeing delivery to the peer entity) and acknowledged (guaranteeing delivery to the peer entity) data transfer.

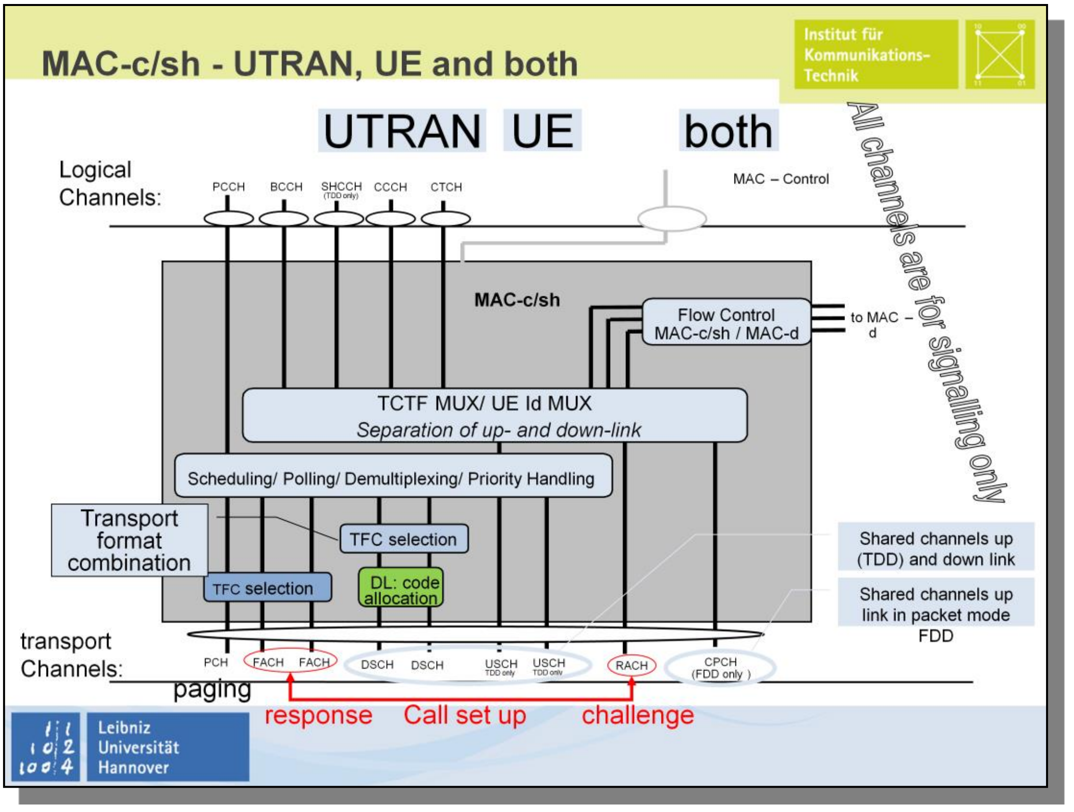
The data transfer can be controlled to provide different Quality of Service QoS levels.

The RLC offers Backward Error Correction BEC in the acknowledged data transfer mode.

Non Real-Time RNT data (acknowledged & unacknowledged RLC mode) are ciphered by the RLC.



C/sh common shared



the Scheduling – Priority Handling;

this function manages FACH (Forward Access channel[common down link channel] and DSCH (Down link Shared Channel) resources between the UEs and between data flows according to their priority.

TCTF MUX

this function represents the handling (insertion for downlink channels and detection and deletion for uplink channels) of the TCTF field in the MAC header, and the respective mapping between logical and transport channels. The TCTF field indicates the common logical channel type, or if a dedicated logical channel is used;

UE Id Mux;

for dedicated type logical channels, the UE Id field in the MAC header is used to distinguish between UEs;

TFC selection:

in the downlink, transport format combination selection is done for FACH and PCH and DSCHs; demultiplex;

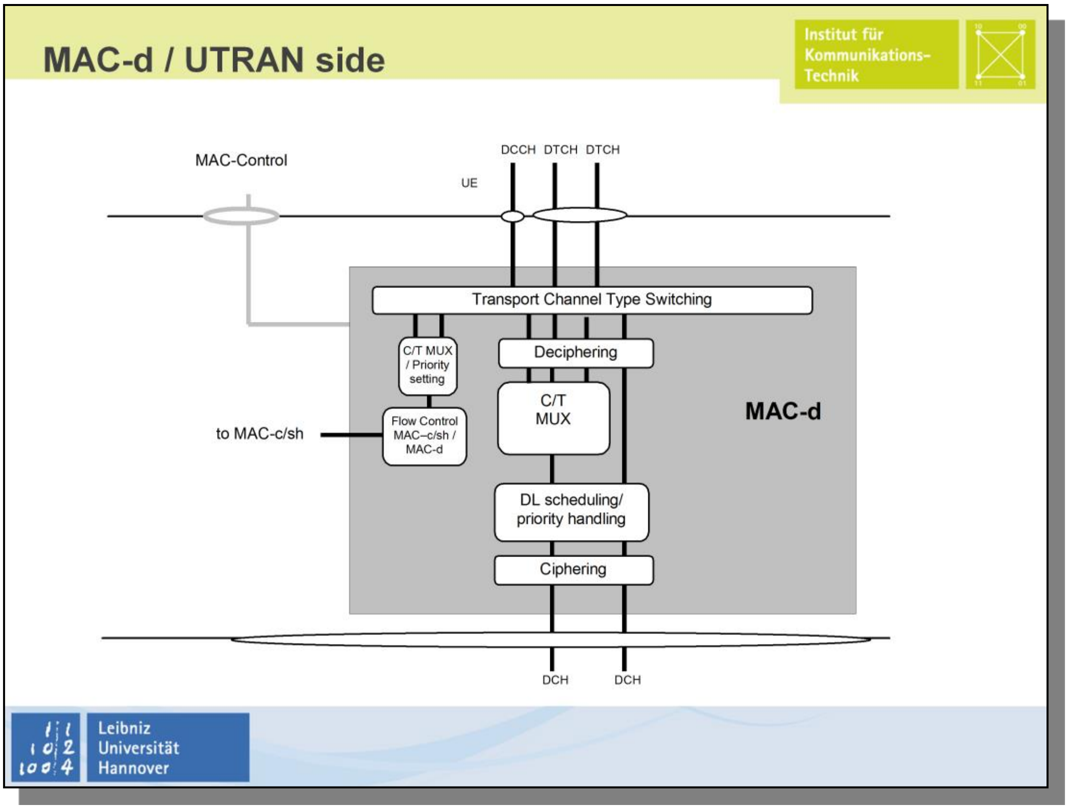
for TDD operation the demultiplex function is used to separate USCH data from different UEs, i.e. to be transferred to different MAC-d entities;

DL code allocation;

this function is used to indicate the code used on the DSCH;

Flow control is provided to MAC-d.

