Chapter 6:
Introduction to UMTS/IMT-2000

Prof. Yuh-Shyan Chen
Department of CSIE
National Taipei University

UMTS and IMT-2000

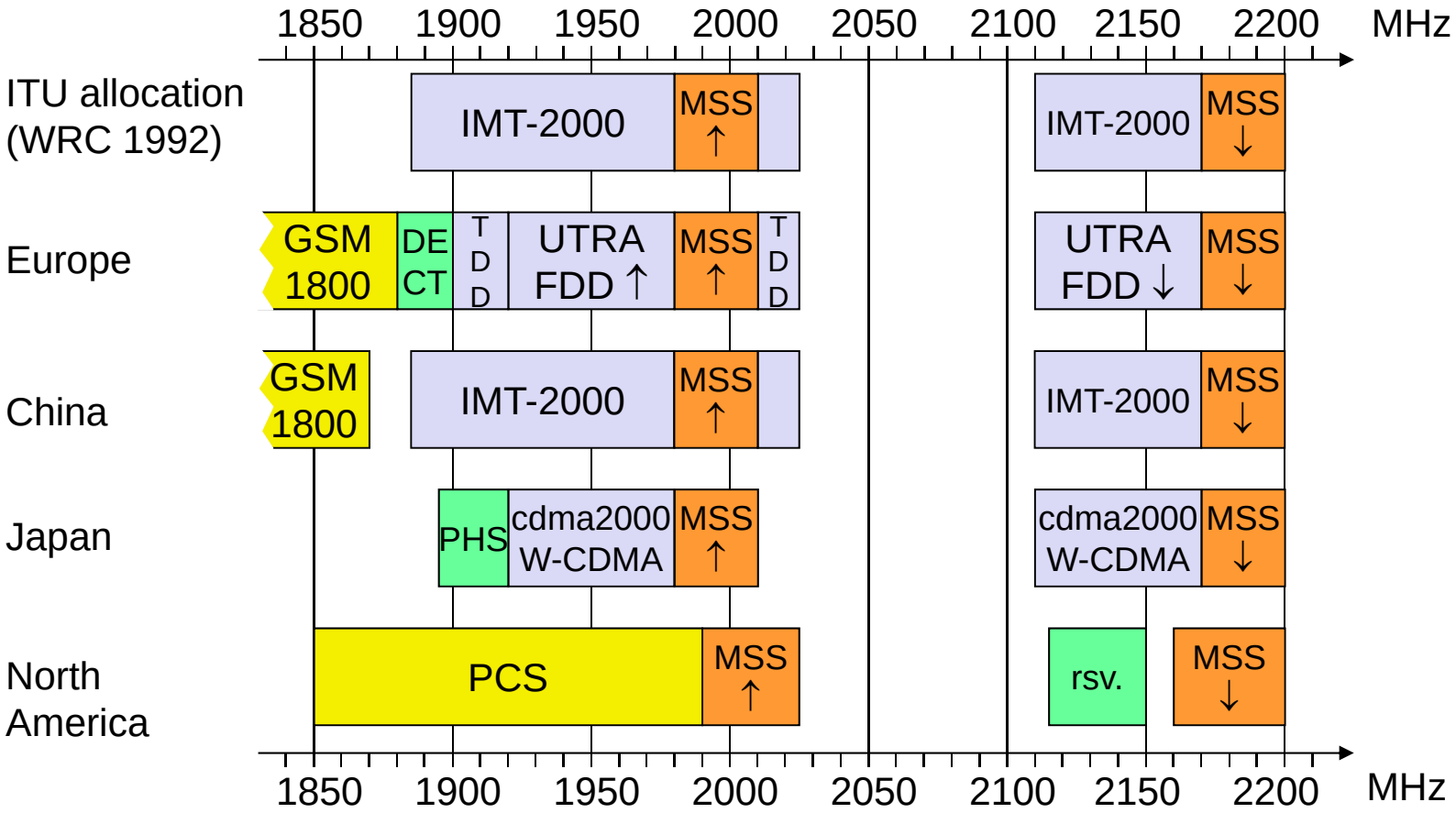
Proposals for IMT-2000 (International Mobile Telecommunications)

- UWC-136, cdma2000, WP-CDMA
- UMTS (Universal Mobile Telecommunications System) from ETSI

UMTS

- UTRA (was: UMTS, now: Universal Terrestrial Radio Access)
- enhancements of GSM
  - EDGE (Enhanced Data rates for GSM Evolution): GSM up to 384 kbit/s
  - CAMEL (Customized Application for Mobile Enhanced Logic)
  - VHE (virtual Home Environment)
- fits into GMM (Global Multimedia Mobility) initiative from ETSI
- requirements
  - min. 144 kbit/s rural (goal: 384 kbit/s)
  - min. 384 kbit/s suburban (goal: 512 kbit/s)
  - up to 2 Mbit/s urban

