Mobile Computing
Lecture 14
Digital Mobile Phone Systems 7

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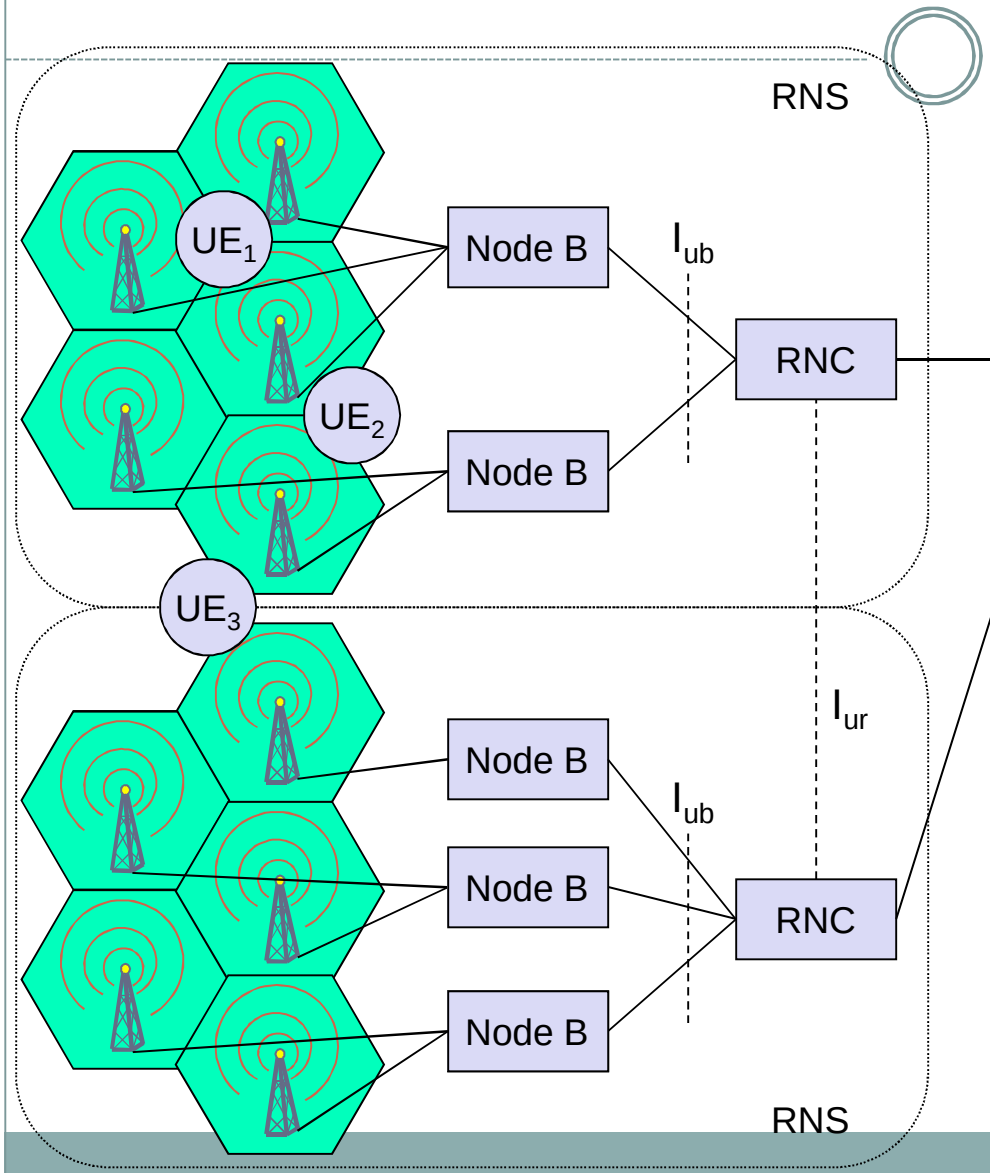
- Early 3G networks
- Some current GSM enhancements
- Some current UMTS enhancements