The RLC provides RLC-PDUs to the MAC, which fit into the available transport blocks on the transport channels. There is one MAC-c/sh entity in the UTRAN for each cell;



Transport Channel type switching:

Transport Channel type switching is performed by this entity, based on decision taken by RRC; this is related to a change of radio resources. If requested by RRC, MAC shall switch the mapping of one designated logical channel between common and dedicated transport channels.

C/T MUX box;

the function includes the C/T field when multiplexing of several dedicated logical channels onto one transport channel is used.

Priority setting;

This function is responsible for priority setting on data received from DCCH / DTCH;

Ciphering;

Ciphering for transparent mode data to be ciphered is performed in MAC-d.

Deciphering;

Deciphering for ciphered transparent mode data is performed in MAC-d.

DL Scheduling/Priority handling;

in the downlink, scheduling and priority handling of transport channels is performed within the allowed transport format combinations of the TFCS assigned by the RRC.

Flow Control;

a flow control function exists toward MAC-c/sh to limit buffering between MAC-d and MAC-c/sh entities. This function is intended to limit layer 2 signalling latency and reduce discarded and retransmitted data as a result of FACH or DSCH congestion. For the Iur interface this is specified in [11].

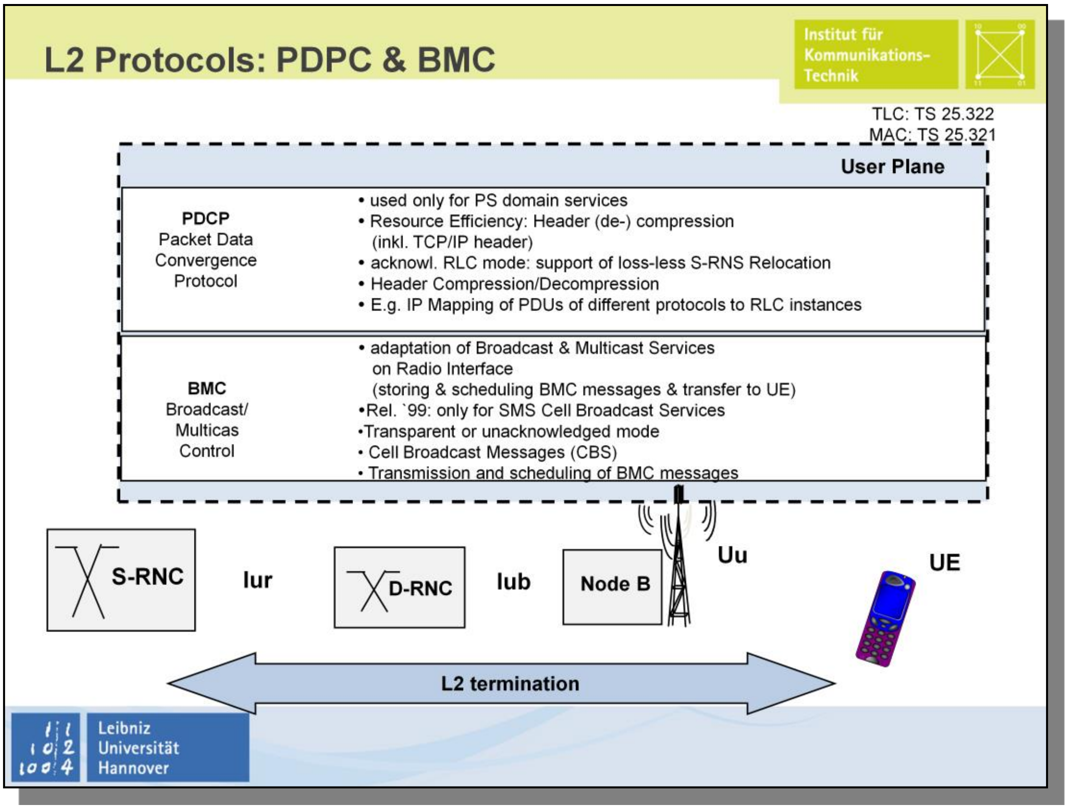
A MAC-d entity using common channels is connected to a MAC-c/sh entity that handles the scheduling of the common channels to which the UE is assigned and DL (FACH) priority identification to MAC-c/sh;

A MAC-d entity using downlink shared channel is connected to a MAC-c/sh entity that handles the shared channels to which the UE is assigned and indicates the level of priority of each PDU to MAC-c/sh;

A MAC-d entity is responsible for mapping dedicated logical channels onto the available dedicated transport channels or routing the data received on a DCCH or DTCH to MAC-c/sh.

One dedicated logical channel can be mapped simultaneously on DCH and DSCH. Different scheduling mechanisms apply for DCH and DSCH.

There is one MAC-d entity in the UTRAN for each UE that has one or more dedicated logical channels to or from the UTRAN.



Layer 2 Protocols: PDCP & BMC

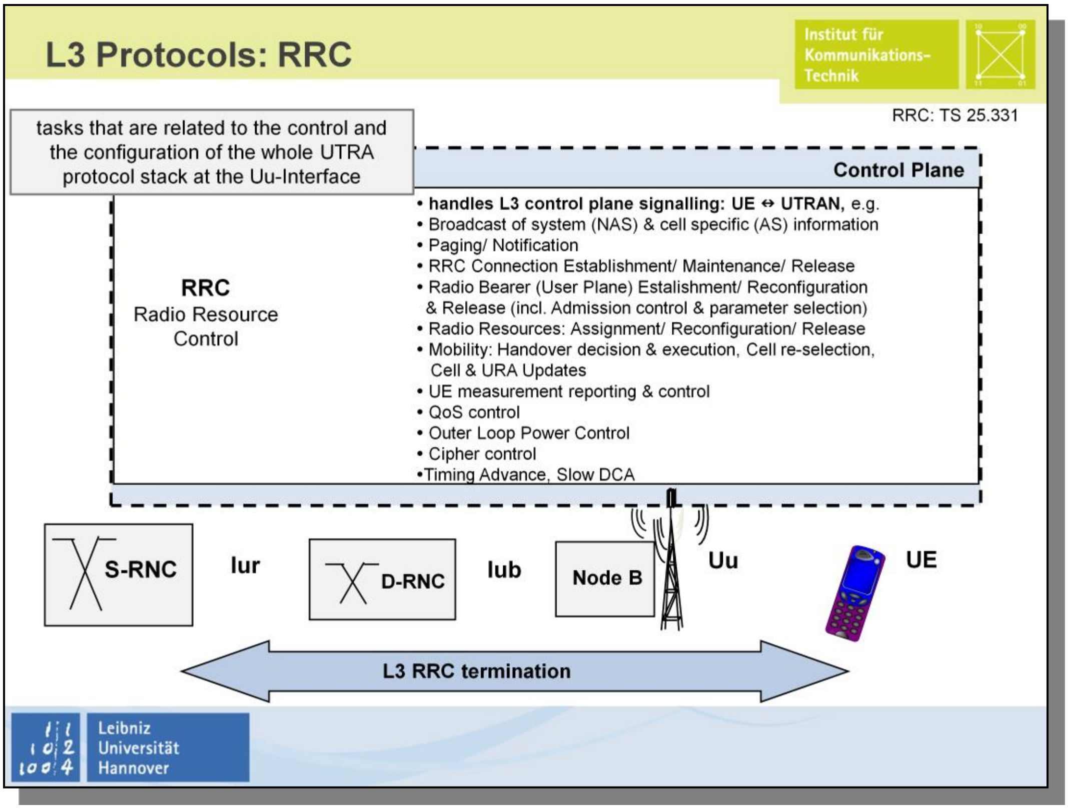
Packet Data Convergence Protocol PDCP

The PDCP (TS 25.323) is used only in the User Plane for Packet Switched PS domain services. The central PDCP function is the (de-)compression of redundant network PDU control information. This may include TCP/IP header (de-)compression. This will be valuable, because the header lengh can dominate the payload (e.g. the header for VoIP in IPv6 can be more than 75 % of the total packet length). Different to GSM/GPRS user data compression is not supported in UMTS, because many application compress data before transport.