Frequencies for IMT-2000



Chinese 3G system TD-SCDMA

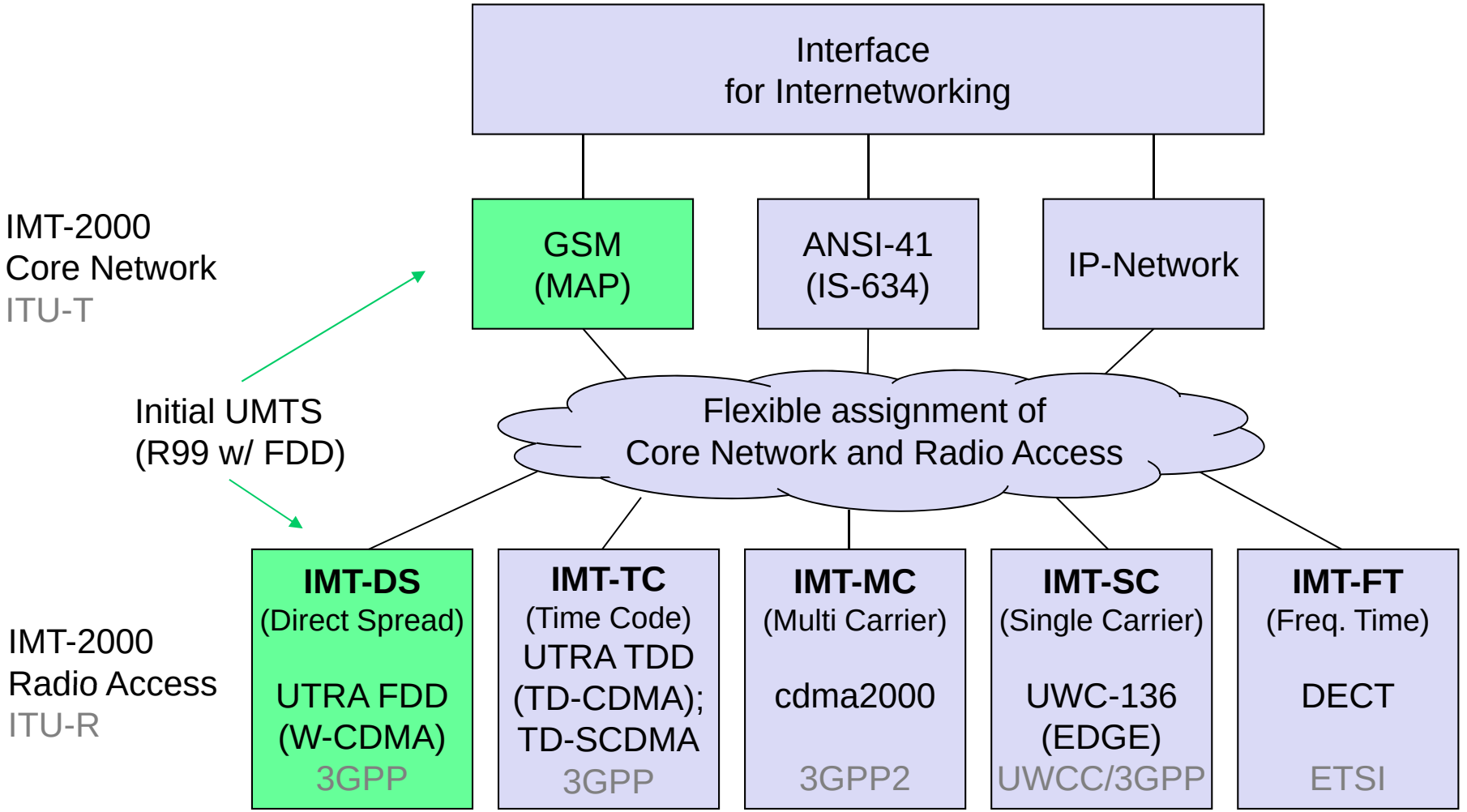
W-CDMA (likes UTRA-FDD)

- European proposal for IMT-2000 prepared by ETSI (1997)
- The special proposal for the radio interface RTT is UMTS (universal) terrestrial radio access (UTRA) (1998, UMTS forum, 2002)