UTRAN architecture



RNC: Radio Network Controller

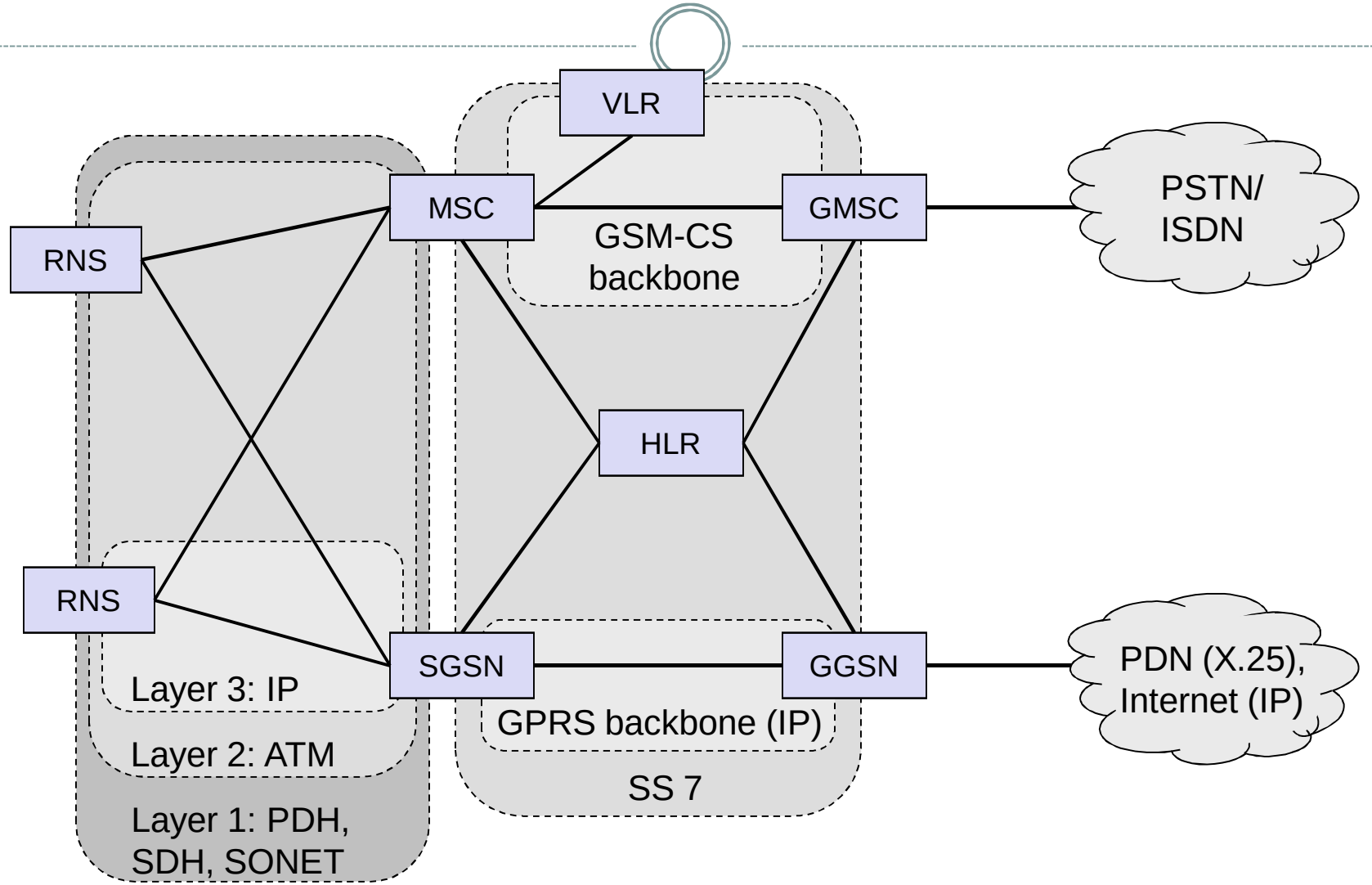
RNS: Radio Network Subsystem

- UTRAN comprises several RNSs
- Node B can support FDD or TDD or both
- RNC is responsible for handover decisions requiring signaling to the UE
- Cell offers FDD or TDD