Furthermore, in the acknowledged RLC mode the PDCP is able to support loss-less S-RNC Relocation.

Broadcast/Multicast Control BMC

The BMC protocol (TS 25.324) is existing only in the User Plane. The BMC provides broadcast or multicast transmission service on the radion interface for common user data in transparent or unacknowledged mode. The BMC is responsible for storage and scheduling of BMC messages and transmission of the messages to the UEs. In Rel.`99 only SMS Cell Broadcast service is using the BMC protocol. The RNC uses the BMC protocol to broadcast these messages in a certain geographical area.

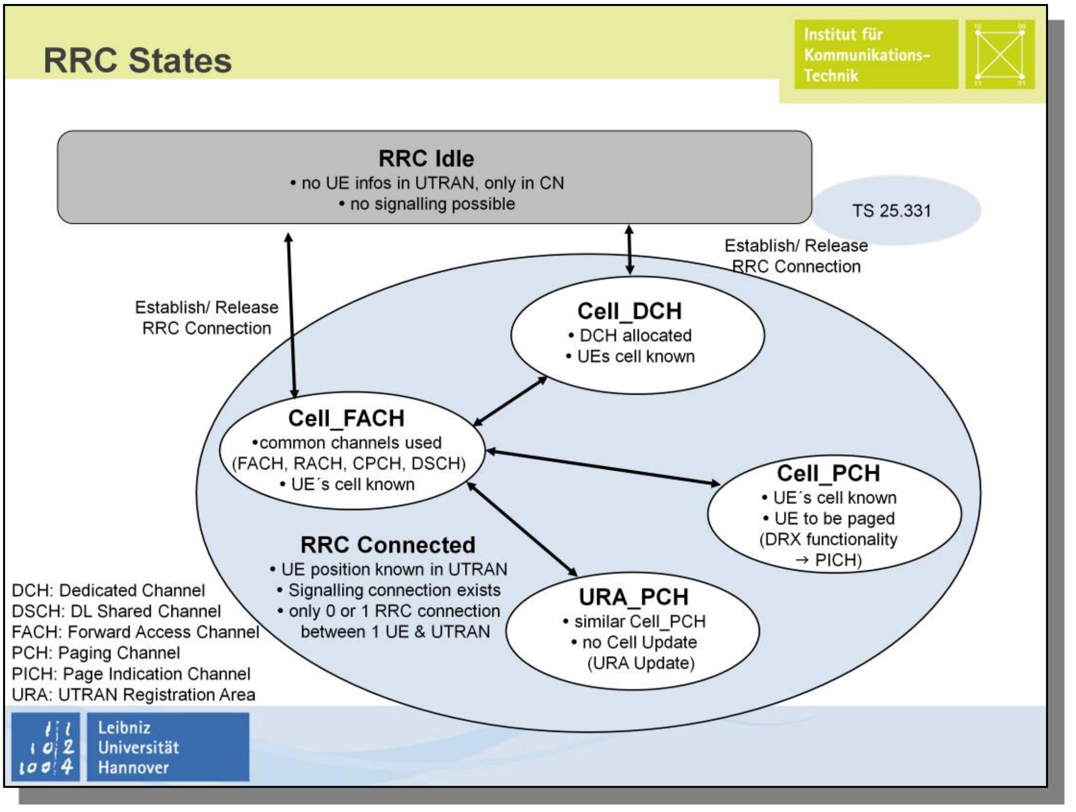


L3 Protocols: Radio Resource Contol RRC

The RRC is described in detail in TS 25.331. It is situated on top of the radion interface protocol architecture. The exchange of control data between the UE and UTRAn is handled via RRC.

Important RRC functions are:

- Broadcasting of Non-Access Stratum NAS system information provided by the Core Network CN as well as cell specific (Access Stratum AS) system information. The information are normally repeated on a regular basis. The RRC protocol is responsible for scheduling, segmentation and repetition of the information.
- Paging & Notification. The RRC protocol is responsible to page or notify certain UEs.
- Handling of RRC connection, i.e. establishment, re-establishment, maintenance and release. RRC connections are a necessary prerequisite for the data exchange between the UE and the S-RNC.
- Handling of Radion Bearer. The RRC layer is able to establish, reconfigure and release Radio Bearer in the User Plane.
- Handling of Radio Resources; The RRC protocol handles the assignment, reconfiguration and release of radio resources (e.g. Codes, CPCH channels) needed for the RRC connection including needs from Control and User Plane. The co-ordination of the radio resource allocation between multiple Radio Bearers related to the same RRC connection is included in theis function.
- RRC Connection Mobility functions. This function is used to keep track of a UEs location, while the UE is connected with UTRAN. It performs the evaluation, decision and execution of Hard & SoftHandover, prepares Inter-System Handover (e.g. to GSM), performs Cell and URA Updates, and many more.
- UE measurement reporting & control. The RRC controls the UE measurement, i.e. what to measure, when to measure and when to report. It performs also the reporting of the measurements from the UE to the S-RNC.
- Quality of Service QoS control; to ensure, that the requested QoS for the Radio Bearers can be met.
- Outer Loop Power Control, i.e. to control the setting of the target of the Closed Loop Power Control.
- Control of Ciphering; to provide procedures for setting of ciphering between the UE and the S-RNC.



RRC States

For the exchange of any information between the UE and the S-RNC, UE location information must be stored in the S-RNC. Two basic modes of RRC Connectivity (TS 25.331) are existing: „RRC Idle“ and „RRC Connected“.

RRC Idle mode

In the RRC Idle mode no UE location information are stored in UTRAN (UE location information only in CN; UE identified by NAS identifier e.g. IMSI, TMSI, P-TMSI). No exchange of signaling information is possible. Before any signaling information is possible. Before any signaling information can be exchanged and Radio Bearer can be established, the UE has to exit the RRC Idle mode by establishing an RRC connection. These transition can only be initiated by the UE with a request for an RRC Connection. The transition can be triggered by the network with a paging request.