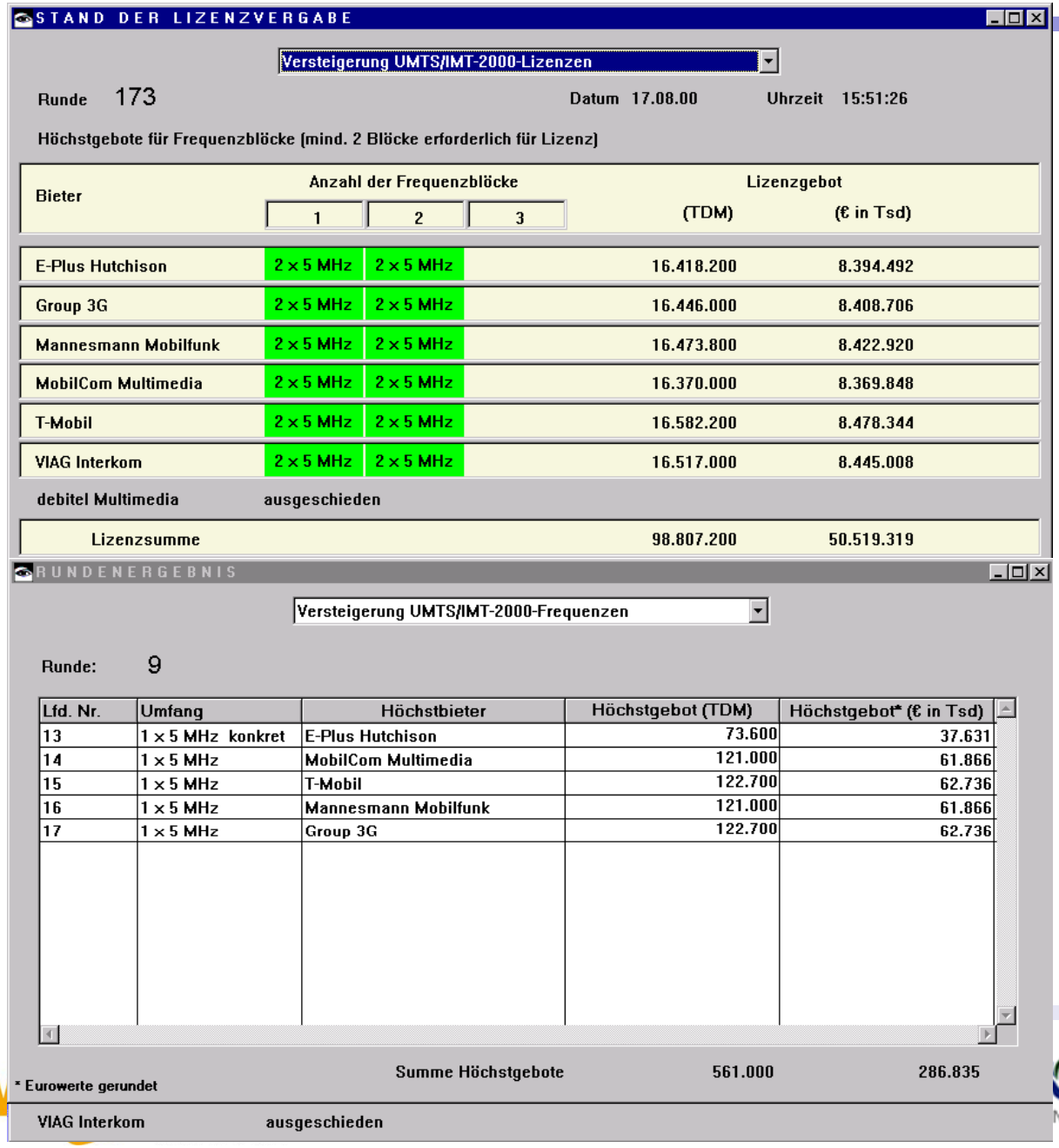
cdma2000

The world radio conference (WRC) allocated new terrestrial IMT-2000 bands in the range of 800-1000 MHz, 1700-1900 MHz, and 2500-2700 MHz in 2000. This approach includes the reuse of 2G spectrum.