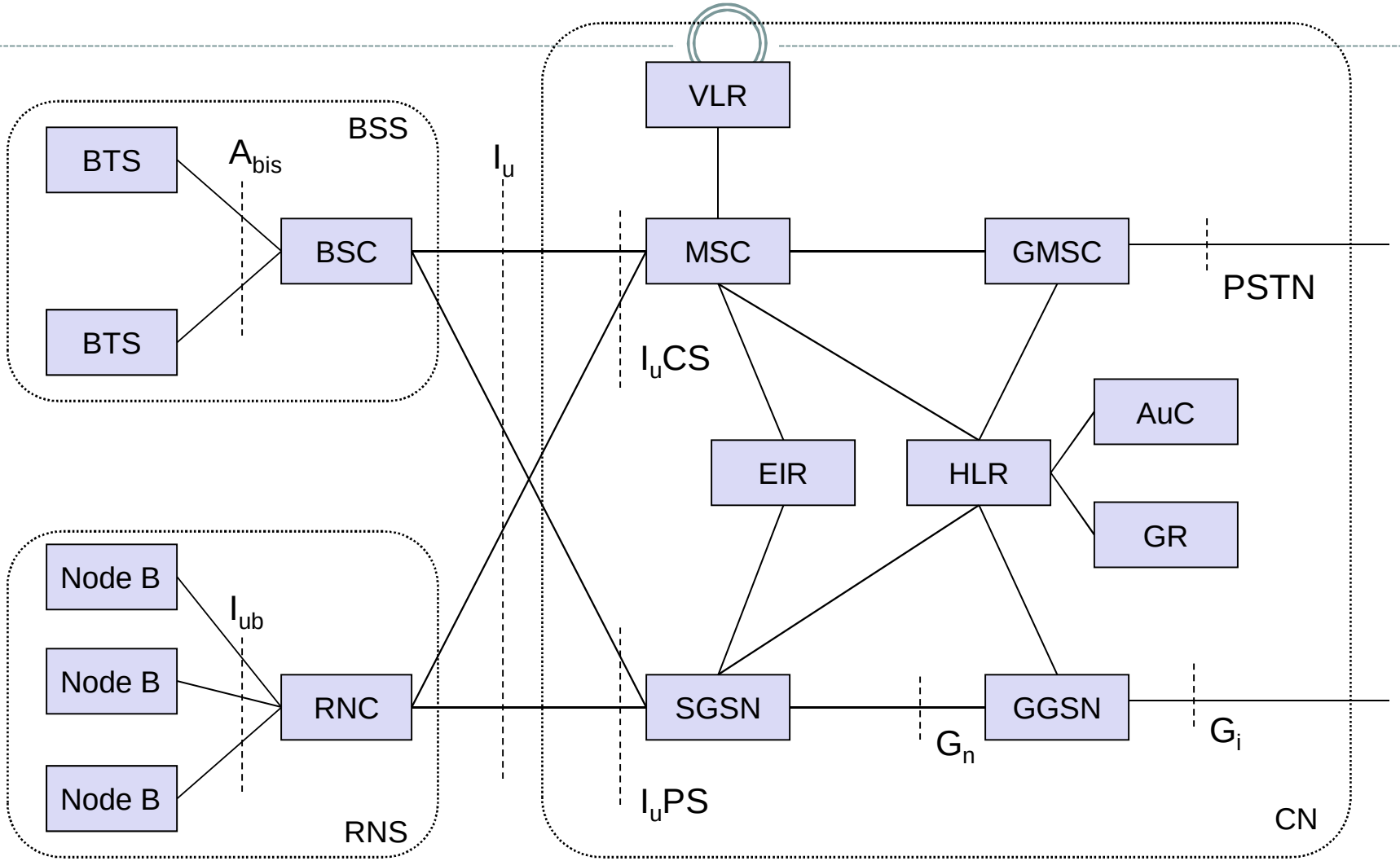
UTRAN functions

- Admission control
- Congestion control
- System information broadcasting
- Radio channel encryption
- Handover
- SRNS moving
- Radio network configuration
- Channel quality measurements
- Macro diversity
- Radio carrier control
- Radio resource control
- Data transmission over the radio interface
- Outer loop power control (FDD and TDD)
- Channel coding
- Access control

