UMTS System Architecture and Protocol Architecture

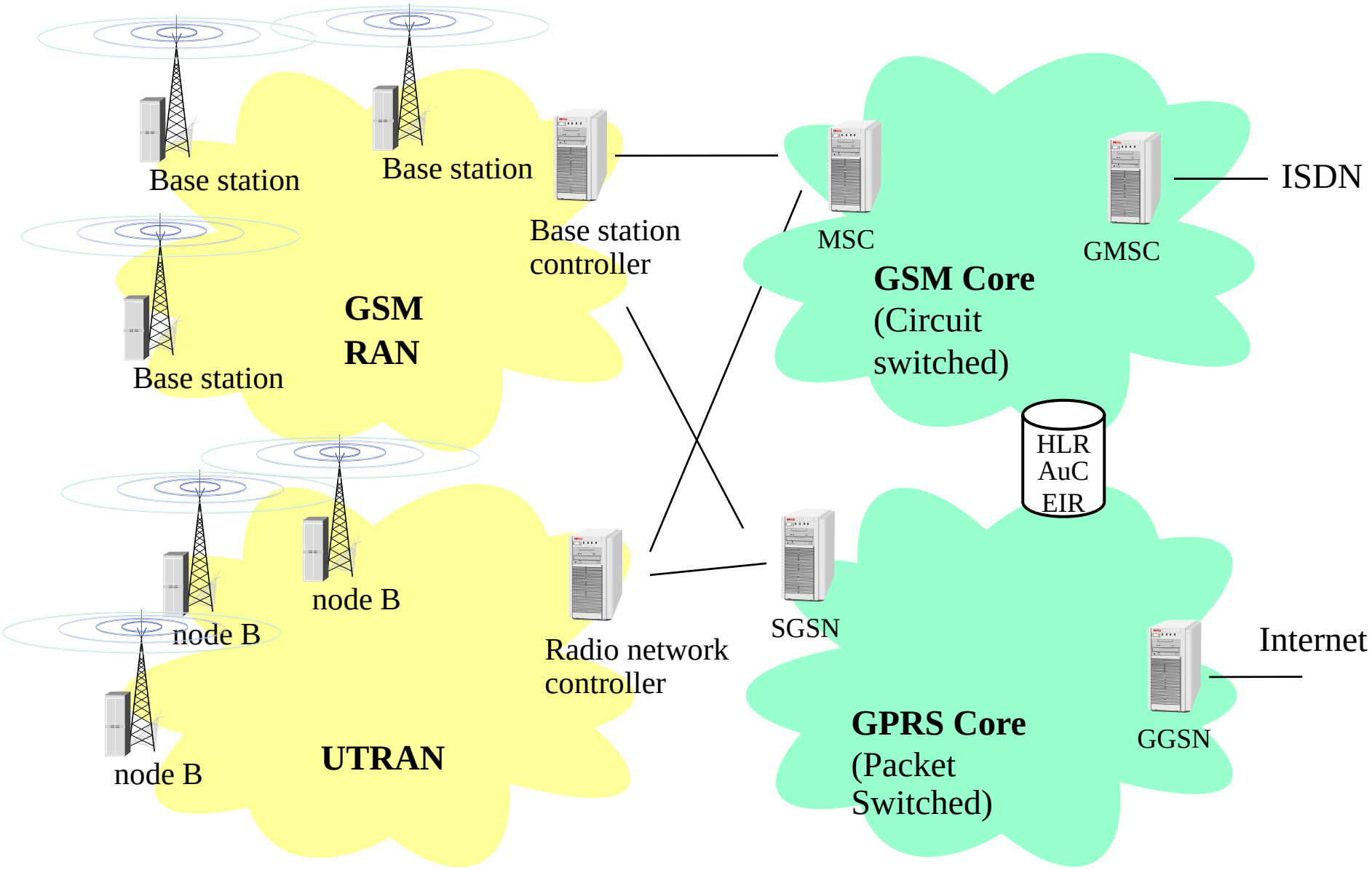
Overview on overall system architecture

- UMTS network architecture and elements
- Mobile station
- High-level functions
- UMTS domains and strata
- UMTS/GPRS protocol architecture

References:

- Kaaranen, Ahtiainen, Laitinen, Naghian, Niemi: UMTS Networks – Architecture, Mobility and Services. 2nd edition, Wiley 2005
  - Ch 5.1: Core Network Architecture Release 3
  - Ch 5.4&5.5: Core Network Architecture Release 4 and 5
  - Ch 6: UMTS Terminal
- Walke, Althoff, Seidenberg: UMTS – Ein Kurs. J. Schlembach Fachverlag, 2001
- 3GPP TS 23.002: UMTS network architecture (CN and AN entities) and procedures
- 3GPP TS 23.101: General UMTS architecture
- 3GPP TS 23.060: GPRS, Service Description
- 3GPP TS 21.101/21.102/21.103: List of standards for Release 3, 4 and 5, respectively
- 3GPP TR 21.905: UMTS vocabulary and abbreviations