RRC Connected mode

The UTRAN Connected mode is entered when the RRC connection is established. In the RRC Connected mode UTRAN stores UR location information and assigns an RNTI. A signaling connection between the UE and UTRAN exists. Four different States exist in the RRC Connected mode:

-Cell_DCH; a DCH is allocated to the UE and the UE location is known in the S-RNC on cell or active level. Handover are used to track the movement of the UE. The S-RNC can decide to change from Cell-DCH to Cell-FACH state due to low activity.

-The location of the terminal is known on cell level and handover procedures are used to track the movement of the terminal

-Dedicated physical channels are used for data transmission

-Transmission at start immediately without additional allocation delay

-The RRC state can be changed to CELL_FACH due to low activity, if all allocated radio bearers can cope with the increased delay in re-establishing dedicated physical resources

-Cell_FACH; no dedicated resources are allocated to the UE. Common channels (FACH, RACH, CPCH) are used for transmitting signaling messages and small amounts of user data. C-RNTI are used to identify the data packets; the U-RNTI is used in Cell Updates. The UE location is known on cell level. If there is higher load, a transition to Cell_DCH is performed. If there is no activity, a transit to Cell_PCH is possible.

-The location of the terminal is known on cell level and a cell update procedure is applied when a new cell is entered

-No dedicated physical connection is maintained, but small amounts of user data can be exchanged on common channels

-If the offered load exceeds a threshold, a transition to Cell_DCH is performed

-If there is no activity, the RRC transits to Cell_PCH

-Cell_PCH; the UE is still known on cell level, Cell Updates are performed, but it can only be reached via Paging. The UE battery consumption is less than in Cell_FACH due to Discontinuous Reception DRX functionality. If a Cell Update time counter exceeds a threshold, a transition to URA_PCH via Cell_FACH is performed.

-The location of the terminal is known on cell level and a cell updates are performed

-No uplink activity is possible

-To perform cell update, or data transmissions, the terminal transits to Cell_FACH

-If transition was due to a cell update, the terminal resumes to Cell_FACH immediately after the procedure is completed

-If a cell update counter exceeds a threshold, a transition to URA_PCH via Cell_FACH is performed

-URA_PCH

-The location of the treminal is known on URA level (UTRAN registration area)

-URA can consist of several cells, reducing the need for mobility-initiated signaling to the network during periods of low activity.

-For any uplink activity, a transition to Cell_FACH is necessary, as in Cell_PCH

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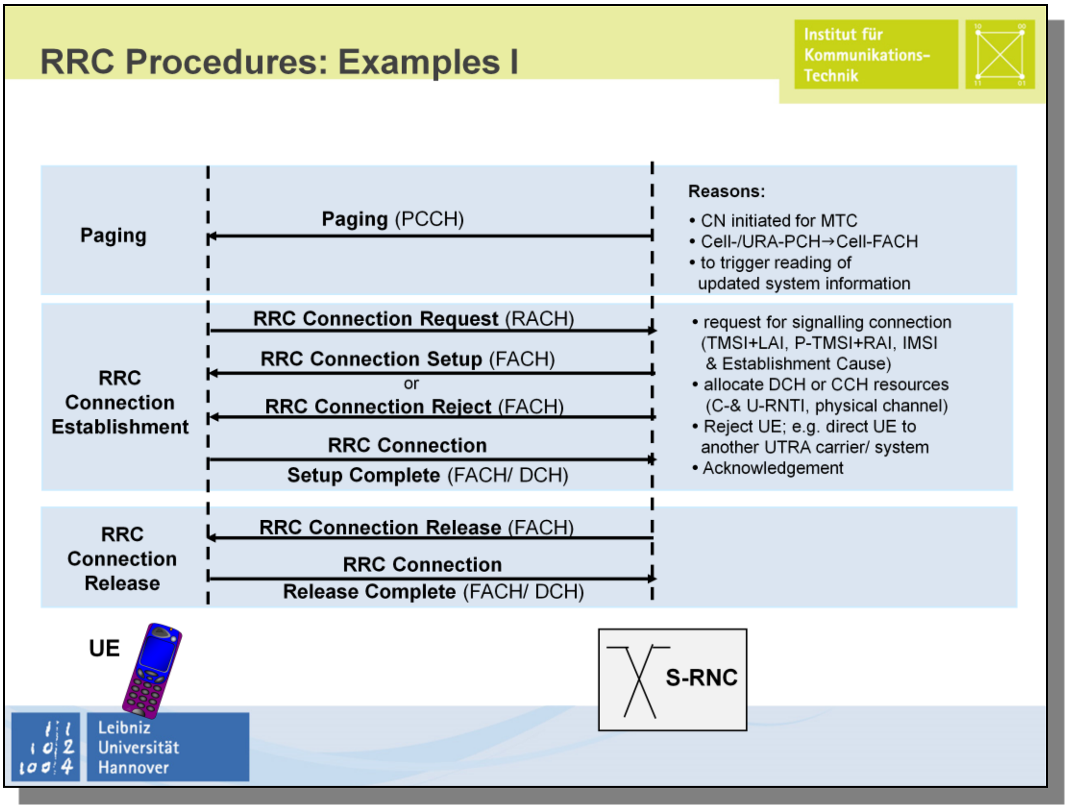


RRC Procedures: Examples I

Paging

„Paging“ is an RRC procedure transmitted from RNC to selected UEs in a cell for the following reasons:

The UE is in RRC Idle Mode (i.e. only LAI/RAI known in the CN) and there is a Mobile Terminating Call MTC or Session Setup for the UE. The CN requests the RNC to page the UE.

The UE is in RRC Connected Mode Cell_PCH or URA_PCH Mode. For e.g. DL packet data transmission it should change to Cell_FACH Mode.