Core network: protocols



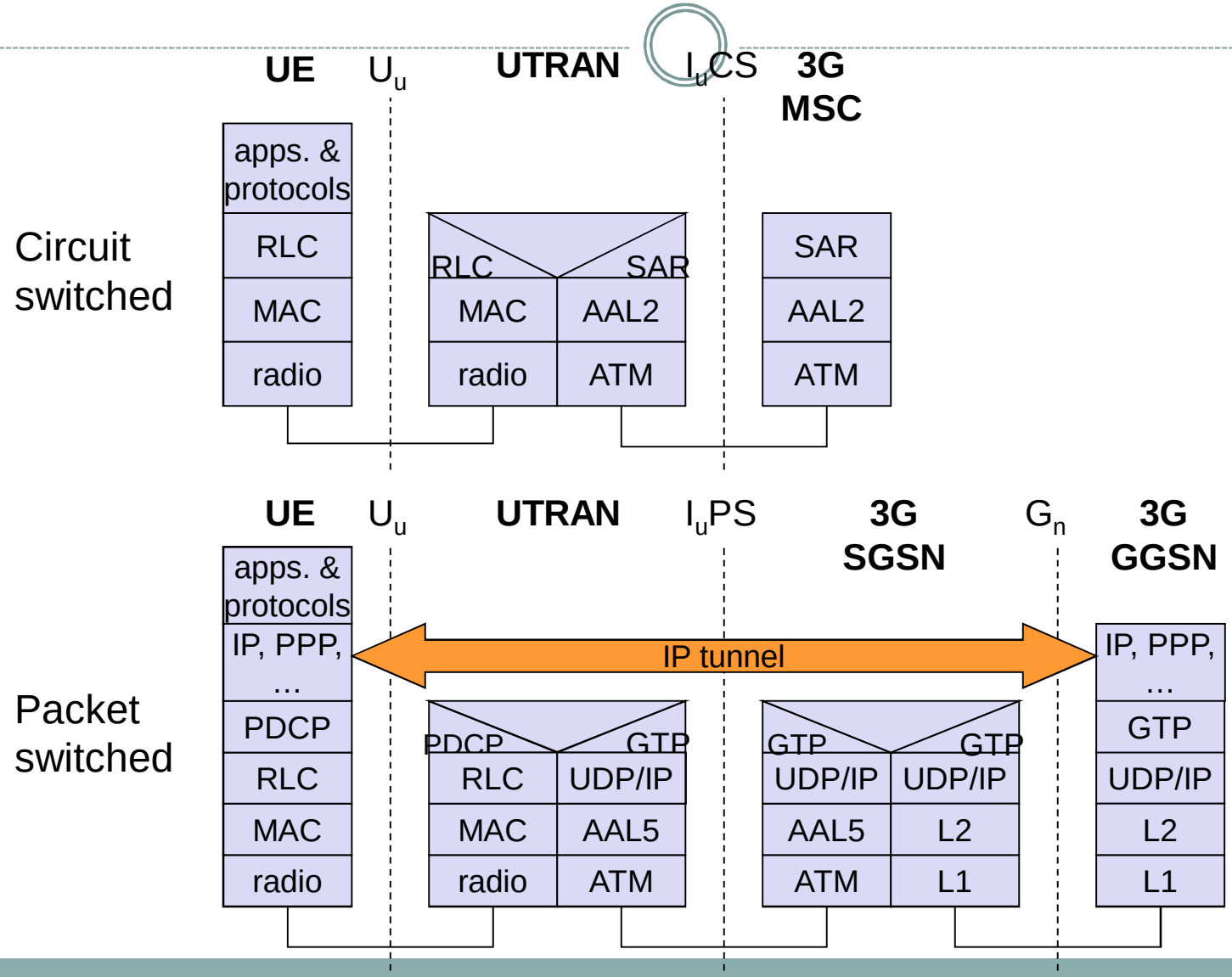
Core network: architecture



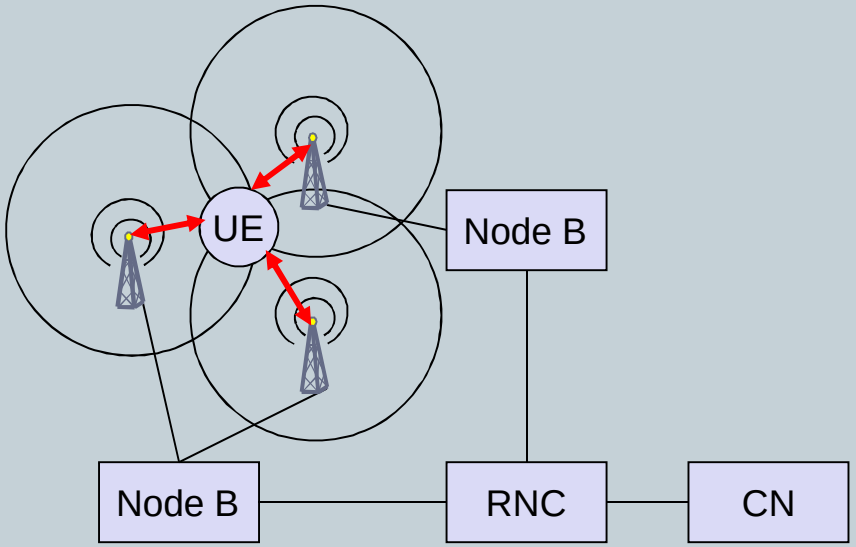
Core network

- The Core Network (CN) and thus the Interface I_u, too, are separated into two logical domains:
- Circuit Switched Domain (CSD)
  - Circuit switched service incl. signaling
  - Resource reservation at connection setup
  - GSM components (MSC, GMSC, VLR)
  - I_uCS
- Packet Switched Domain (PSD)
  - GPRS components (SGSN, GGSN)
  - I_uPS
- Release 99 uses the GSM/GPRS network and adds a new radio access!
  - Helps to save a lot of money ...
  - Much faster deployment
  - Not as flexible as newer releases (5, 6, ... 12)

UMTS protocol stacks (user plane)