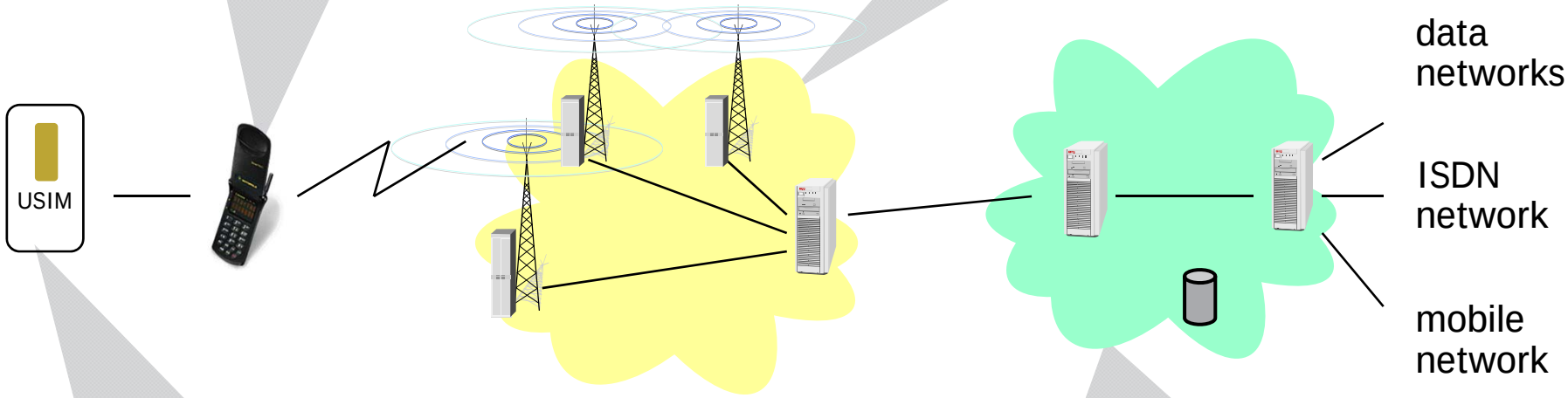
UMTS/GSM Network Architecture



UMTS System Architecture

Mobile Station (MS):
- radio interface
- service control and user interface

Radio Access Network (RAN):
- radio-specific functions



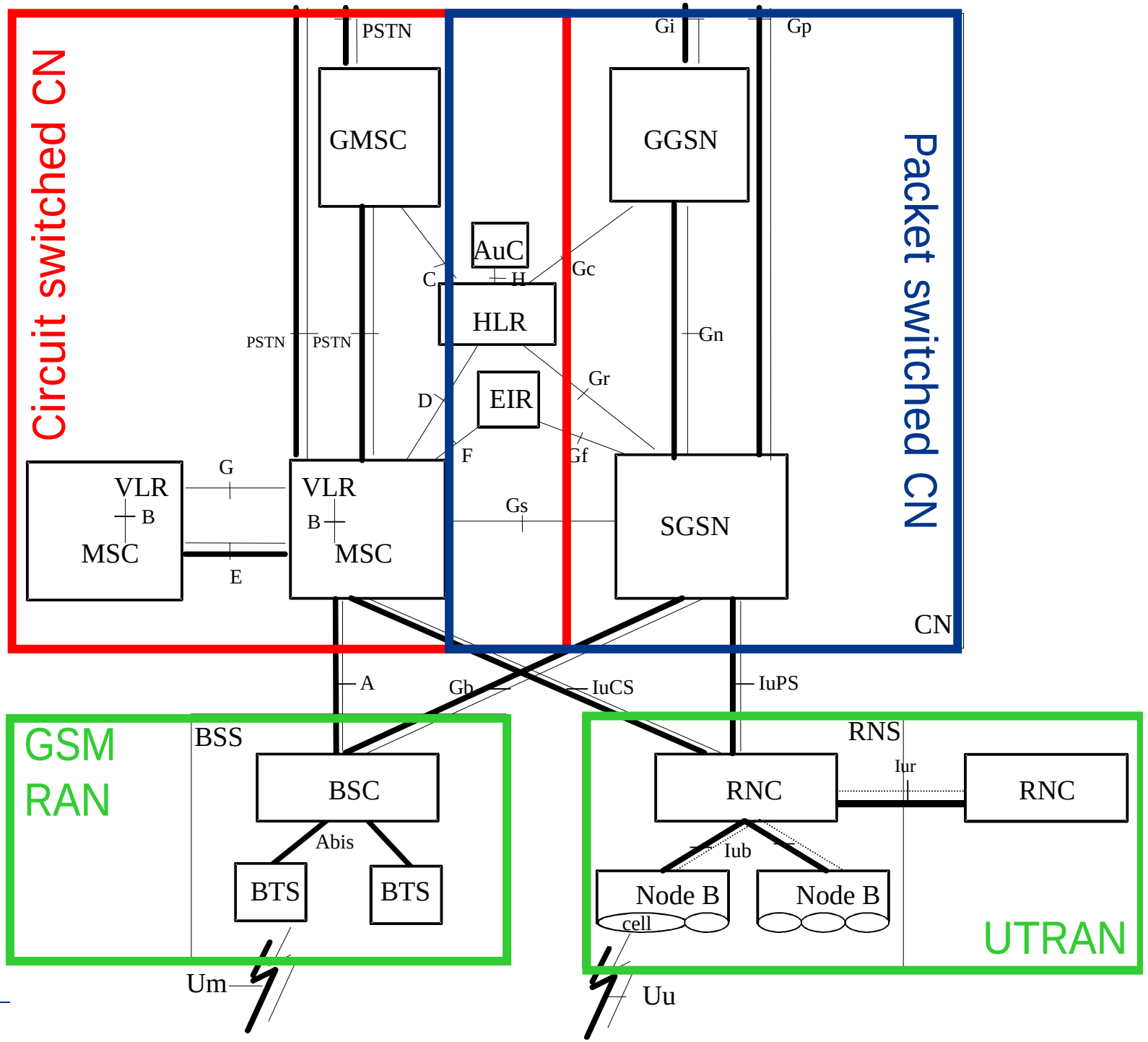
UMTS Subscriber Identity Module (USIM):
- subscriber-specific data
- support of authorized access to network

Core Network (CN):
radio-independent functions
- transport
- mobility management
- subscriber data
- service control

UMTS Network Architecture

Basic Configuration, Release 3

Source: 3GPP 23.002-3.4.0



Mobile-services Switching Centre (MSC)

Source: 3GPP 23.002-3.5.0

An exchange performing all the switching and signalling functions (CS only) for mobile stations

MSC controls mobile-originated and mobile-terminated CS calls

Functions

- call management
- mobility management (handling attach and authentication)
- subscriber administration
- maintenance of charging data (for radio network usage)
- CS data services (FAX, modem)
- supplementary call services (call forwarding, etc.)
- SS7-based signaling

Main difference to an exchange in a fixed network: deal with mobility (e.g. location registration, handover)

Gateway MSC (GMSC)

- Provides interconnection between the UMTS core network and external PSTN/ISDN networks

GPRS Support Node (GSN)

Source: 3GPP 23.002-3.5.0

GSNs constitute the interface between the radio access network and the fixed networks for packet switched services (similar to MSC for CS calls)

Serving GSN (SGSN)

- session management
- mobility management
- subscriber database management (interface with HLR)
- maintenance of charging data (for radio network usage)

- IP-based transport of user data between SGSN and the UTRAN
- IP- or SS7-based signaling transport

Gateway GSN (GGSN)

- gateway for UMTS packet service to external data networks (e.g. the Internet)
- IP interface towards SGSN
- performs user data screening and security
- maintenance of charging data (for external data network usage)

Home Location Register (HLR)

Source: 3GPP 23.002-3.5.0

Home (primary) data base in charge of the management of mobile subscribers

Basic information:

- International Mobile Subscriber Identity (IMSI)
- CS subscription information
  - one or more Mobile Subscriber International ISDN number(s) (MSISDN)
- PS subscription information
  - zero or more Packet Data Protocol (PDP) address(es)
  - permission for GGSN to dynamically allocate PDP addresses for a subscriber
- location information enabling the charging and routing of calls towards the MSC or SGSN where the MS is registered (e.g. VLR Number)

Other information:

- teleservices and bearer services subscription information
- service restrictions (e.g. roaming limitation)
- parameters attached to supplementary services

Visitor Location Register (VLR)

Source: 3GPP 23.002-3.5.0

(Secondary) data base supporting the management of mobile subscribers currently located within its VLR area

Motivation: minimize load for HLR (i.e. of the primary data base)

Tasks:

- control MSs roaming in an MSC assigned to it
- exchange information with HLR to allow the proper handling of calls

Information maintained by VLR (for call handling):

  - International Mobile Subscriber Identity (IMSI)
  - Mobile Station International ISDN number (MSISDN)
  - Mobile Station Roaming Number (MSRN)
  - Temporary Mobile Station Identity (TMSI), if applicable
  - location area where the mobile station has been registered
  - the last known location and the initial location of the MS
  - supplementary service parameters attached to the mobile subscriber (received from the HLR)

Authentication Centre (AuC)

Source: 3GPP 23.002-3.5.0

Stores data for each mobile subscriber

- to authenticate the International Mobile Subscriber Identity (IMSI)
- to support ciphering of the communication over the radio path

The AuC transmits the data needed for authentication and ciphering via the HLR to the VLR, MSC and SGSN which need to authenticate a mobile station

AuC is associated with an HLR, and stores an identity key for each mobile subscriber

The AuC communicates solely with its associated HLR (H-interface)

Equipment Identity Register (EIR)

Source: 3GPP 23.002-3.5.0

Logical entity storing the International Mobile Equipment Identities (IMEIs)

Equipment is classified as

- white listed: serie number of equipment
- grey listed: equipment tracked by network
- black listed: barred equipment
- unknown to EIR

Other CN entities

Source: 3GPP 23.002-3.5.0

SMS Gateway MSC (SMS-GMSC)

- gateway between Short Message Service Center and PLMN
- deliver SMSs from service center to MS

SMS Interworking MSC (SMS-IWMSC)

- gateway between PLMN and Short Message Service Center
- deliver SMSs from MS to service center

Interworking Function (IWF)

- associated with MSC
- supports interworking of PLMN with fixed networks, e.g. ISDN, PSTN, PDN (protocol conversion)

Border Gateway (BG)

