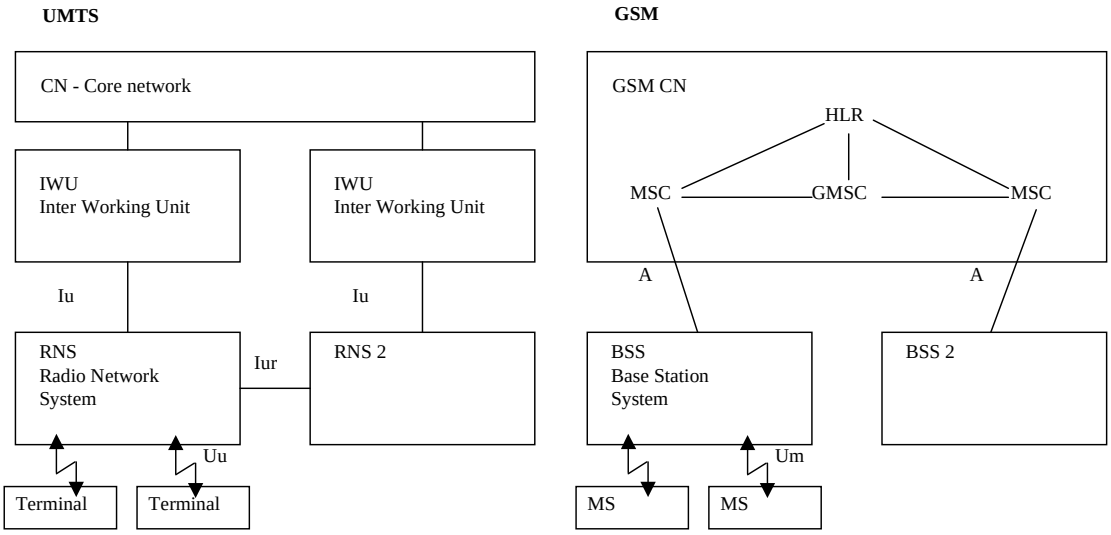
´2 System Introduction

Objectives:
After this chapter the student will: • be able to understand the UMTS system architecture.

2.1 Nodes and Architecture

UMTS System Architecture



UMTS Architecture

Terminal

UMTS data rates will exceed those of GSM. Shifting from GSM to UMTS will result in a new generation of terminals with enhanced user interfaces and vastly increased functionality.

The terminal encompasses a variety of equipment types with different levels of functionality. These equipment types are referred to as user equipment (terminals), and they may also be compatible with one or more existing access interfaces e.g. dual mode UMTS-GSM user equipment. The user equipment may include a removable smart card that may be used in different user equipment types.

The user equipment is further sub-divided in to the Mobile Equipment (ME) and the User Services Identity Module (USIM).

Mobile Equipment

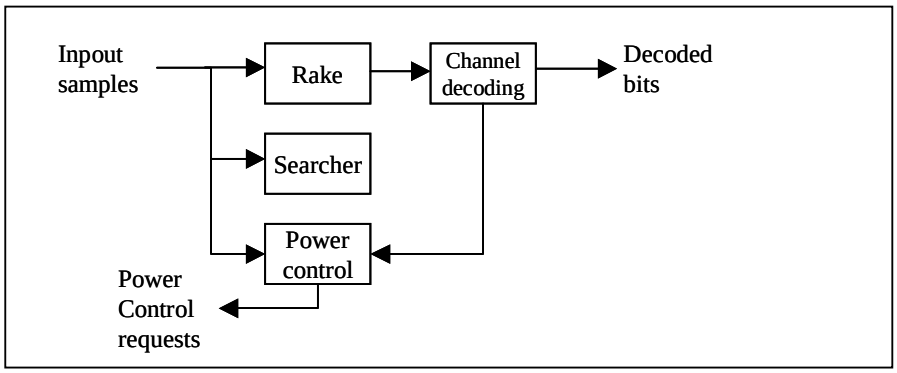
The Mobile Equipment performs radio transmission and contains applications. The mobile equipment may be further sub-divided into several entities, e.g. the one which performs the radio transmission and related functions, Mobile Termination, MT, and the one which contains the end-to-end application or (e.g. laptop connected to a mobile phone), Terminal Equipment**,** TE. No reference point is defined in this specification.