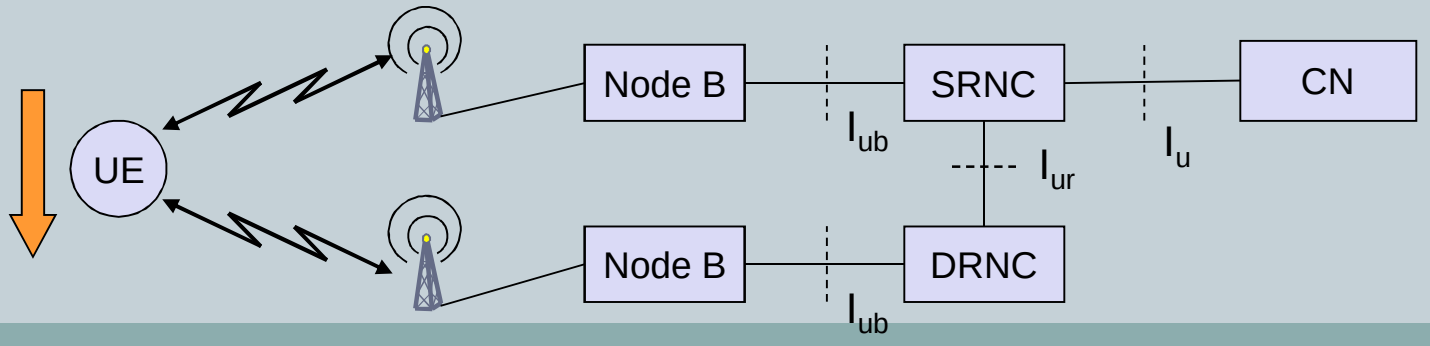
Support of mobility: macro diversity



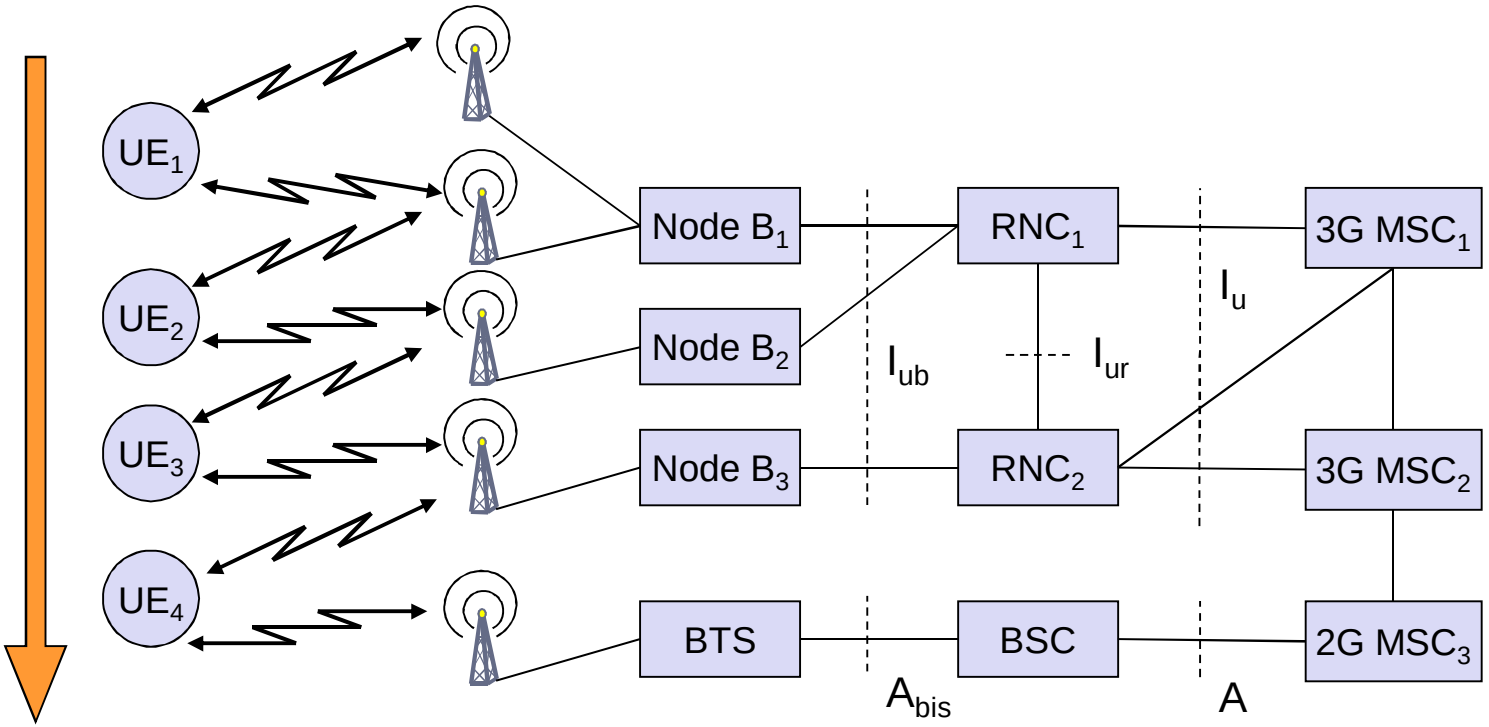
- Multicasting of data via several physical channels
  - Enables soft handover
  - FDD mode only
- Uplink
  - simultaneous reception of UE data at several Node Bs
  - Reconstruction of data at Node B, SRNC or DRNC
- Downlink
  - Simultaneous transmission of data via different cells
  - Different spreading codes in different cells

Support of mobility: handover

- From and to other systems (e.g., UMTS to GSM)
  - This is a must as UMTS coverage will be poor in the beginning
- RNS controlling the connection is called SRNS (Serving RNS)
- RNS offering additional resources (e.g., for soft handover) is called Drift RNS (DRNS)
- End-to-end connections between UE and CN only via I_u at the SRNS
  - Change of SRNS requires change of I_u
  - Initiated by the SRNS
  - Controlled by the RNC and CN