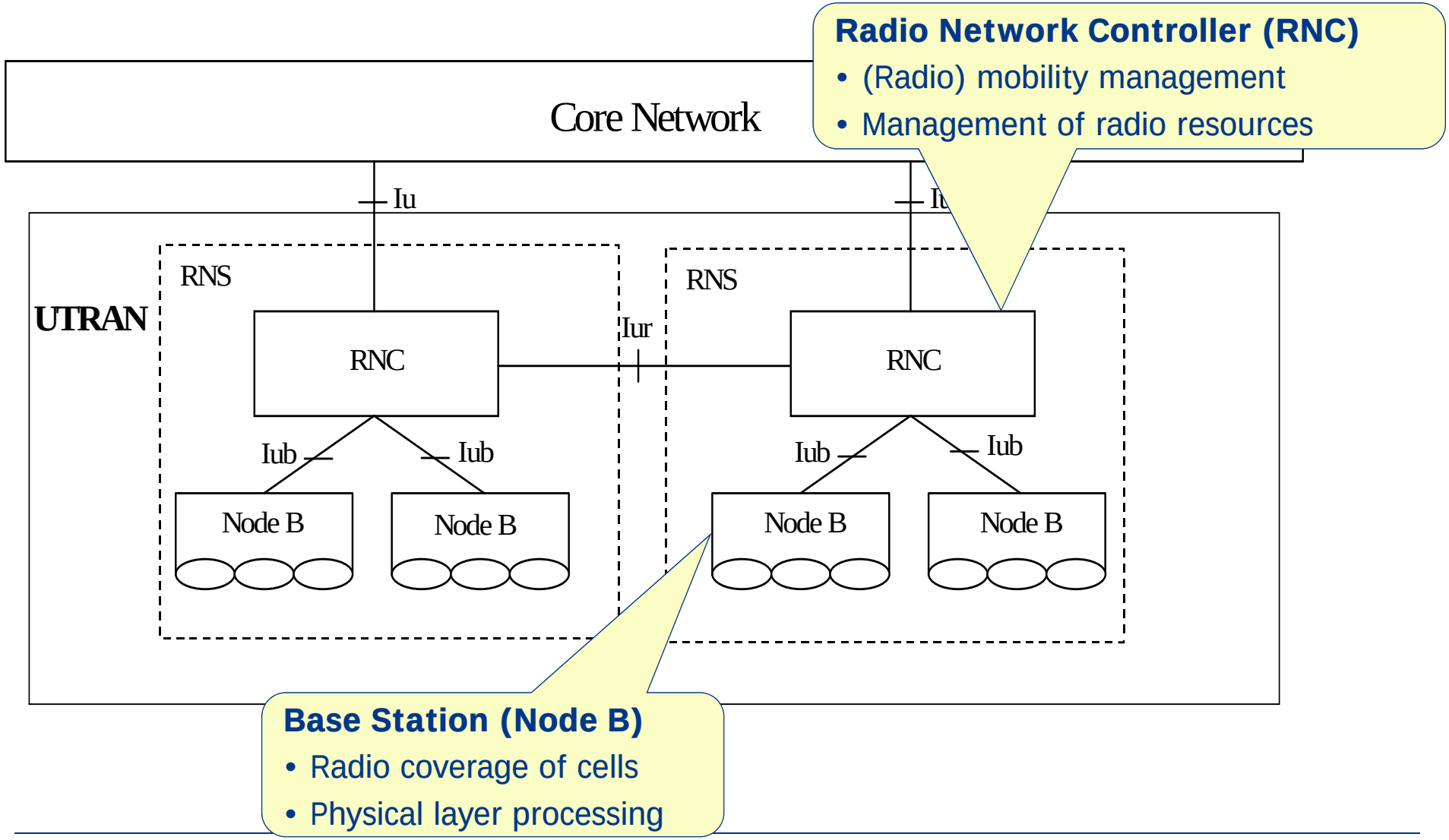
- PS gateway to other PLMNs
- firewall functionality

Charging Gateway Functionality (CGF)

- collects charging records from SGSNs and GGSNs

Radio Network System (RNS)

Provide access to the UMTS terrestrial radio interface



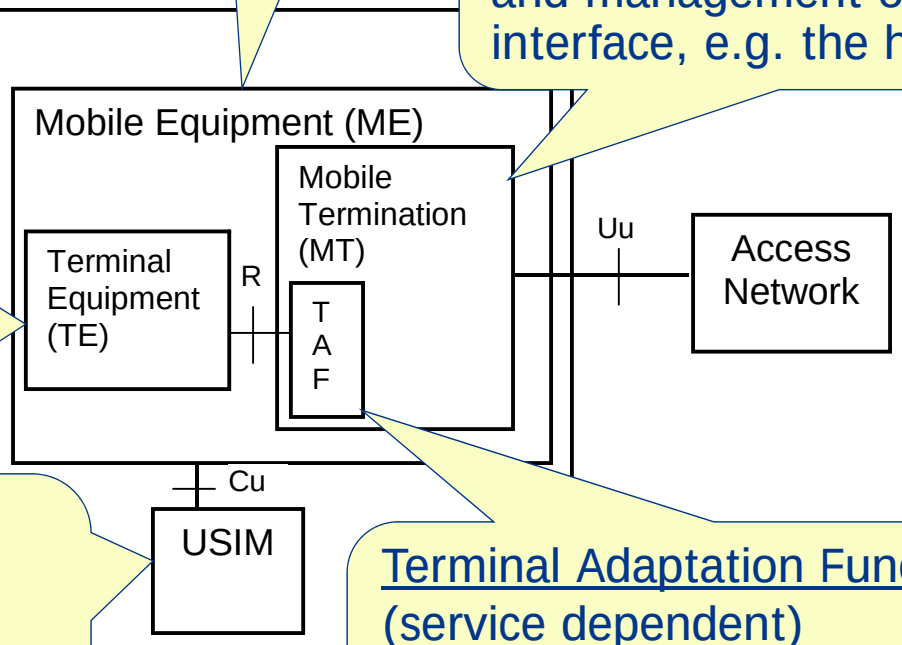
Mobile Station (MS)

Mobile station (MS)/
User Equipment (UE)
physical equipment used by a PLMN subscriber

Mobile Equipment (ME)
radio transmission and application

Mobile Termination (MT)
functions for radio transmission and management of the radio interface, e.g. the handset

Terminal Equipment (TE)
support for end-to-end application
functions necessary for the operation of the access protocols by the user, e.g. a laptop



UMTS Subscriber Identity Module (USIM)
user identity
contains data and procedures to unambiguously and securely identify itself

Terminal Adaptation Functions (TAF)
(service dependent)
- mapping of terminal requests on network capabilities
- flow control/rate adaptations

UMTS High-level Functions (PS Domain)

Network Access Control

Provide means by which a user is connected to a telecommunication network

- Registration

  Association of Mobile ID with the user's packet data protocol(s) and address(es) within the PLMN, and with the user's access point(s) to the external PDP network

- Authentication and Authorisation

  Identification and authentication of the service requester, and the validation of the service request type

- Admission Control

  Check available network resources required to provide the quality of service (QoS)

- Message Screening

  A screening function with filtering out unauthorised or unsolicited messages (firewall)

- Packet Terminal Adaptation

  Adaptation of data packets suitable for transmission across the packet domain network

- Charging Data Collection

  Collection of data necessary to support subscription and/or traffic fees

- Operator Determined Barring

  Limitation of the service provider's financial risk with respect to new subscribers or to those who have not promptly paid their bills by restricting a particular packet-switched service

UMTS High-level Functions (PS Domain)

Packet Routing and Transfer

Determining and using the route for transmission of a message within and between the PLMN(s)

- Relay

  Forwarding of data received from one node to the next node in the route

- Routing

  Selection of the transmission path for the "next hop" in the route using the destination address of the message

- Address Translation and Mapping

  Conversion of one address to another address of the same or different type, i.e. to convert an external network protocol address into an internal network address

- Encapsulation/Decapsulation

  Addition/removal of address and control information to a data unit for routing packets within and between the PLMN(s) and between the SGSN and the MS

- Tunneling

  Transfer of encapsulated data units within and between the PLMN(s) from the point of encapsulation to the point of decapsulation

  A tunnel is a two-way point-to-point path

- Compression

  Optimisation of radio path capacity

- Ciphering

  Preservation of the confidentiality of user data and signalling across the radio channels