IMT-2000 family



Licensing Example: UMTS in Germany, 18. August 2000



STAND DER LIZENZVERGABE

Versteigerung UMTS/IMT-2000-Lizenzen

Runde 173 Datum 17.08.00 Uhrzeit 15:51:26

Höchstgebote für Frequenzblöcke (mind. 2 Blöcke erforderlich für Lizenz)

Bieter	Anzahl der Frequenzblöcke 1	2	3	Lizenzgebot (TDM)	(€ in Tsd)
E-Plus Hutchison	2 x 5 MHz	2 x 5 MHz		16.418.200	8.394.492
Group 3G	2 x 5 MHz	2 x 5 MHz		16.446.000	8.408.706
Mannesmann Mobilfunk	2 x 5 MHz	2 x 5 MHz		16.473.800	8.422.920
MobilCom Multimedia	2 x 5 MHz	2 x 5 MHz		16.370.000	8.369.848
T-Mobil	2 x 5 MHz	2 x 5 MHz		16.582.200	8.478.344
VIAG Interkom	2 x 5 MHz	2 x 5 MHz		16.517.000	8.445.008
debitel Multimedia	ausgeschieden				
Lizenzsumme				98.807.200	50.519.319

RUNDENERGEBNIS

Versteigerung UMTS/IMT-2000-Frequenzen

Runde: 9

Lfd. Nr.	Umfang	Höchstbieter	Höchstgebot (TDM)	Höchstgebot* (€ in Tsd)
13	1 x 5 MHz konkret	E-Plus Hutchison	73.600	37.631
14	1 x 5 MHz	MobilCom Multimedia	121.000	61.866
15	1 x 5 MHz	T-Mobil	122.700	62.736
16	1 x 5 MHz	Mannesmann Mobilfunk	121.000	61.866
17	1 x 5 MHz	Group 3G	122.700	62.736
		Summe Höchstgebote	561.000	286.835

* Eurowerte gerundet

VIAG Interkom ausgeschieden

- UTRA-FDD:
  - Uplink 1920-1980 MHz
  - Downlink 2110-2170 MHz
  - duplex spacing 190 MHz
  - 12 channels, each 5 MHz
- UTRA-TDD:
  - 1900-1920 MHz,
  - 2010-2025 MHz;
  - 5 MHz channels
- Coverage: 25% of the population until 12/2003, 50% until 12/2005

Sum: 50.81 billion €

UMTS architecture (Release 99 used here!)

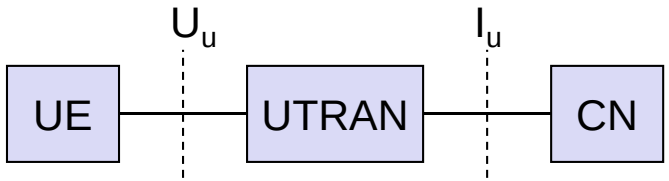
UTRAN (UTRA Network)

- Cell level mobility
- Radio Network Subsystem (RNS)
- Encapsulation of all radio specific tasks

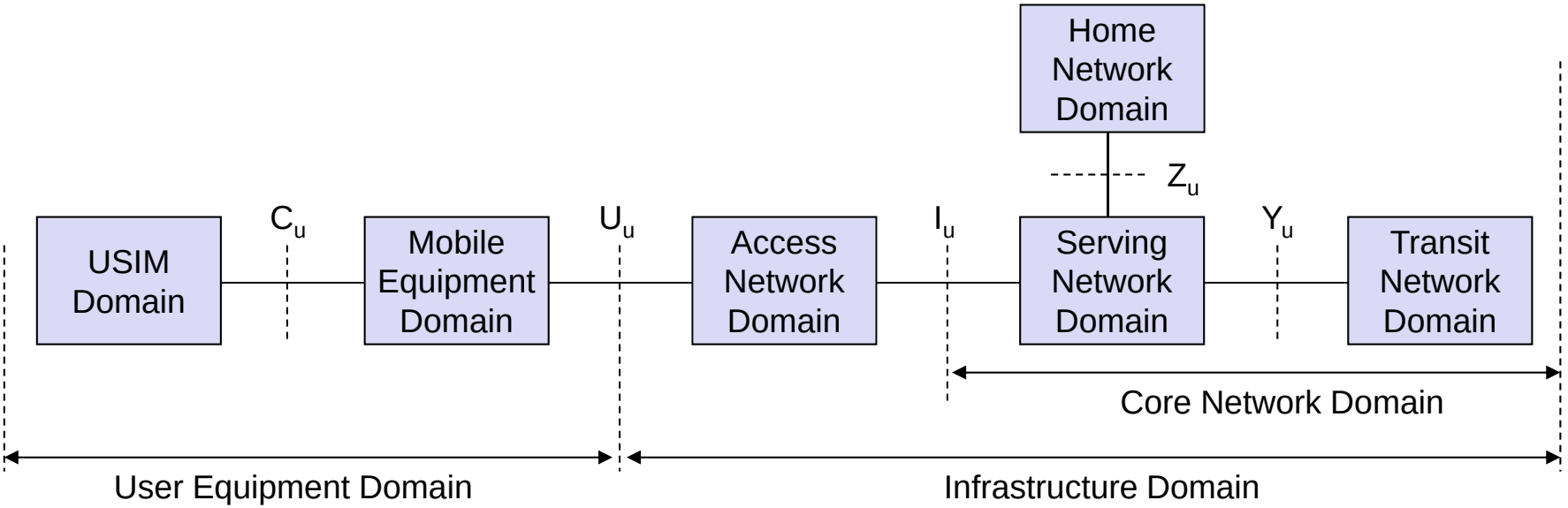
UE (User Equipment)