USIM

The USIM contains data and procedures that unambiguously and securely identify itself. These functions are typically embedded in a stand-alone smart card. This device is associated to a given user, and as such allows identifying this user regardless of the ME he uses.

Inside the UMTS terminals Rake reception is used to generate soft decisions that are fed into the channel decoder. As well as decoding the received bits the channel decoding helps set the target for the power control, which if poorly implemented could decimate network capacity. The searcher identifies the radio wave echoes and detects other basestations for inclusion in macro diversity.

UTRA-FDD Terminal Receiver



Receiver Algorithm

Rake Receiver:
Once acquisition has been achieved the rake receiver uses information about the radio wave echoes – generated by the searcher – to mitigate the echo corruption. The UTRA scrambling codes enables the rake receiver to extract separate echoes from the received signal. Not only is it possible to perform the demodulation on an echo free signal but also, once separated, the individual echoes may be added coherently. Because each echo will be suffering from some fast fading, and this fading will be independent from echo to echo, coherently combining the echoes statistically improves the overall performance. This is known as micro-diversity. In macro-diversity (soft handover) the rake functions in a similar way except the different echoes come from different basestations.

Searcher:
The scrambling codes and the primary and secondary synchronisation channels may be used by the searcher to determine the offset and magnitude of the echoes and the strengths of other basestastions. The primary synchronisation channels are used initially to identify the strength of surrounding basestations. The secondary synchronisation channel is then used to identify the specific basestation and the scrambling code group employed there. Once the scrambling code is known the searcher identifies separate echoes from the scrambled pilot symbols. The echo

profile is highly correlated from one power control period to the next. This can be exploited in the searcher to reduce its complexity.

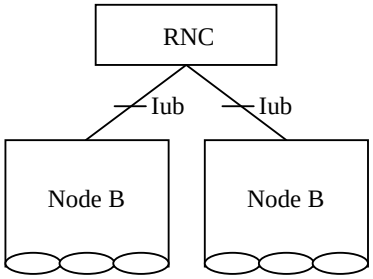
Power Control:
Down link interference is reduced by minimising the basestation transmission power for a particular user so the link performance – throughput and error rate – are only just achieved. The mobile requests basestation transmission power changes every power control period (0.625 ms) with intent to drive the signal to noise interference ratio at the mobile to a target value. The signal to noise interference ratio target is re-evaluated e.g. every 10 ms depending on the channel decoding status.

Channel Decoding:
As well as supporting a more powerful version of the convolutional channel decoding used in GSM, UMTS terminals are likely to employ high performance turbo decoders.

Radio Network System, RNS

Access Network
The Access Network consists of the physical entities that manage the resources of the access network and provides the user with a mechanism to access the core network.

RNS Architecture
A RNS consists of a Radio Network Controller and one or more entities currently called Node. Node B is connected to the RNC through the Iub interface.

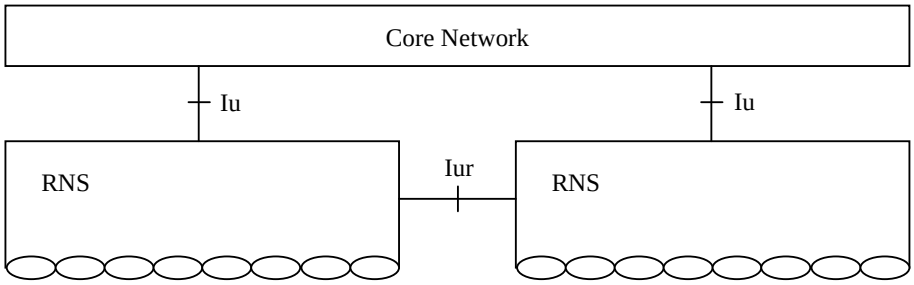


RNS Architecture

Radio Network Controller, RNC
The RNC is responsible for the Handover decisions that require signalling to the UE. The RNC comprises a combining/splitting function to support macro diversity between different Node B.