Mobility Management

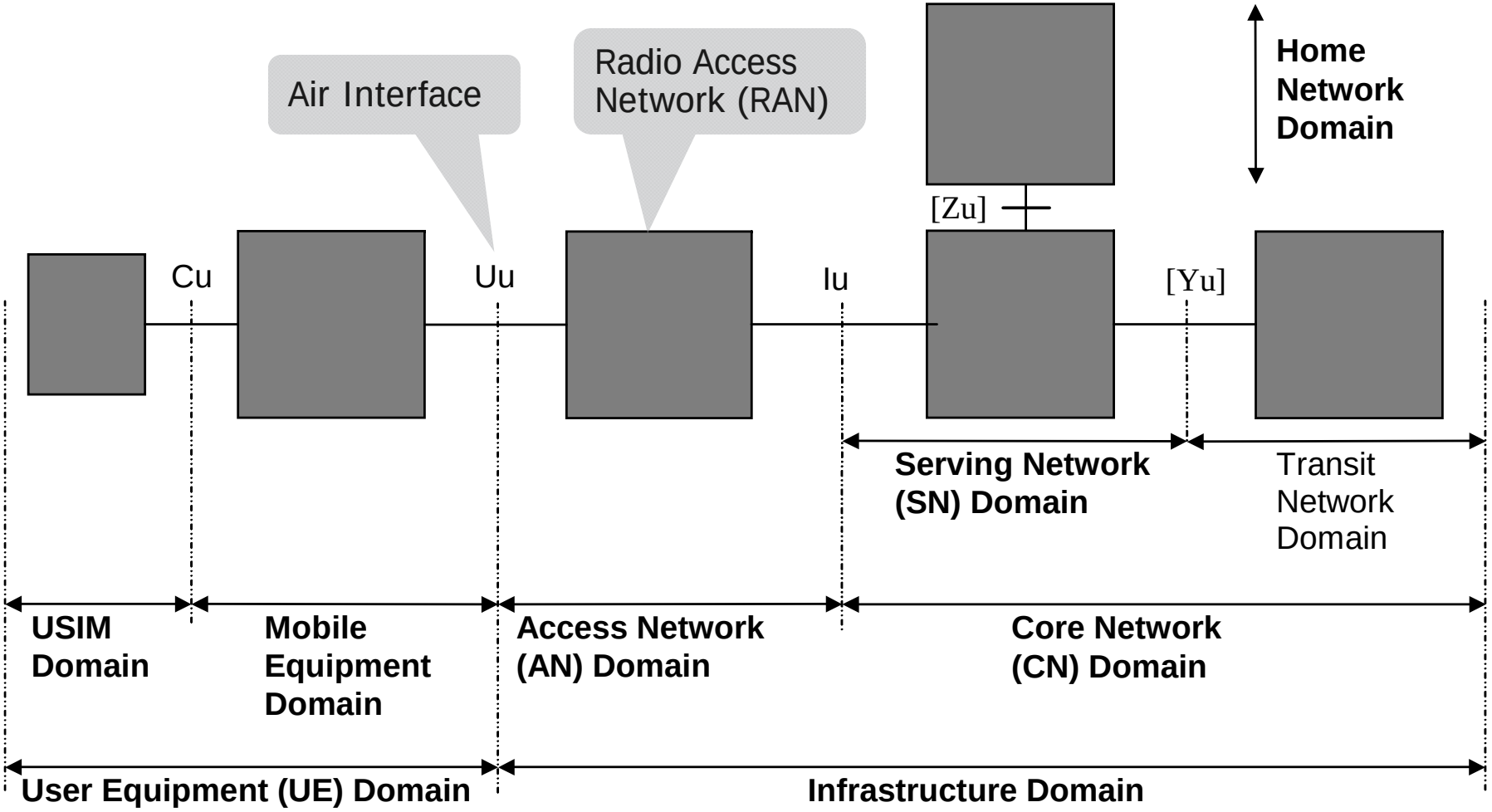
- Keep track of location of MS

Radio Resource Management

- Management of radio resources

UMTS Functional Entities: Domains

Domain: grouping of physical entities of the system



Source: 3GPP 23.101-4.0.0

Functions of the UMTS Domains

Infrastructure domain
- Access network (AN) domain: functions specific to access technique
- Core network (CN) domain: functions independent of access technique

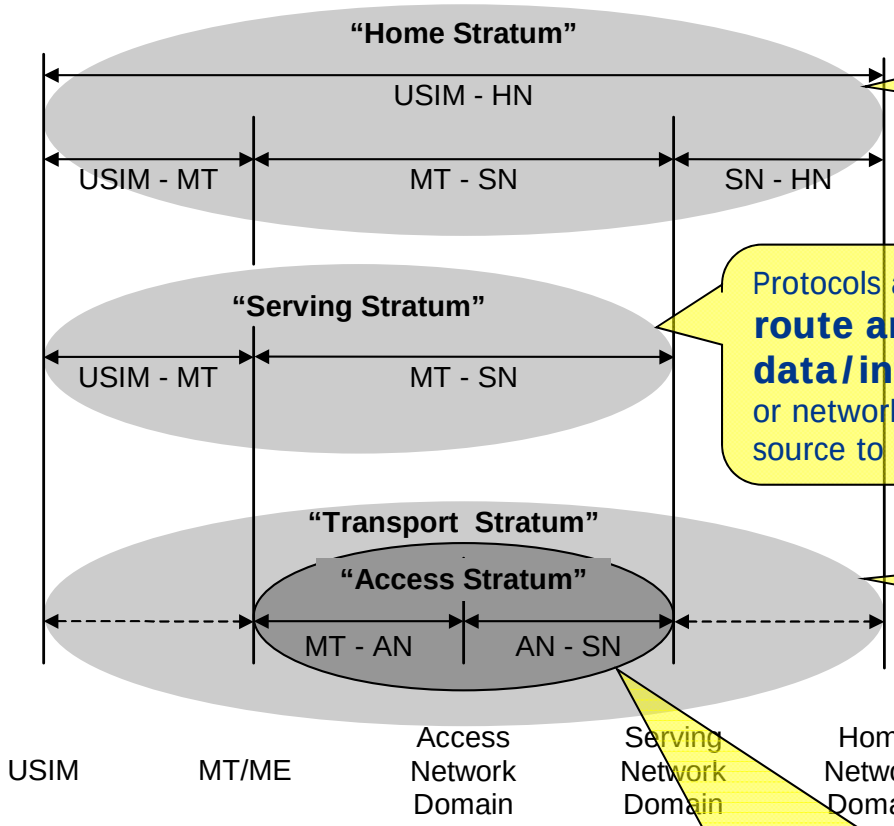
Access network domain
- physical entities managing the resources of the access network
- provides the user with a mechanism to access the core network domain

Serving network (SN) domain
- part of the CN domain to which the AN domain that provides the user's access is currently connected
- responsible for routing calls and transport user data/information from source to destination
- provides CN functions that are local to the user's access point (i.e. SN changes when the user moves)

Home network (HN) domain
- provides CN functions that are conducted at a permanent location regardless of the location of the user's access point (i.e. does not change due to user mobility)
- contains user-specific data and is responsible for management of subscription information
- handle home-specific services, not offered by the serving network domain

User Services Identity Module domain (USIM)
- related to the home network domain by subscription

Functional Communication between UMTS domains



Protocols and functions related to the **handling and storage of subscription data and possibly home network specific services**

- functions related to subscription data management, customer care, including billing and charging, mobility management and authentication
- functions to allow domains other than the home network domain to act on behalf of the home network

Protocols and functions to **route and transmit data / information** (user or network generated) from source to destination

Transport of user data and network control signalling

- error correction and recovery
- encrypt data over the radio interface and in the infrastructure part
- adaptation of data to use the supported physical format
- transcoding of data to make efficient use of, e.g. the radio interface

Parts of infrastructure, user equipment and protocols specific to the access technique

- provides services related to the **transmission of data over the radio interface and the management of the radio interface**