CN (Core Network)

- Inter system handover
- Location management if there is no dedicated connection between UE and UTRAN



UMTS domains and interfaces I



User Equipment Domain

- Assigned to a single user in order to access UMTS services

Infrastructure Domain

- Shared among all users
- Offers UMTS services to all accepted users

UMTS domains and interfaces II

Universal Subscriber Identity Module (USIM)

- Functions for encryption and authentication of users
- Located on a SIM inserted into a mobile device

Mobile Equipment Domain

- Functions for radio transmission
- User interface for establishing/maintaining end-to-end connections

Access Network Domain

- Access network dependent functions

Core Network Domain

- Access network independent functions
- Serving Network Domain
  - Network currently responsible for communication
- Home Network Domain
  - Location and access network independent functions

Spreading and scrambling of user data

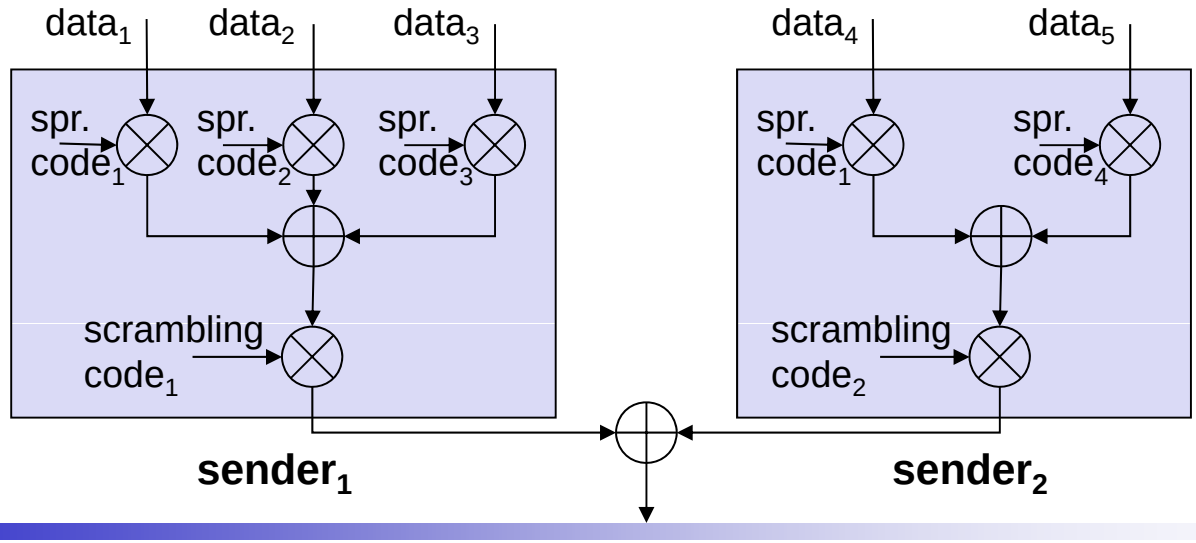
Constant chipping rate of 3.84 Mchip/s

Different user data rates supported via different spreading factors

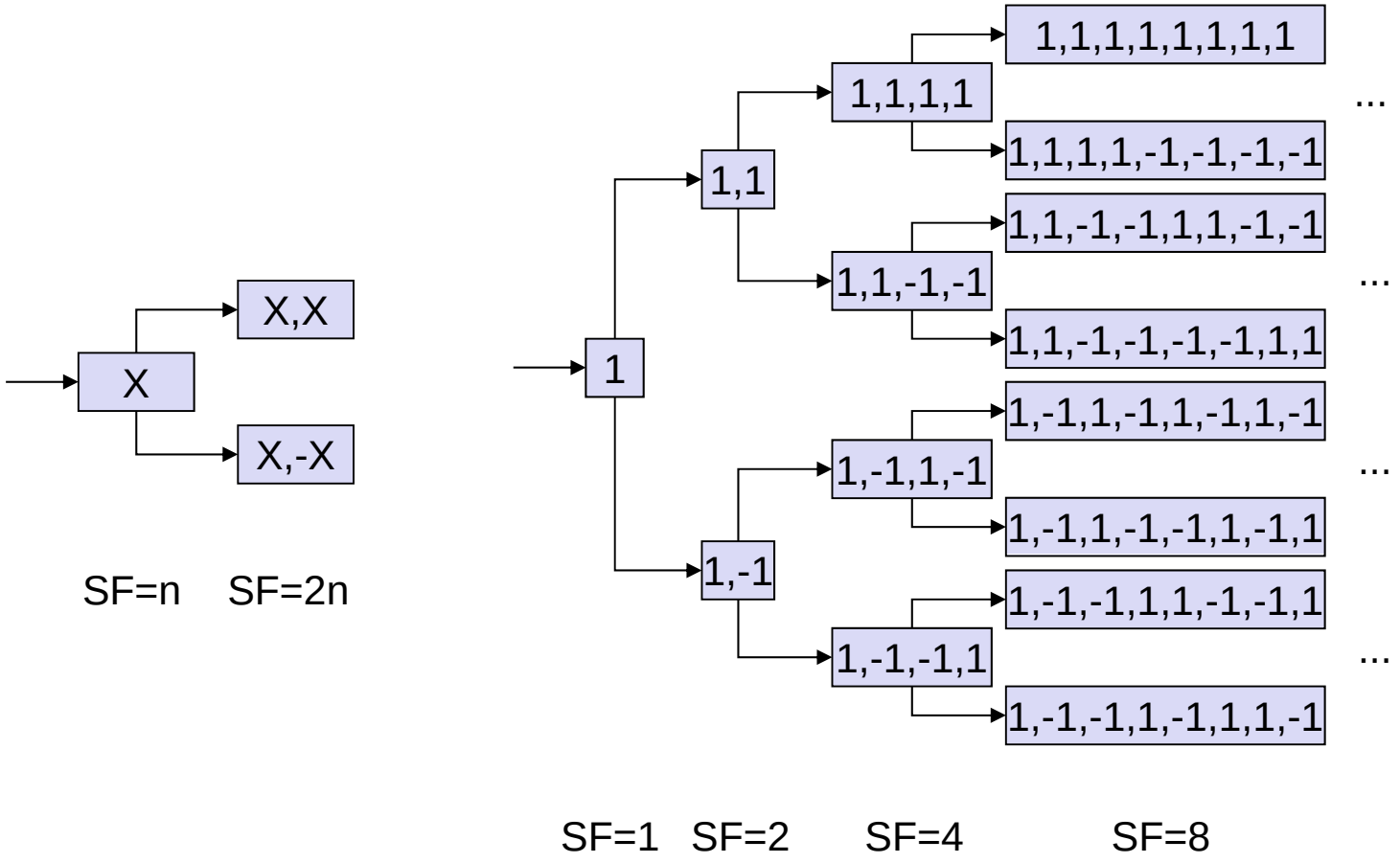
- higher data rate: less chips per bit and vice versa