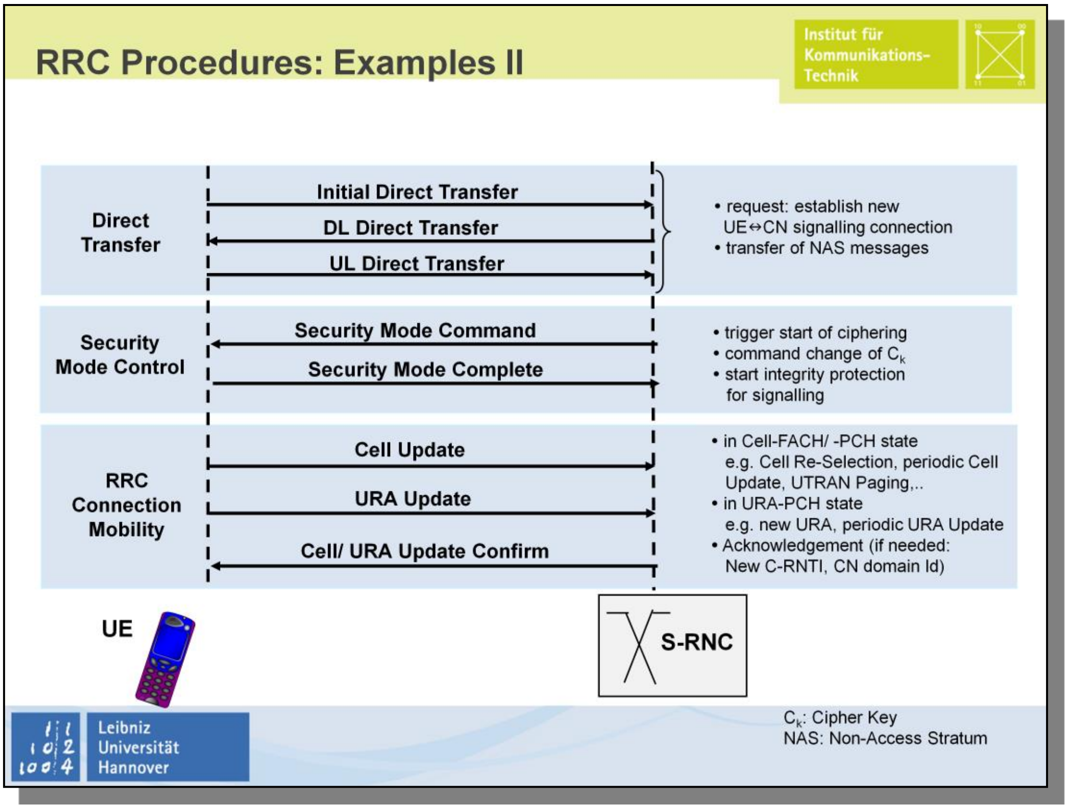
System information have been updated. The RNC sends a paging message to all UEs in the cell with the new information.

RRC Connection Setup

An RRC Connection is necessary for the exchange of signaling information between the UE and RNC. It is always requested by the UE with an „RRC Connection Request“ procedure on the Random Access Channel RACH. The „RRC Connection Request“ directly includes a unique UE identity (IMSI, TMSI + LAI or P-TMSI + RAI) and the Establishment Cause (e.g. Originating Call, Terminating Call, Emergency Call, Detach, SMS). The RNC allocates either Dedicated or Common Channel (DCH or CCH) resources to the UE with the „RRC Connection Setup“ procedure on an Forward Access Channel FACH. So the UE turns over to the Cell_DCH or Cell_FACH state. The UE request can be rejected using the „RRC Connection Reject“ procedure. The UE may be directed to another UTRA carrier or system. In case of receiving „RRC Connection Setup“ the UE acknowledges with „RRC Connection Setup Complete“.

RRC Connection Release

The UEs RRC Connection, including the signaling link and all radio bearers, is released with „RRC Connection Release“. It is acknowledged by the UE with „RRC Connection Release Complete“. The UE turns back from Cell_DCH or Cell_FACH state to RRC Idle Mode.



RRC Procedures: Examples II

Direct Transfer DT

Direct Transfer procedures are used to transmit higher layer signaling (Non-Access-Stratum NAS functions) between UE and CN. The RRC DT procedures transmit these information between the UE and the S-RNC, RANAP DT procedures to transmit between the S-RNC and the CN.

The RRC procedure „Initial DT“ is used in the UL to establish a signaling link between UE and CN. It is also used to carry initial NAS messages. The „DL DT“ and „UL DT“ procedures are used to carry NAS messages DL or UL over the radio interface.

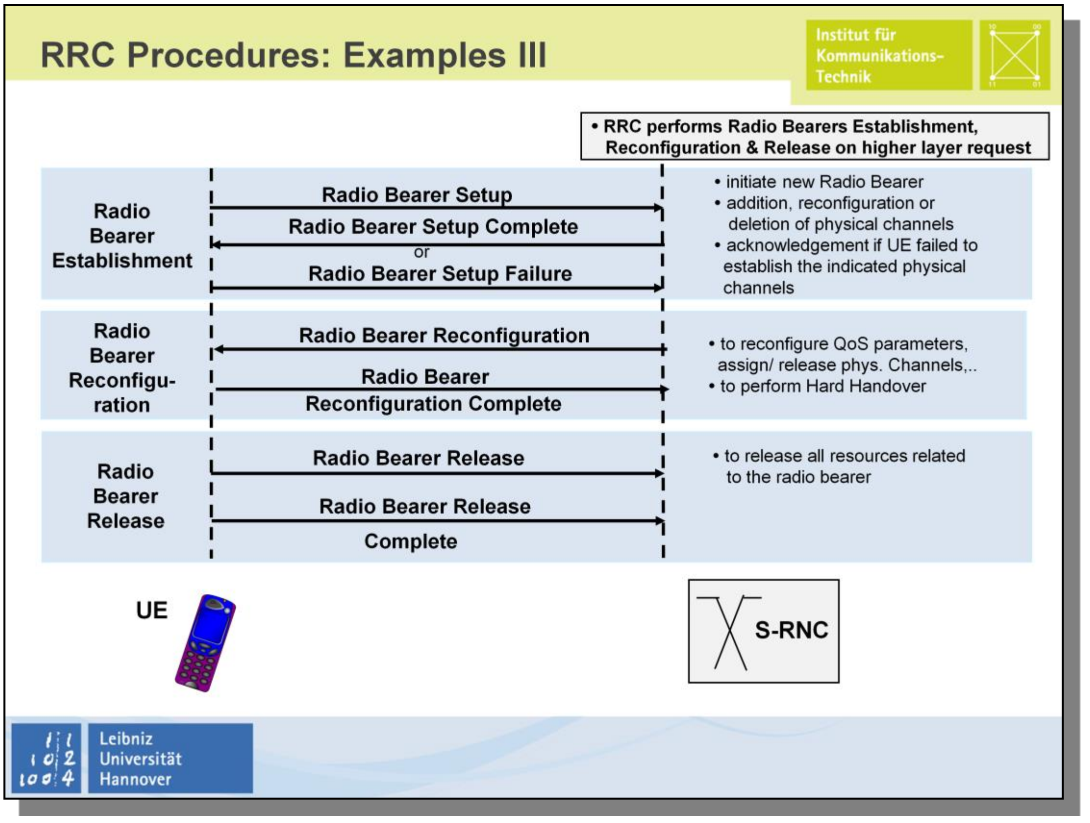
Security Mode Control

The DL RRC procedure „Security Mode Command“ is used to trigger the start of ciphering or to change the cipher key for the UEs signaling link and the radio bearer(s). It is also used to start intergrity protection for UL and DL signaling. The UE acknowledges the procedure with „Security Mode Complete“.

RRC Connection Mobility

The RRC procedure „Cell Update“ is used keep the track of an UE in Cell_FACH or Cell_PCH state. In the same way, „URA Update“ is used to keep the UE track in URA_PCH state. After Cell/URA Re-Selection the S-RNC. Furthermore, the „Cell Update“ or „URA Update“ procedure can be used periodically (Periodic Cell/URA Update) or if the UE is in the Cell_PCH or URA_PCH state and wishes to transmit UL data respectively the UE has been paged for DL data transmission. Then the UE turns over to Cell_FACH state.