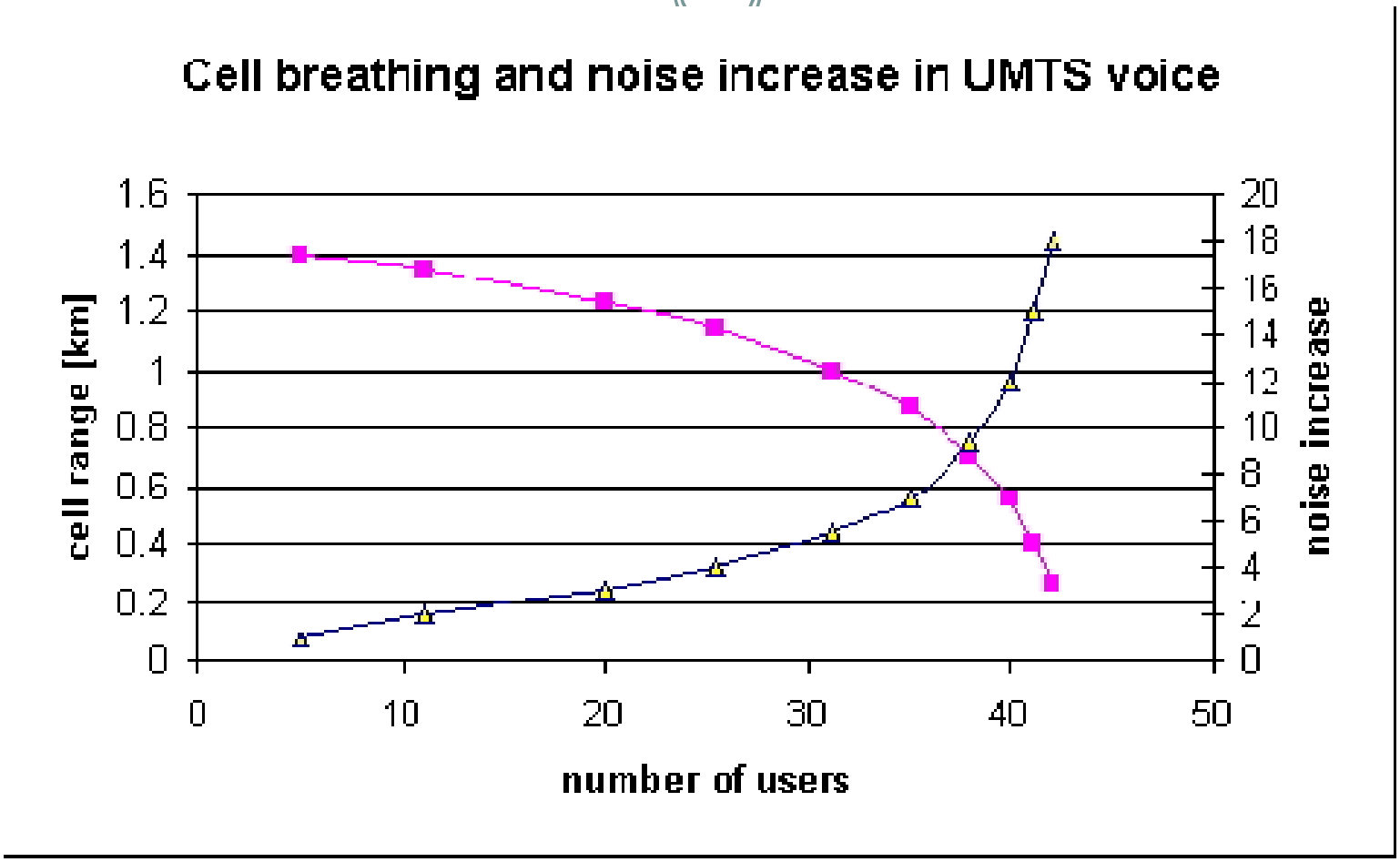
Example handover types in UMTS/GSM



Breathing Cells

- GSM
  - Mobile device gets exclusive signal from the base station
  - Number of devices in a cell does not influence cell size
- UMTS
  - Cell size is closely correlated to the cell capacity
  - Signal-to-nose ratio determines cell capacity
  - Noise is generated by interference from
    - other cells
    - other users of the same cell
  - Interference increases noise level
  - Devices at the edge of a cell cannot further increase their output power (max. power limit) and thus drop out of the cell
    ⇨ no more communication possible
  - Limitation of the max. number of users within a cell required
  - Cell breathing complicates network planning