User separation via unique, quasi orthogonal scrambling codes

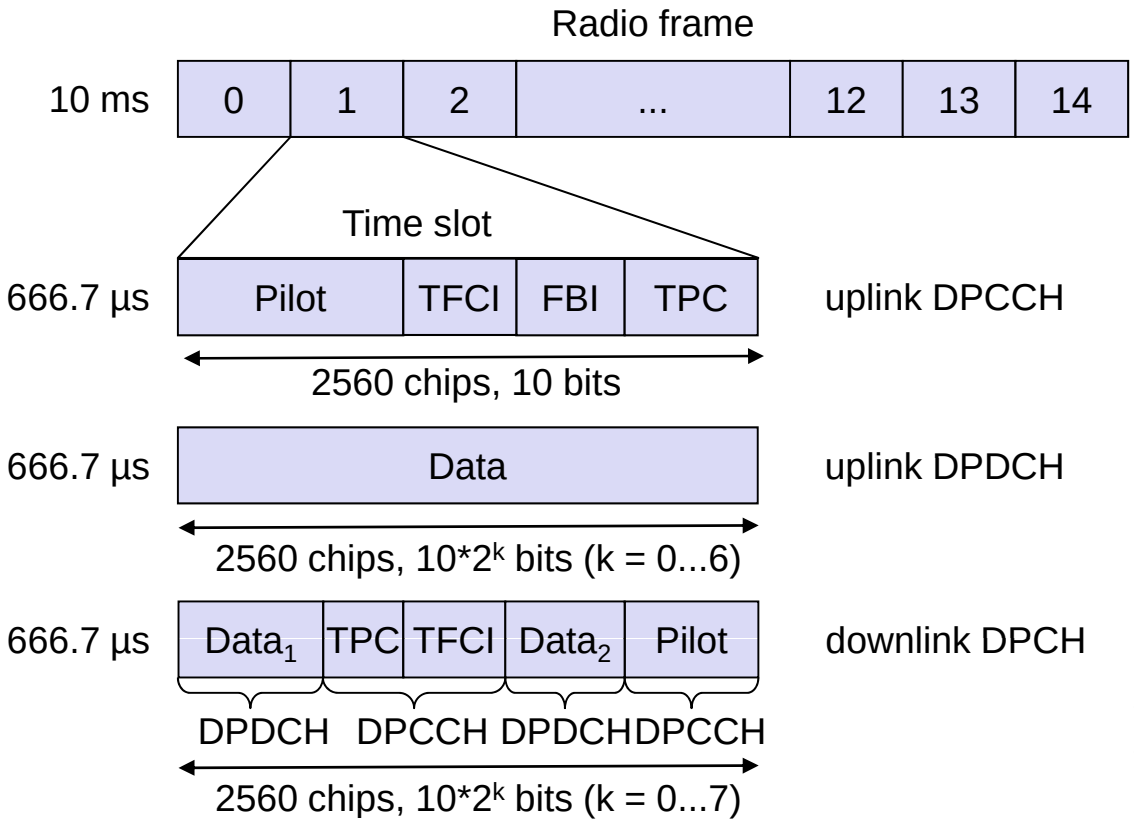
- users are not separated via orthogonal spreading codes
- much simpler management of codes: each station can use the same orthogonal spreading codes
- precise synchronisation not necessary as the scrambling codes stay quasi-orthogonal



OSVF coding


X
X,X
X,-X
SF=n
SF=2n
1
1,1
1,-1
1,1,1,1
1,1,-1,-1
1,-1,1,-1
1,-1,-1,1
1,1,1,1,1,1,1,1
1,1,1,1,-1,-1,-1,-1
1,1,-1,-1,1,1,-1,-1
1,1,-1,-1,-1,-1,1,1
1,-1,1,-1,1,-1,1,-1
1,-1,1,-1,-1,1,-1,1
1,-1,-1,1,1,-1,-1,1
1,-1,-1,1,-1,1,1,-1
...
...
...
SF=1
SF=2
SF=4
SF=8

UMTS FDD frame structure



W-CDMA

- 1920-1980 MHz uplink
- 2110-2170 MHz downlink
- chipping rate: 3.840 Mchip/s
- soft handover
- QPSK
- complex power control (1500 power control cycles/s)
- spreading: UL: 4-256; DL:4-512

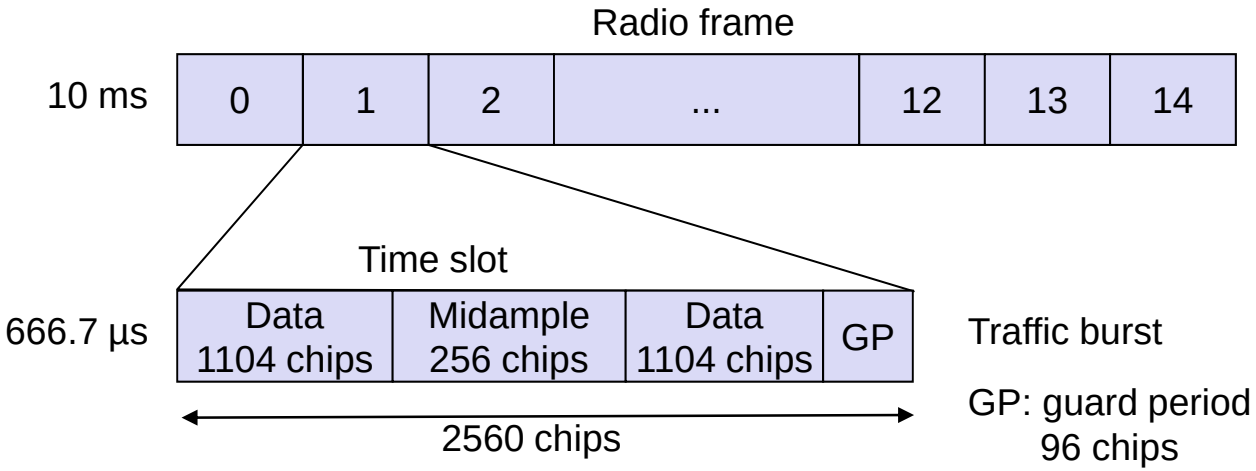
FBI: Feedback Information
TPC: Transmit Power Control
TFCI: Transport Format Combination Indicator
DPCCH: Dedicated Physical Control Channel
DPDCH: Dedicated Physical Data Channel
DPCH: Dedicated Physical Channel

Slot structure NOT for user separation but synchronisation for periodic functions!