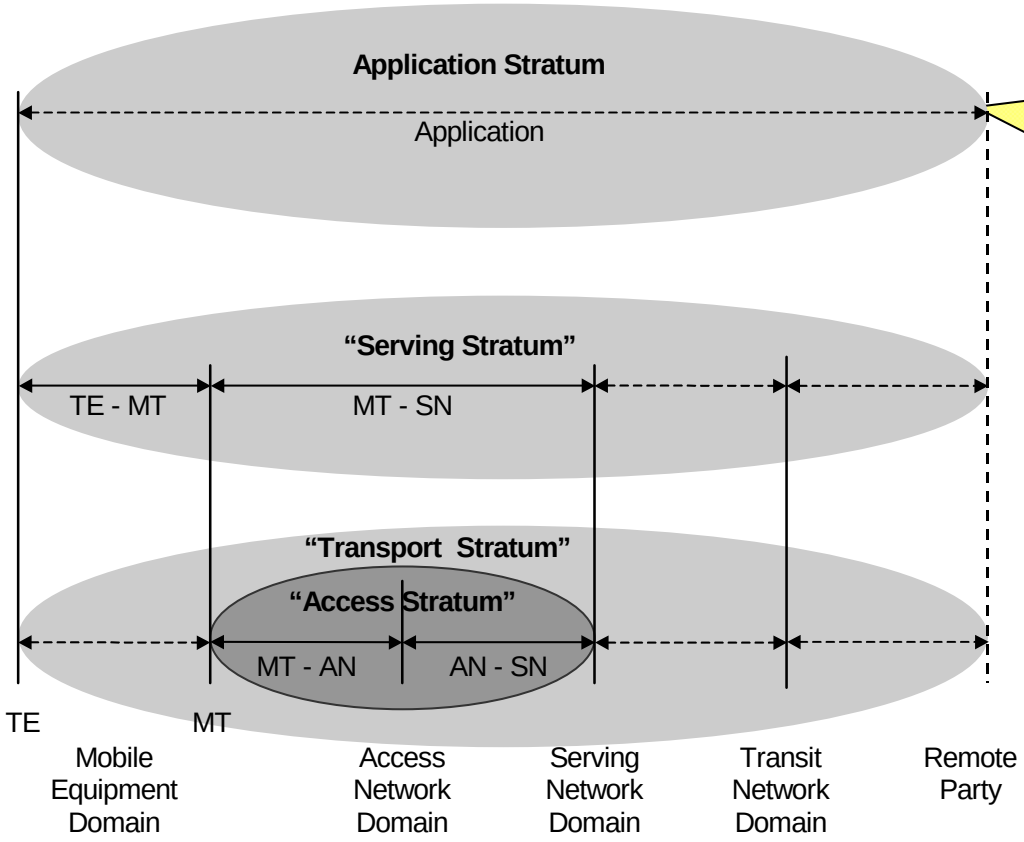
Strata concept:

- grouping of functions
- grouping of respective protocols

Source: 3GPP 23.101-4.0.0

ow1

Functional Communication between UMTS domains



End-to-end protocols and functions which make use of services provided by the home, serving and transport strata and infrastructure to support services and/or value added services.

The functions and protocols within the application stratum may adhere to GSM/UMTS standards such as MExE or may be outside the scope of the UMTS standards.

Source: 3GPP 23.101-4.0.0

ow1 Hier ist das Serving Stratum seltsam!

Oliver Waldhorst; 17.10.2011

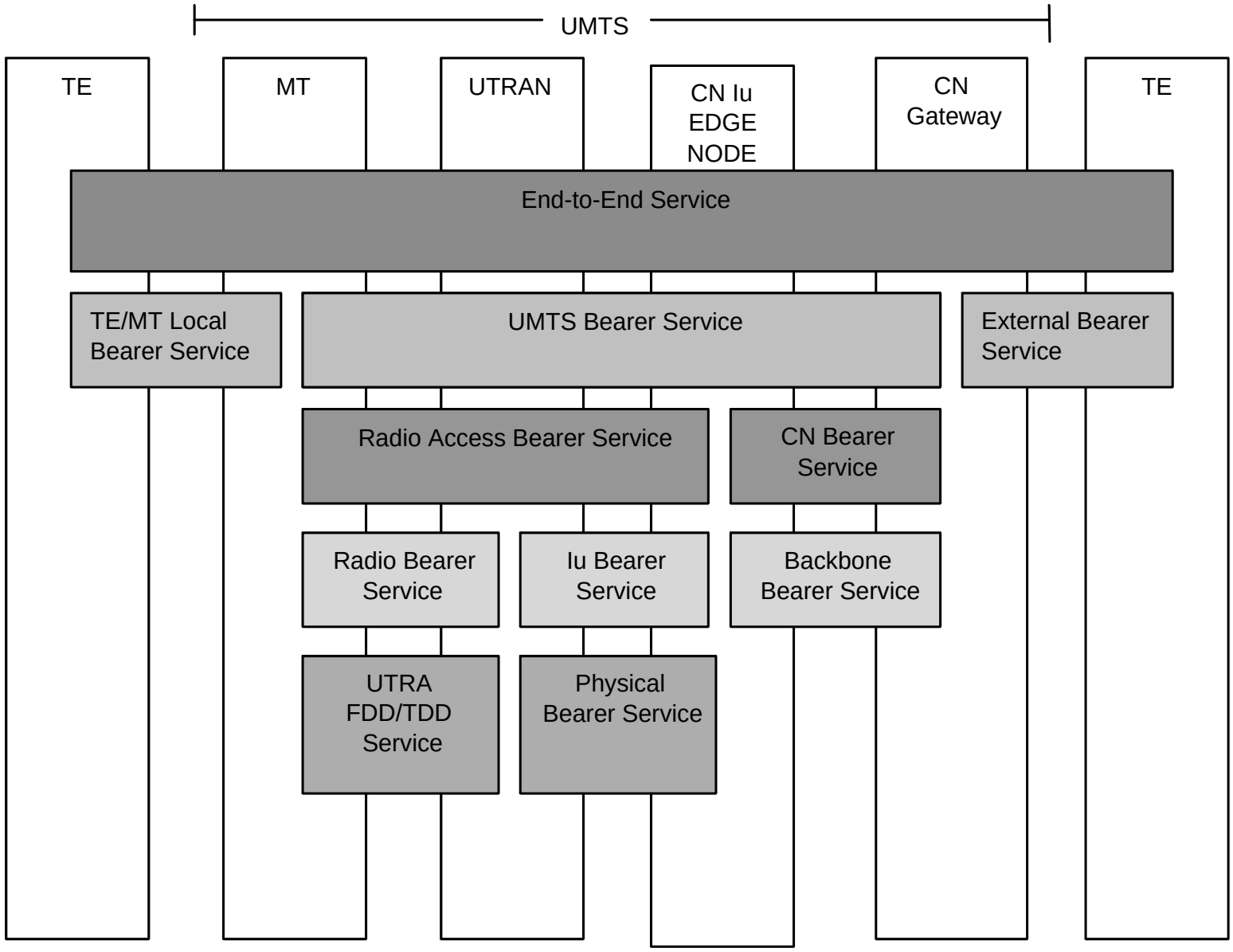
UMTS Protocol Architecture

We will focus on the packet switched mode here

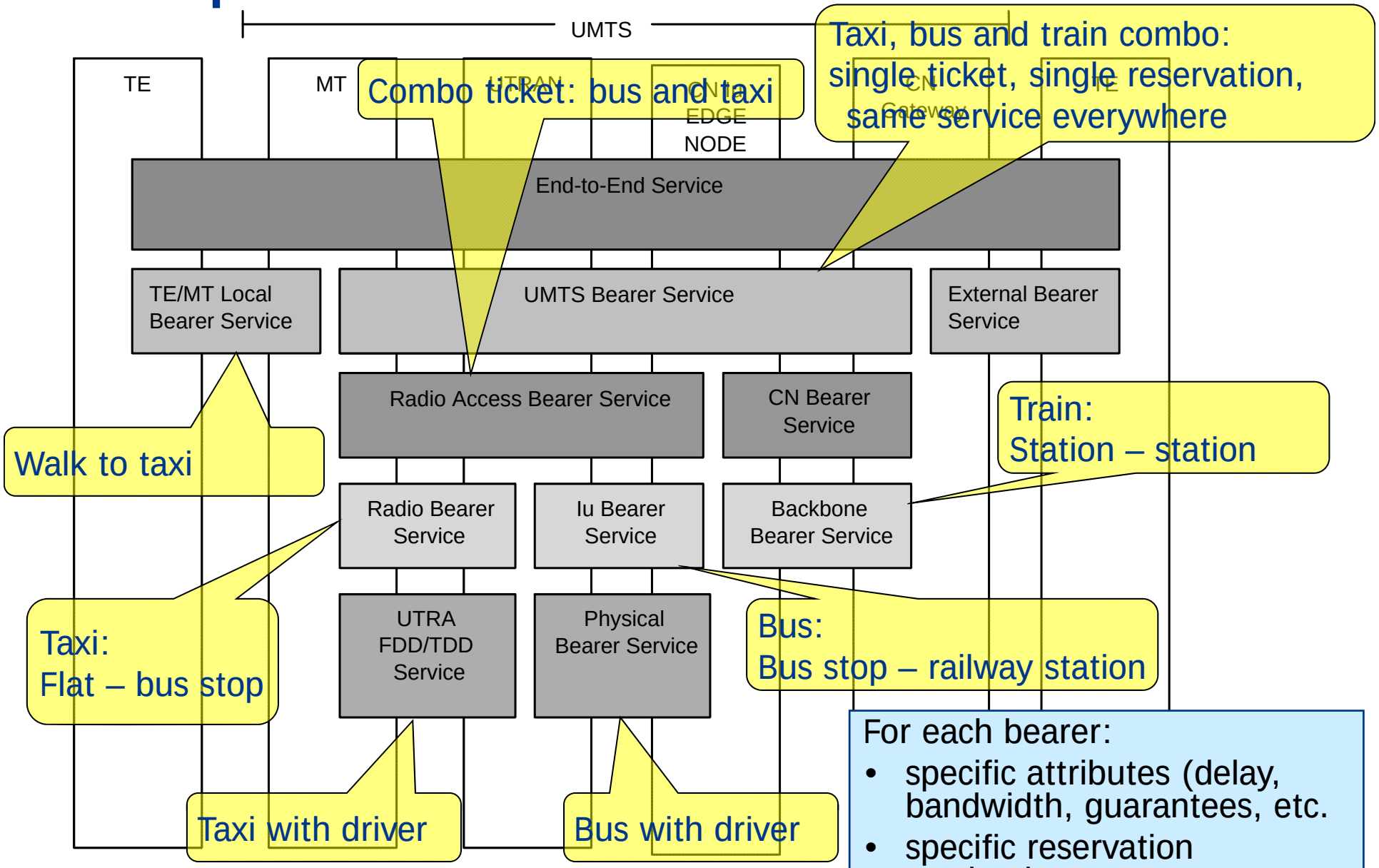
References:

- Kaaranen, Ahtiainen, Laitinen, Naghian, Niemi: UMTS Networks – Architecture, Mobility and Services. Wiley 2001, Ch. 5.1
- Walke, et al: UMTS – ein Kurs, Ch. 5 (air interface only)
- 3G TS 23.060: GPRS, Service Description

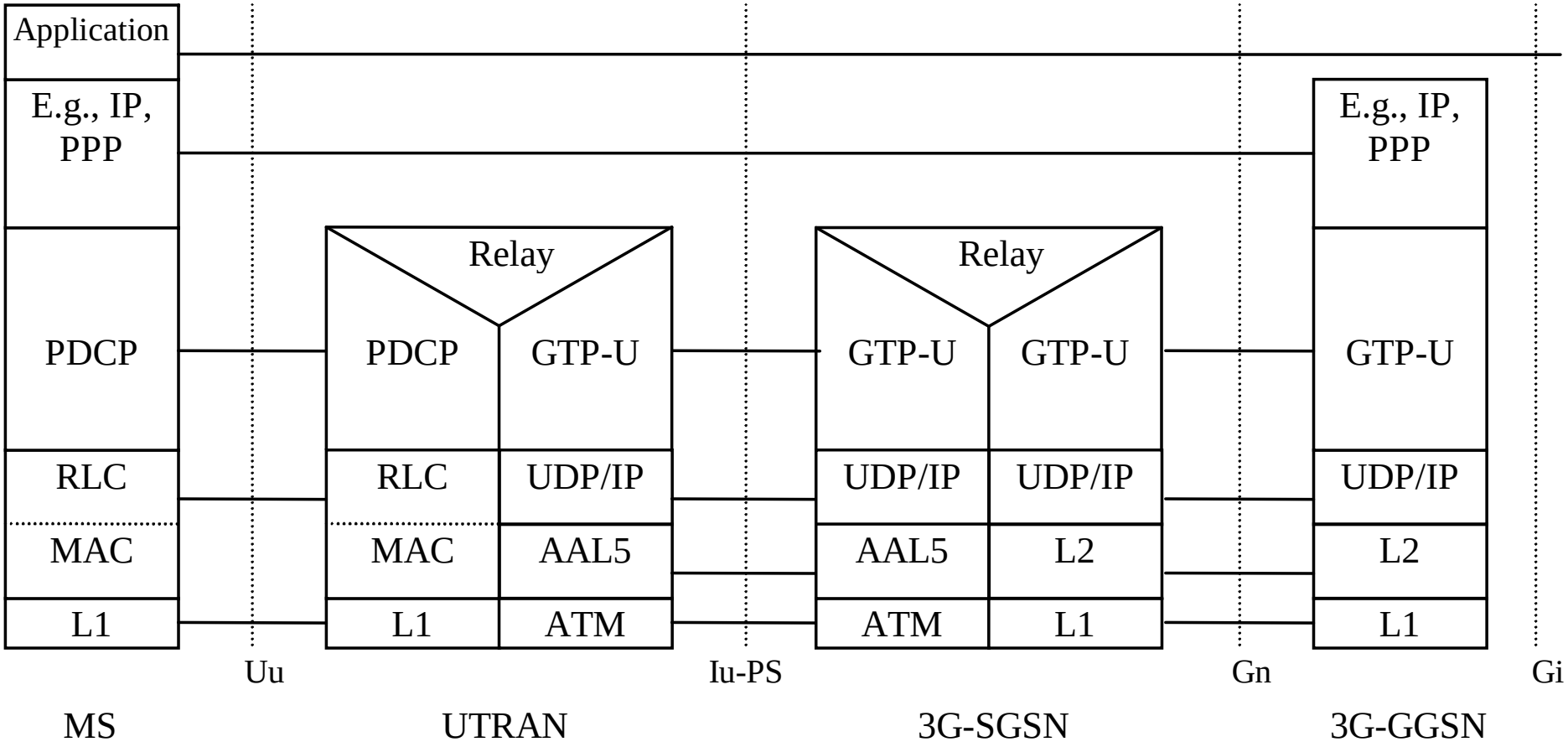
User Plane Bearer Services – Overview



Bearer Services – Analogy with Public Transportation

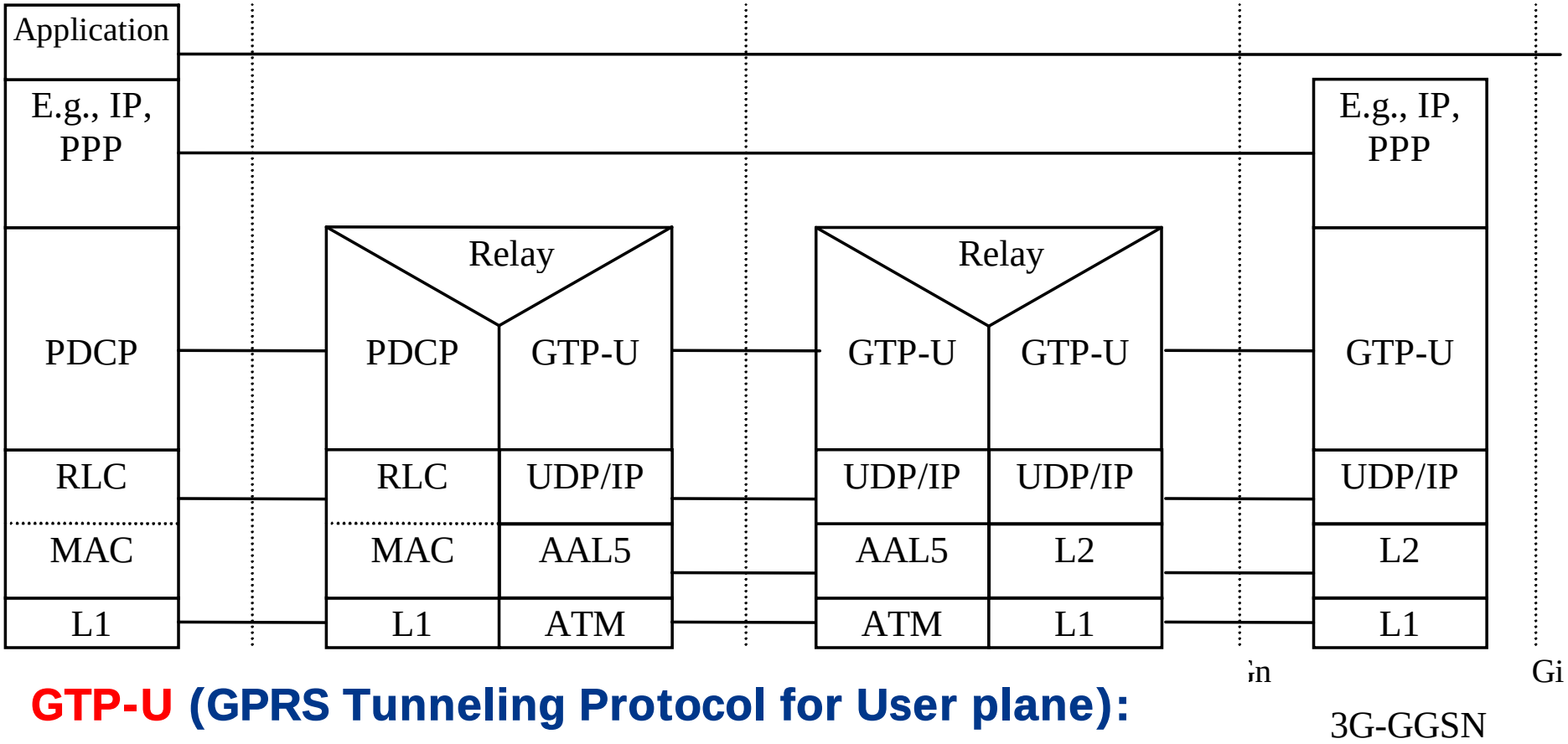


MS-RNS-SGSN-GGSN – User Plane



Source: 3GPP 23.060-4.1.0

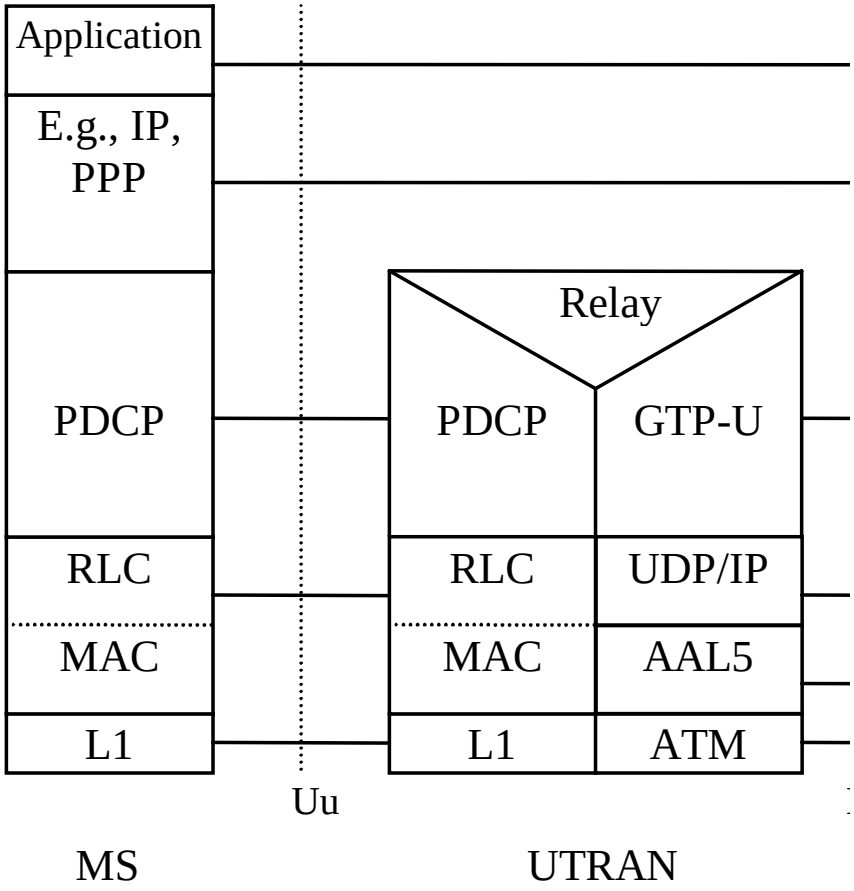
MS-RNS-SGSN-GGSN – User Plane



GTP-U (GPRS Tunneling Protocol for User plane):