Breathing Cells: Example



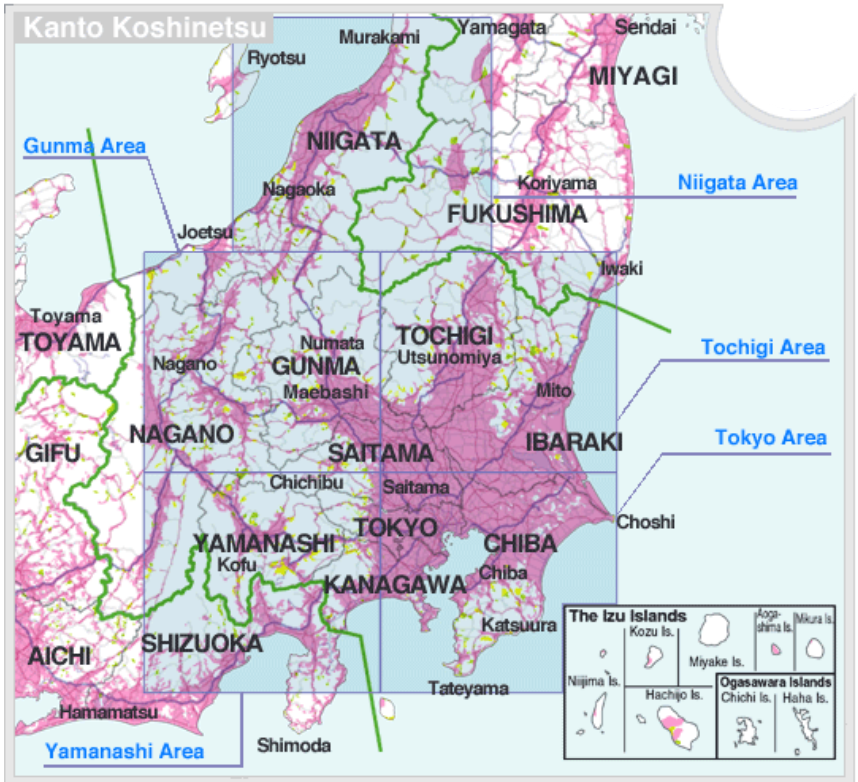
UMTS services (originally)

- Data transmission service profiles

Service Profile	Bandwidth	Transport mode	
High Interactive MM	128 kbit/s	Circuit switched	Bidirectional, video telephone
High MM	2 Mbit/s	Packet switched	Low coverage, max. 6 km/h
Medium MM	384 kbit/s	Circuit switched	asymmetrical, MM, downloads
Switched Data	14.4 kbit/s	Circuit switched	
Simple Messaging	14.4 kbit/s	Packet switched	SMS successor, E-Mail
Voice	16 kbit/s	Circuit switched	

- Virtual Home Environment (VHE)
  - Enables access to personalized data independent of location, access network, and device
  - Network operators may offer new services without changing the network
  - Service providers may offer services based on components which allow the automatic adaptation to new networks and devices
  - Integration of existing IN services

Early 3G Networks: Japan



FOMA (Freedom Of Mobile multimedia Access) in Japan

With Videophone you can enjoy conversations while facing each other.