Node B
Node B can comprise an optional combining/splitting function to support macro diversity inside a Node B.

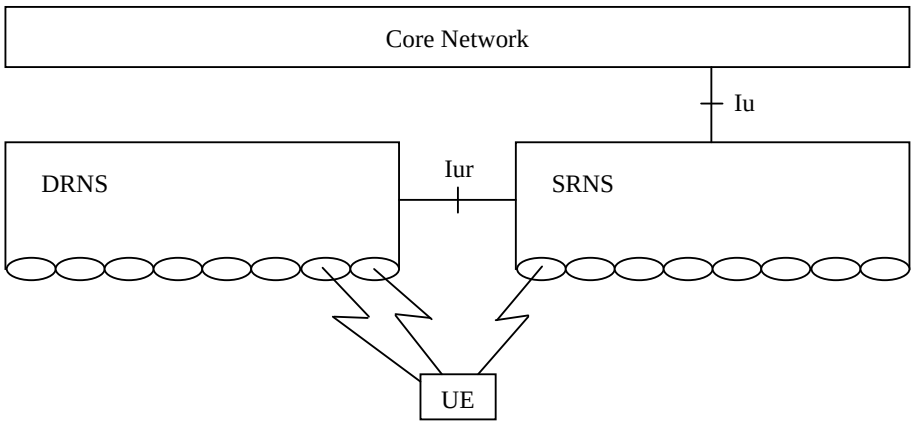
The UTRAN, UMTS Terrestrial Radio Access Network, consists of a set of Radio Network Subsystems connected to the Core Network through the Iu and interconnected together through the Iur.



UTRAN Architecture

Each RNS is responsible for the resources of its set of cells.

For each connection between User Equipment and the UTRAN, one RNS is the Serving RNS. When required, Drift RNSs support the Serving RNS by providing radio resources. The role of an RNS (Serving or Drift) is on a per connection basis between a UE and the UTRAN.



Serving and Drift RNS

Inter Working Function, IWF

The IWF adapts the Iu interface towards the Core Network, CN. It is a logical unit that will support the connection between different CN with different protocols to one Iu interface.

Core Network, CN

The Core Network Domain consists of the physical entities that provide support for the network features and telecommunication services. The support provided includes functionality such as the management of user location information, control of network features and services, the transfer

(switching and transmission) mechanisms for signalling and for user generated information.

The CN should in the beginning be able to handle circuit switched data < 64 kbit/s, packet data < 2 Mbit/s, handle different quality of service parameters such as maximum delay and variable bandwidth, support of VHE.

The core network is sub-divided into the Serving Network, the Home Network and the Transit Network. Additional sub-divisions and reference points within the core network may be identified in other specifications.

Serving Network
The serving network is the part of the core network to which the access network that provides the user's access is connected. It represents the core network functions that are local to the user's access point. The serving network is responsible for routing calls and transport user data/information from source to destination.

Home Network
The home network represents the core network functions that are conducted at a permanent location regardless of the location of the user's access point.

The USIM is related by subscription to the home network. The home network therefore contains at least permanently user specific data and is responsible for management of subscription information.

Transit Network
The transit network is the core network part located on the communication path between the serving network (or home network) and the remote party.

UMTS Mobility Management

From a logical point of view, the CN encompasses two domains, a PSTN/ISDN domain and an IP domain. It shall be possible to connect the UTRAN either to both these CN or to one of the CN domains.