- tunneling of user data between UTRAN and the 3G-SGSN
- tunneling between the GSNs in the backbone network
- encapsulation of all PDP PDUs

MS-RNS-SGSN-GGSN – User Plane

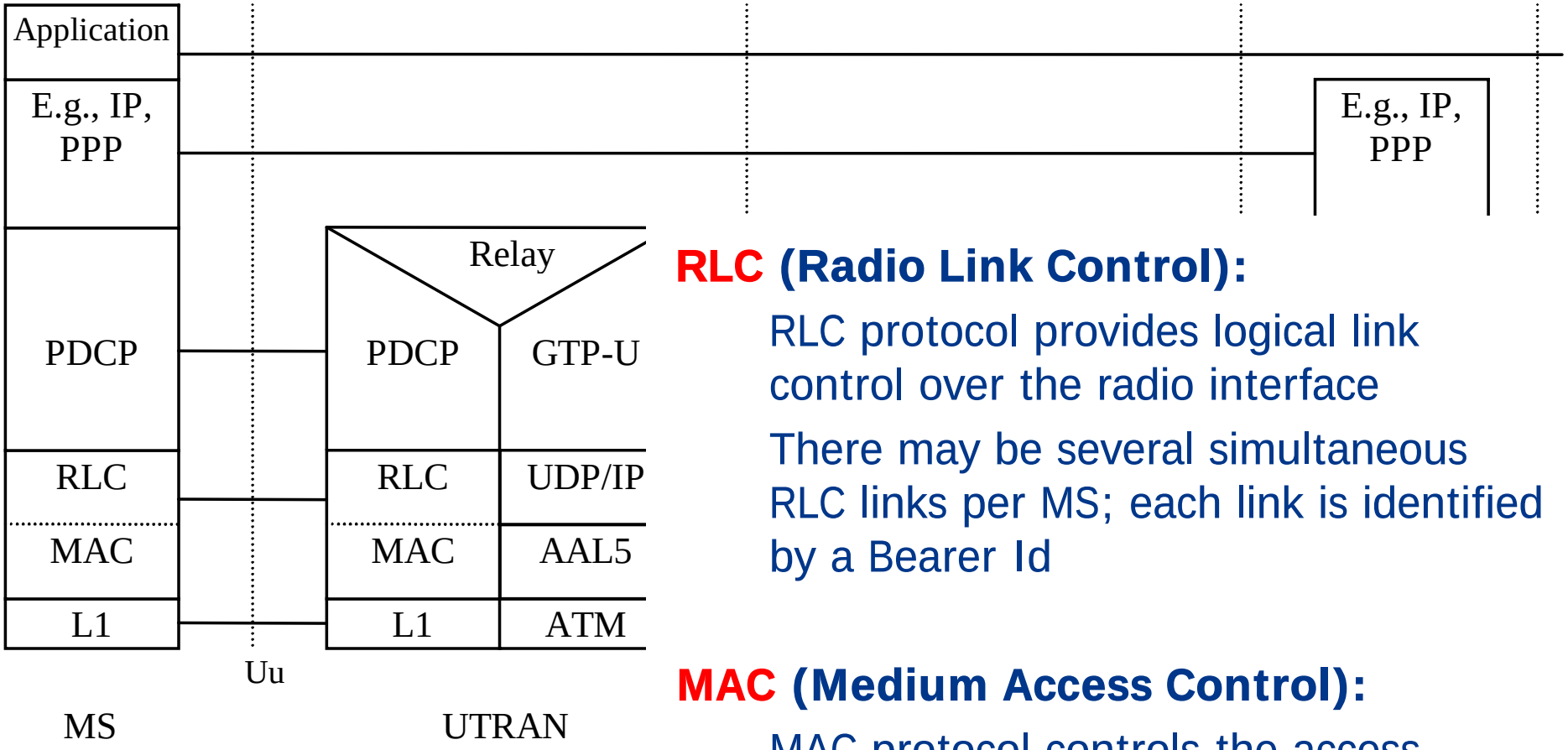


PDCP (Packet Data Convergence Protocol):

- provides protocol transparency (wrt the underlying radio-interface protocols) for higher-layer protocols
- support for e.g., IPv4, PPP and IPv6 (easy introduction of new higher-layer protocols)
- compression of control information (header compression)
- no user data compression in Iu mode (because the data compression efficiency depends on the type of user data)