Examples for FOMA phones

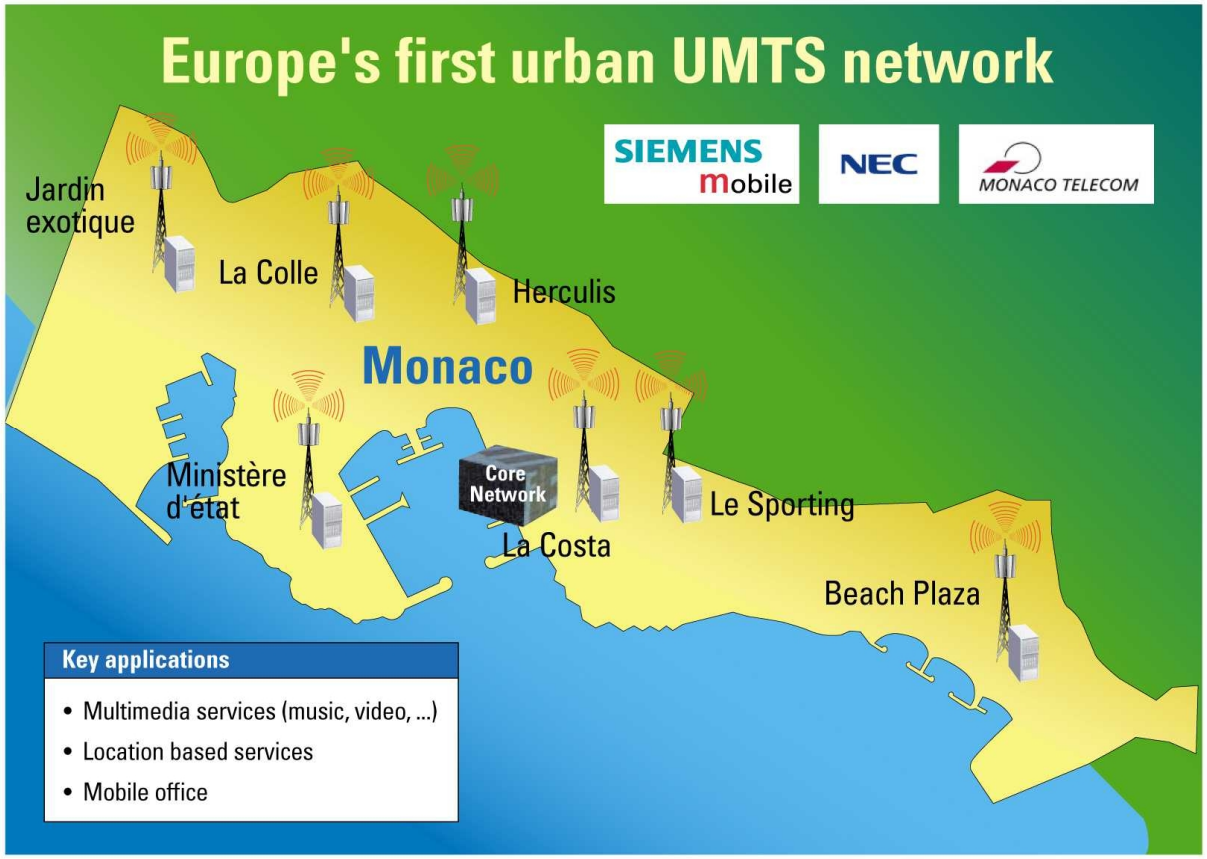
Early 3G networks: Australia

cdma2000 1xEV-DO in Melbourne/Australia

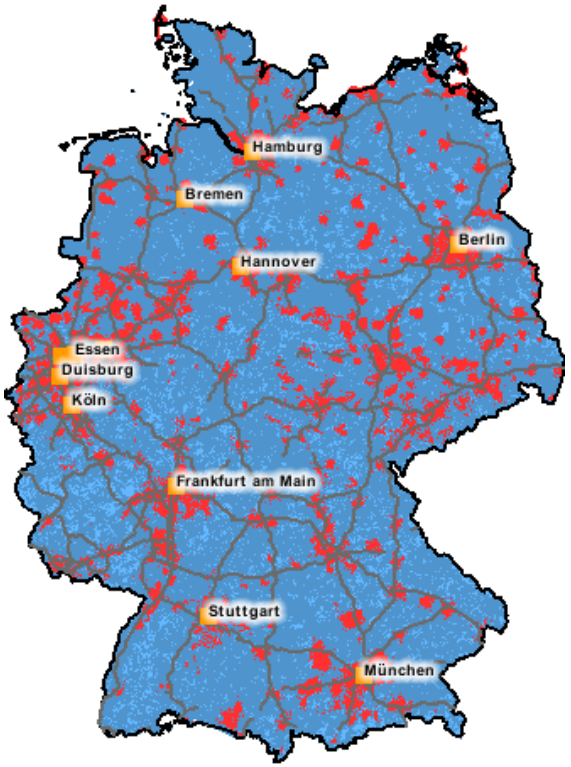
Examples for 1xEV-DO devices

Isle of Man – Start of UMTS in Europe as Test

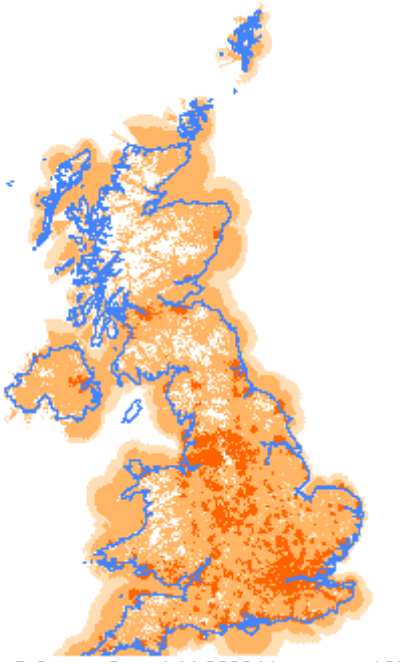
UMTS in Monaco



Early UMTS in Europe



Vodafone/Germany



Orange/UK

Some current GSM enhancements

- EMS/MMS
  - EMS: 760 characters possible by chaining SMS, animated icons, ring tones, was soon replaced by MMS (or simply skipped)
  - MMS: transmission of images, video clips, audio
    - see WAP 2.0 / chapter 10 – not really successful, typically substituted by email with attached multimedia content
  - Today, more and more IP-based messaging used
- EDGE (Enhanced Data Rates for Global [was: GSM] Evolution)
  - 8-PSK instead of GMSK, up to 384 kbit/s
  - new modulation and coding schemes for GPRS ➔ EGPRS
    - MCS-1 to MCS-4 uses GMSK at rates 8.8/11.2/14.8/17.6 kbit/s
    - MCS-5 to MCS-9 uses 8-PSK at rates 22.4/29.6/44.8/54.4/59.2 kbit/s

Some current UMTS enhancements

- HSDPA (High-Speed Downlink Packet Access)
  - initially up to 10 Mbit/s for the downlink, later > 20 Mbit/s using MIMO-(Multiple Input Multiple Output-) antennas
  - can use 16-QAM instead of QPSK (ideally > 13 Mbit/s)
  - user rates e.g. 3.6 or 7.2 Mbit/s
- HSUPA (High-Speed Uplink Packet Access)
  - initially up to 5 Mbit/s for the uplink
  - user rates e.g. 1.45 Mbit/s
- HSPA+ (Evolved HSPA)
  - Rel-7/Rel-8/Rel-9/...
  - Downlink 28/42/84/> 100 Mbit/s
  - Uplink 11/23/>23 Mbit/s
  - 2x2 MIMO, 64 QAM
- Dual-/Multi-Carrier HSPA (DC-/MC-HSPA
  - Connect 2 (Rel-8/9) or more carriers (Rel-11) e.g. of two cells offering up to 672 Mbit/s (4x4 MIMO)