The „Cell/URA Update Confirm“, which is used to acknowledge the update, can include a new C-RNTI or CN Domain-Id.



RRC Procedures: Examples III

The RRC protocol performs the establishment, reconfiguration and release of Radio Bearers an request from higher layers. For the establishment and reconfiguration it is necessary for the S-RNC to perform Admission Control and selection of the parameters for the L1 and L2 handling of the Radio Bearers.

Radio Bearer Establishment

The „Radio Bearer Setup“ procedure is used to establish new radio bearer(s) for control plane signaling or for a Radio Access Bearer RAB in the user plane. UTRAN has to configure new Radio Links and start transmission and reception on the new RL(s). Transport channels can be added, reconfigured or deleted in UL/DL therefore.

„Radio Bearer Setup Complete“ is sent in the UL to acknowledge or „Radio Bearer Setup Failure“ is sent in UL if the UE failed to establish the physical channel(s) indicated in the „Radio Bearer Setup“ message.

Radio Bearer Reconfiguration

The „Radio Bearer Reconfiguration“ procedure is sent in the DL to reconfigure radio bearer or signaling link parameters. This is necessary after changing the related QoS. Physical channels can be assigned or released. Hard Handover can be performed using the „Radio Bearer Reconfiguration“ procedure. „Radio Bearer Reconfiguration Complete“ is sent in the UL to acknowledge the reconfiguration.

Radio Bearer Release

The „Radio Bearer Release“ procedure is sent in the DL to release all resources related to a radio bearer or signaling link. It is acknowledged in the UL with „Radio Bearer Release Complete“.

UTRAN Signalling Procedures

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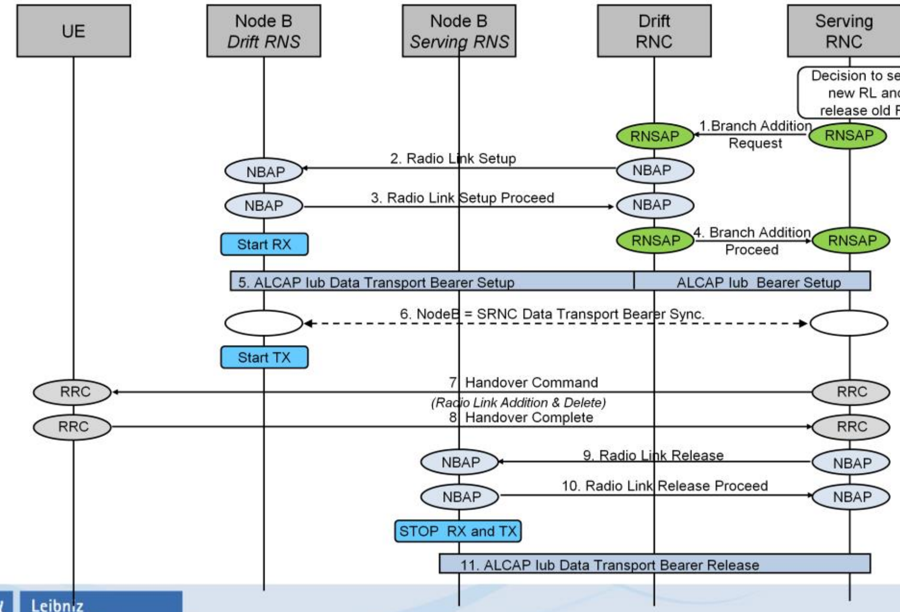

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Data transmission services

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- Transparent mode
  - No protocol overhead added to higher layer data
  - Error detection provided by PHY
- Unacknowledged mode
  - No retransmission protocol
  - Erroneous data detected and marked or discarded
  - SAR
- Acknowledged mode
  - ARQ used for error correction
  - Controlled and configured by RRC
  - Hybrid ARQ type I (FEC and selective reject/ repeat)

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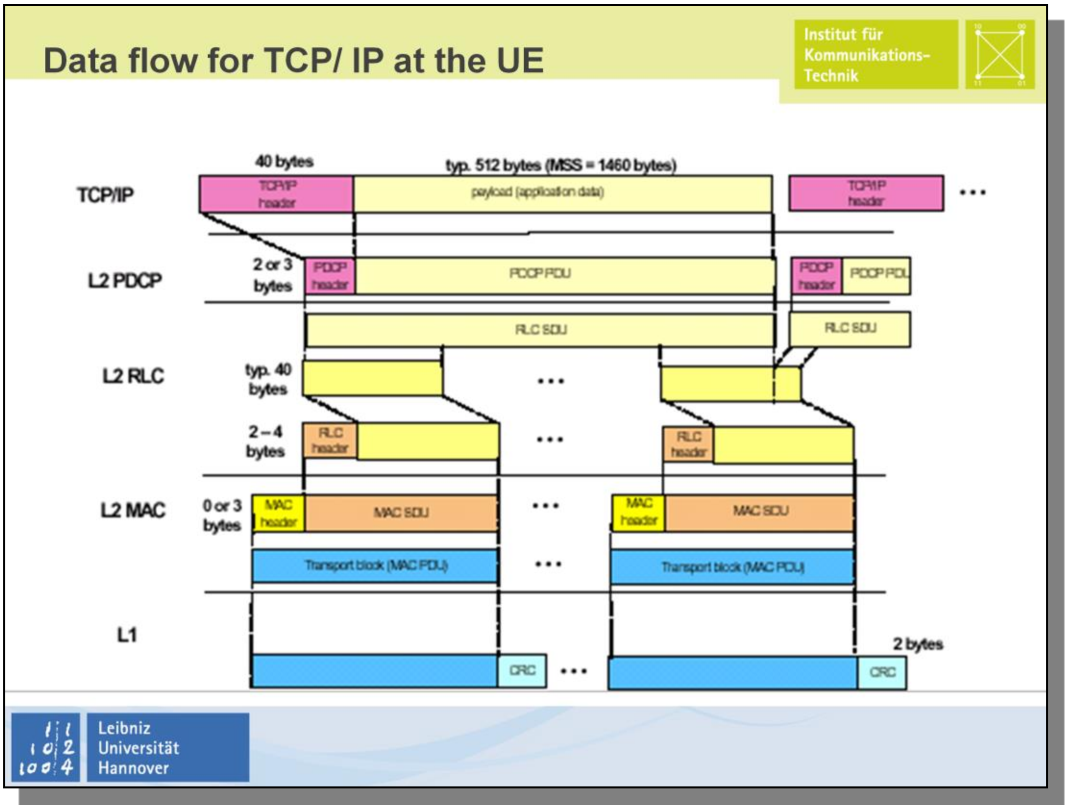

This is an example for the handling of TCP/IP user data in the user equipment (UE). First the 40 byte header of TCP/IP is compressed to 2 or 3 bytes. This compression happens in the Layer 2 PDCP (Packet Data Convergance Protocol). Next the Layer 2 RLC (Radio Link Control) performes segmentation into portions of 40 bytes (320 bits). This restriction to short packets is necessary in order to perform a sufficient error correction. 2 to 4 bytes RLC-header are added in the L2-RLC. The MAC layer adds another 0 to 3 bytes. Finally the physical layer adds 2 bytes CRC-information, in order to perform error correction using an ARQ mode.