UMTS shall support compatibility with GSM network from the point of view of roaming and handover. This implies that IMSI, International Mobile Subscriber Identity, shall be used as the common user identity in the two CN.

Common MAP signalling will be applied to both GSM and UMTS. The GSM MAP mobile service operations shall be evolved and re-used as fast as possible.

Radio network parameters and radio resource management should be isolated in the UTRAN.

The Core Network consists of two service domains, a Circuit Switched service domain (PSTN/ISDN) and a Packet Switched service domain (IP). Each service domain has its own service state machine. A terminal that is supporting both CS and PS services, has a CS service state machine and a PS service state machine. The two peers of the service state machine are working independently to each other, although associated to the same terminal (or UE). The UE-CN signalling aims to keep the peer entities synchronised.

The aim of UTRAN is to offer one unified set of radio bearers which may be used for bursty packet traffic and for traditional telephony traffic. The radio resource handling is UTRAN internal functionality and the CN does not define the type of radio resource allocated.

When the terminal is powered on and an initial connection has been set up the radio resource control has two modes, Connected mode and Idle mode. The different modes describes which identity is used to identify the UE. In Idle mode the UE is identified by a CN associated identity. In Connected mode the UE is assigned a Radio Network Temporary Identity to be used as UE identity on common transport channels. When the UE is allocated dedicated transport channels, it uses the inherent addressing (code and frequency) provided by these transport channels.

For the mobility functionality, four different area concepts are used. Location Areas (related to CS services) and Routing Areas (related to PS services) are used in the Core Network. UTRAN Registration Areas and Cell Areas are used in UTRAN.

Location Area for CS services: one Location Area is handled by the CN. This means that the terminal (UE) is registered in the CN node responsible for handling this specific location area. The LA is used by the 3G_MSC/VLR for paging the terminal.

Routing Area for PS services: one Routing Area is handled by the CN. This means that the terminal (UE) is registered in the CN node responsible for handling this specific routing area. RA is used by the 3G_SGSN for paging the terminal.

UTRAN Registration Areas and Cell Areas are only visible in UTRAN and used in connected mode. UTRAN internal areas are used when the terminal is in connected mode. The areas are used at e.g. UTRAN initiated paging. UTRAN internal area updating is a radio network procedure and the UTRAN internal area structure should not be visible outside UTRAN. In connected mode, the UE position is known on cell level or on UTRAN Registration Area (URA) level.

For the relation between LA and RA it shall be possible for the operator to have a LA and a RA equal (same cell) or a RA as part of a LA, or a LA as a part of RA, and LA and RA independently. If an area consists of both UMTS cells and GSM cells the GSM defined relation shall apply.

In idle mode it is the broadcasted system information, e.g. information about the present LA and RA) that determines when the UE initiates a location registration procedure towards the CN. An CS-IDLE terminal will initiate Location Update towards the CN when crossing LA border. An PS-IDLE terminal will initiate Routing Area update towards the CN when crossing RA border.

In connected mode, the UE receives the system information on the established connection. A UE in CS-IDLE will in connected mode initiate Location Area update towards the CN when receiving information about a new LA. A UE in PS-IDLE will in connected mode initiate Routing Area update towards the CN when receiving information about new RA.

A UE in CS-CONNECTED mode will *not* initiate Location Area update and a UE in PS-CONNECTED mode will *not* initiate Routing Area update towards CN.

The use of separated PS and CS mobility mechanisms within the UE and within the CN may lead to non-optimal usage of the radio resource. To avoid this the use of combined updates may be used. It should be possible to use combined mechanisms for location management purposes as well as for attach/detach status purposes.

UMTS Phase 1 R99 terminals should support the use of both combined and separate mechanisms.

In the UMTS specifications the radio access network will not co-ordinate mobility management procedures that are logically between the CN and the Terminal. This includes location management, authentication, temporary identity management and equipment identity check.