Source: 3GPP 23.060-4.1.0

MS-RNS-SGSN-GGSN – User Plane



RLC (Radio Link Control):

RLC protocol provides logical link control over the radio interface

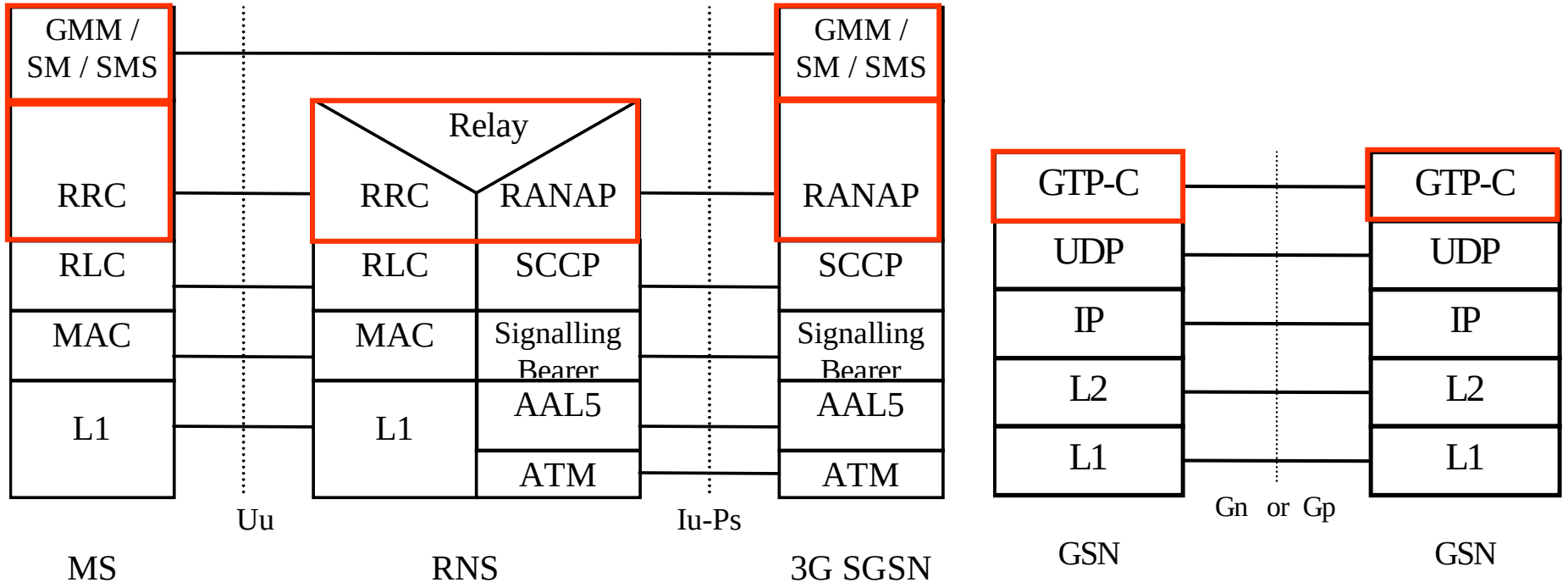
There may be several simultaneous RLC links per MS; each link is identified by a Bearer Id

MAC (Medium Access Control):

MAC protocol controls the access signaling (request and grant) procedures for the radio channel

Source: 3GPP 23.060-4.1.0

MS-RNS-SGSN-GGSN – Control Plane



MS-RNS-SGSN – Control Plane

GMM (GPRS Mobility Management):

- GMM supports mobility management functionality such as attach, detach, security, and routing area update

SM (Session Management):

- SM supports PDP context activation and deactivation

SMS supports short message service

GTP-C (GPRS Tunneling Protocol for Control plane):

- establish, manage and release GTP tunnels

RANAP (Radio Access Network Application Protocol):

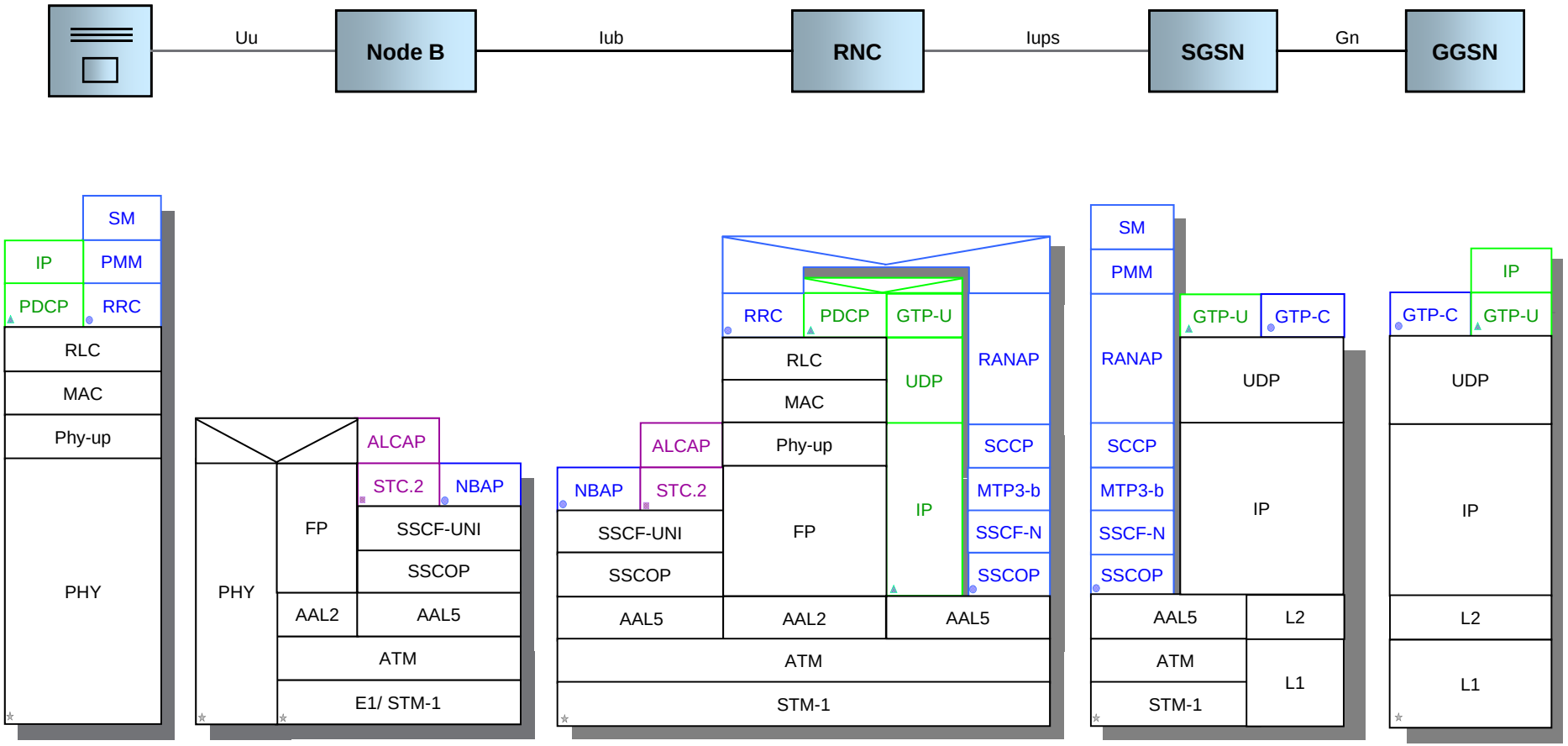
- transport of higher-layer signalling
- handling of signalling between the 3G-SGSN and UTRAN
- management of the GTP connections on the Iu interface

RRC (Radio Resource Control):

- Information Broadcast (AS and NAS)
- RRC connection management (setup, release, reconfiguration)
- Radio Bearers management (setup, release, reconfiguration)
- Management of radio resources for the RRC connection
- RRC connection mobility functions
- Paging/notification

Source: 3GPP 23.060-4.1.0

UMTS Protocol Architecture: The Complete Picture (Packet Switched)



UMTS Protocol Architecture: The Complete Picture (Circuit Switched)