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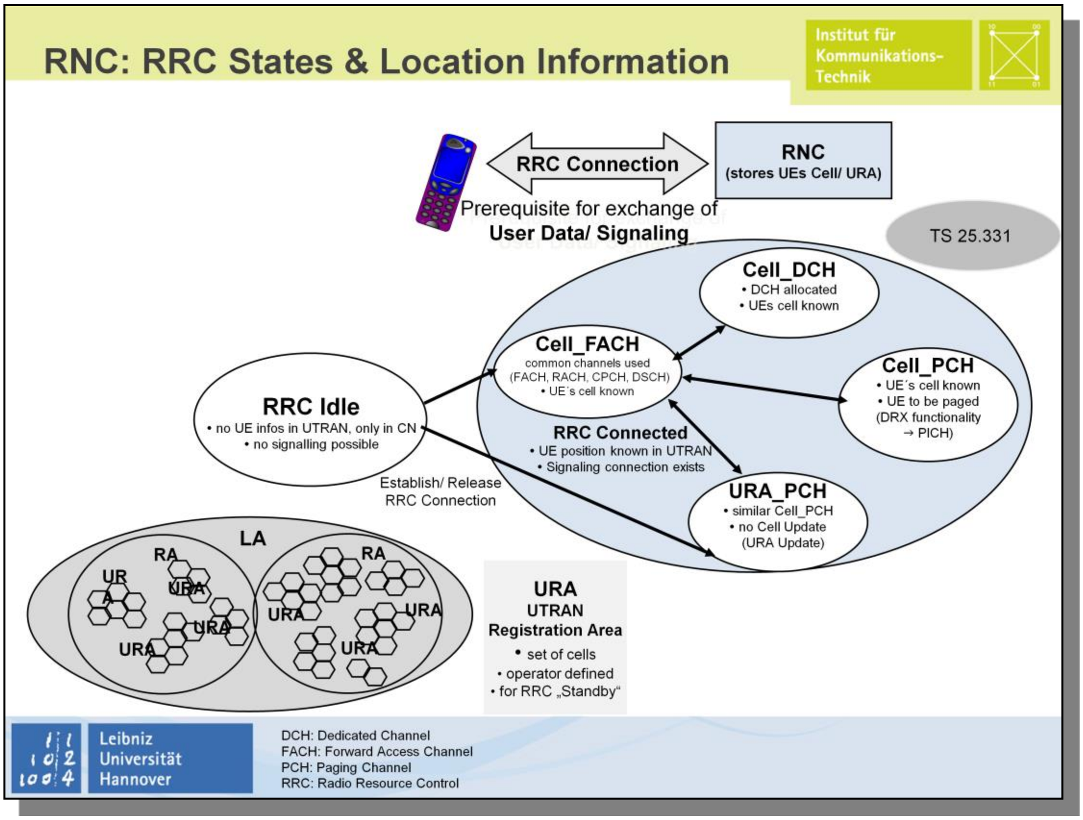


RNC: RRC State & Location Information

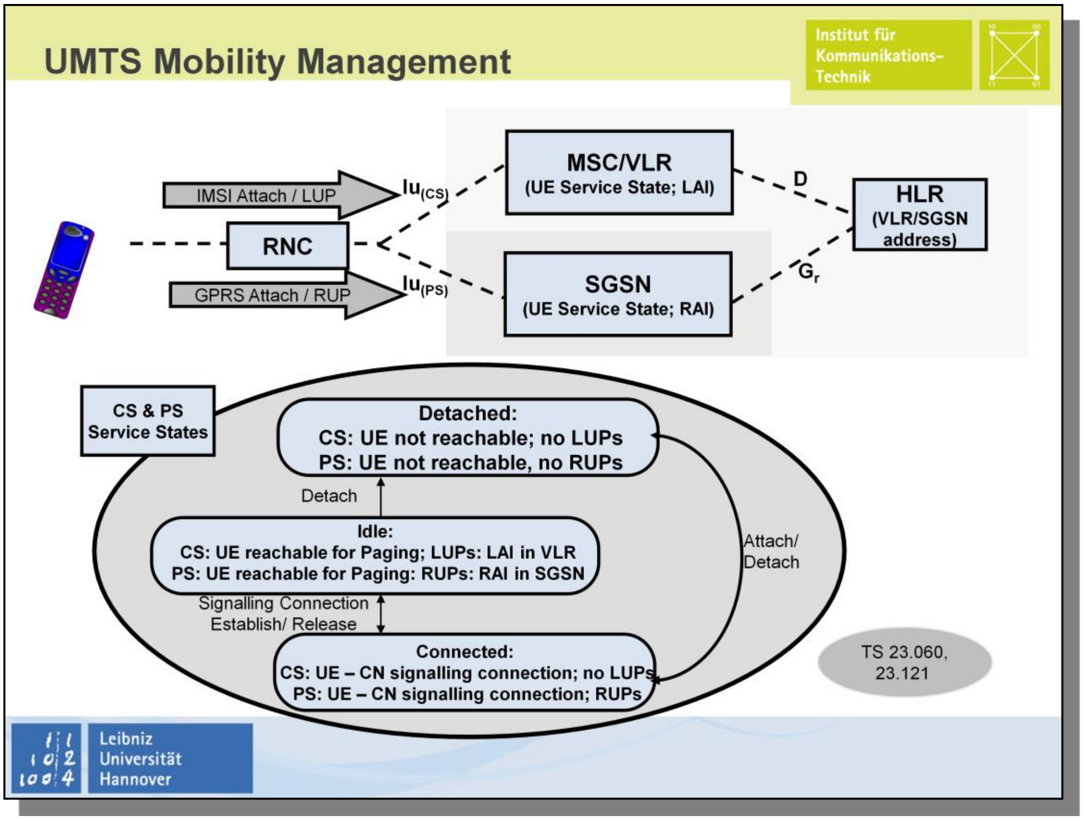
RRC States: For the exchange of any information between the UE and ist Serving RNC, UE location information must be stored in this RNC. Two basic models of RRC Connectivity (TS 25.331) are existing: „RRC Idle“ and „RRC Connected“.

RRC Idle mode: In the RRC Idle mode on UE location information are stored in UTRAN (UE location information only in CN; UE identified by NAS identifier e.g. IMSI, TMSI, P-TMSI). No exchange of signaling information is possible. Before any signaling information can be exchanged and Radio Bearer can be establiched, the UE to establish a RRC connection. This transition can only be initiated by the UE. The transition can be triggered by the network with a paging request.

RRC Connected mode: The UTRAN Connected mode is entered when the RRC connection is established. In the RRC Connected mode UTRAN stores UE location information. A signaling connection between the UE and UTRAN exists. Four different States exist in the RRC Connected mode:

- **Cell_DCH;** a Dedicated Channel is allocated to the UE and UEs cell is known in the Serving RNC. Handover are used to track the movement of the UE. The RNC can decide to change from Cell_DCH to Cell_FACH state due to low activity.
- **Cell-FACH;** no dedicated resources are allocated to the UE. Common channels are used for transmitting signaling messages and small amounts of user data. The UE location is known on cell level. If there is higher load, a transition to Cell_DCH is performed. If there is no activity, a transit to Cell_PCH is possible.
- **Cell_PCH;** the UE is still known on cell level, Cell Updates are performed, but is can only be reached via Paging. The UE battery consumption is less than in Cell_FACH due to Discontinuous Reception DRX functionality. If a Cell Update time counter exceeds a threshold, a transition to URA_PCH via Cell_FACH is performed.
- **URA_PCH;** similar to Cell_PCH, but the UE is only known on URA level; only URA Updates are performed to reduce the Uu signaling load.

UTRAN Registration Area URA: The URA is a set of cells, specified by the network operator. The UE location is stored in the Serving RNC on cell or URA level. A Packet UE is tracked at the URA level when no data are actively transferred, and the probability of data transfer is quite high. An UE registered at URA level must be paged by UTRAN in the case of network side packet data delivery. The URA is an UTRAN internal area; it is not visible outside UTRAN. There may not be any relation between URA and Location Area LA respectively Routing Area RA. URA updating is a radio network procedure.



UMTS Mobility Management UMM

The task of the UMTS Mobility Management is to keep track of the UEs location. Different UMTS CN network elements store location information.

In the CS Domain, the VLR stores location information on level of the Location Area LA. In the PS Domain, the SGSN stores location information on level of the Routing Area RA. In the HLR, the actual location of the UE is stored on basis of the MSC area (VLR address) respectively the SGSN area (SGSN address).

Location Update Procedures LUP respectively Routing area Update Procedures RUP are triggered by the UE to inform the CN about changes of the UEs location.

CN domain: CS and PS Service States

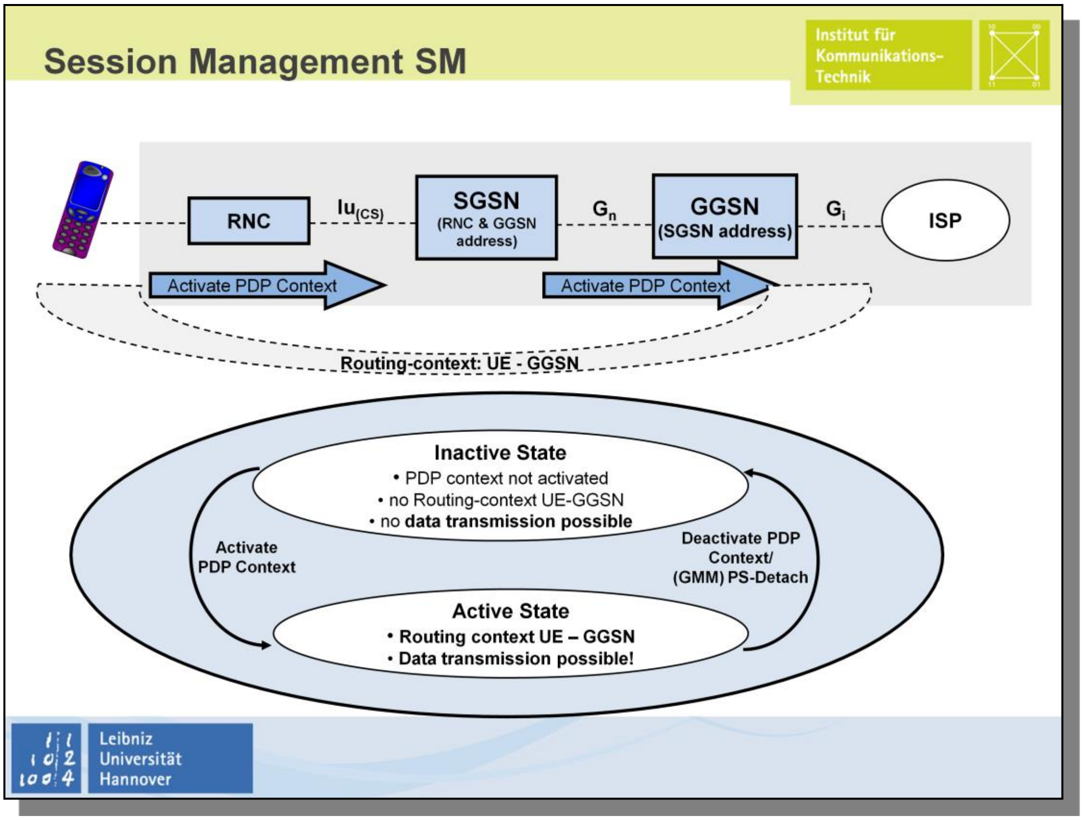
In the integrated UMTS CN architecture, the CN consists of a CS and a PS service domain. The main PS Service State (TS 23.060; 23.121) are: PS-Detached, PS-Idle and PS-Connected. The main CS Service States are CS-Detached, CS-Idle and CS-Connected.

CS-/PS-Detached: The UE is not reachable by the network for CS/PS services. No Location Area LA/Routing Area RA Updates are initiated by the UE.

CS-/PS-Idle: The UE is reachable via Paging for CS/PS Services. LA/RA Updates are initiated by the UE periodically and at LA/RA change.

CS-/PS-Connected: A UE-CN signaling connection for CS/PS services has been established. The UE initiates no LA Updates; RA Updates are initiated when the RA changes (no periodic RA Updates).

Transitions between the Detach state and Connected state are done via UE Attach/Detach procedures, between the Idle and Connected state via Signaling Connection Establishment/Release procedures and from Idle to Detach state via UE Detach procedure.



UMTS Session Management (PDP) States

A UMTS PS subscription contains the subscription of one or more Packet Data Protocol PDP addresses. Each PDP address is described by one or more PDP contexts in the UE, SGSN and GGSN. Every PDP context exists independently in one of two PDP states. The Packet Data Protocol PDP state indicates whether packet data transfer is enabled for a specific PDP address or not.

Inactive State

The Inactive State characterizes that the data service for a certain PDP address of the subscriber is not activated. The PDP context contains no routing information. No packet data can be transmitte. If Mobile-terminated PDP PDUs receive in INACTIVE state the GGSN, the Network-Requested PD Context Activation procedure (if allowed for that PDP address) may be initiated. Otherwise, the PDP PDUs may be discarded.

The UE initiates the transition from Inactive to Active state by initiating the PDP Context Activatioon procedure.

Active State

In the Active State, the PDP context for the PDP address in use is activated in the UE, SGSN and GGSN. Routing information are existing for transmission of packets between the UE and GGSN. The Active state is permitted only is the UMM is PS-Idle or PS-Connected. An Active PDP context for an UE moves to Inactive when the Deactivation procedure is initiated or the UMM state chages to PMM-Detached.

More detailed information on the PDP Context Activation Procedure are given in TS 23.060.