Typical UTRA-FDD uplink data rates

User data rate [kbit/s]	**12.2 (voice)**	**64**	**144**	**384**
DPDCH [kbit/s]	60	240	480	960
DPCCH [kbit/s]	15	15	15	15
Spreading	64	16	8	4

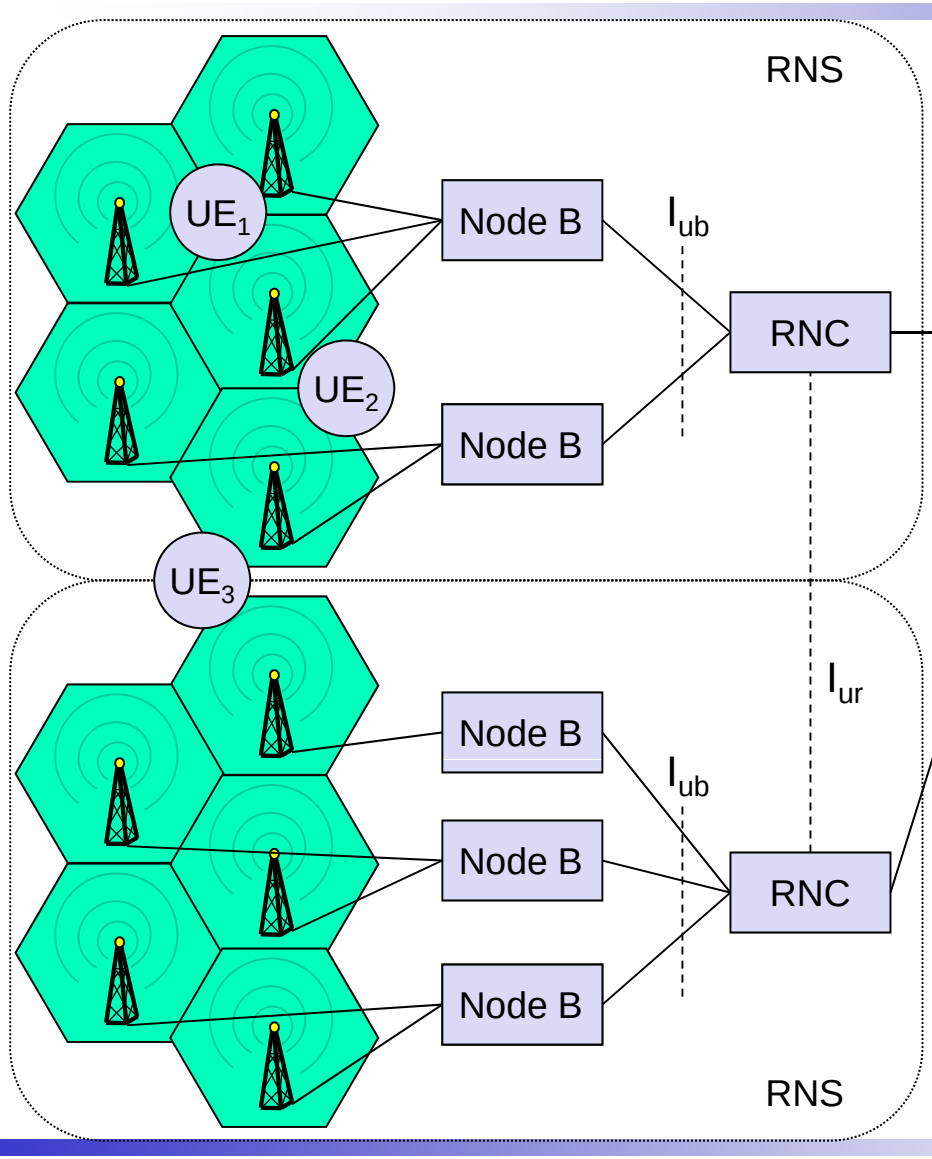
UMTS TDD frame structure (burst type 2)



TD-CDMA

- 2560 chips per slot
- spreading: 1-16
- symmetric or asymmetric slot assignment to UL/DL (min. 1 per direction)
- tight synchronisation needed
- simpler power control (100-800 power control cycles/s)

UTRAN architecture



RNC: Radio Network Controller

RNS: Radio Network Subsystem

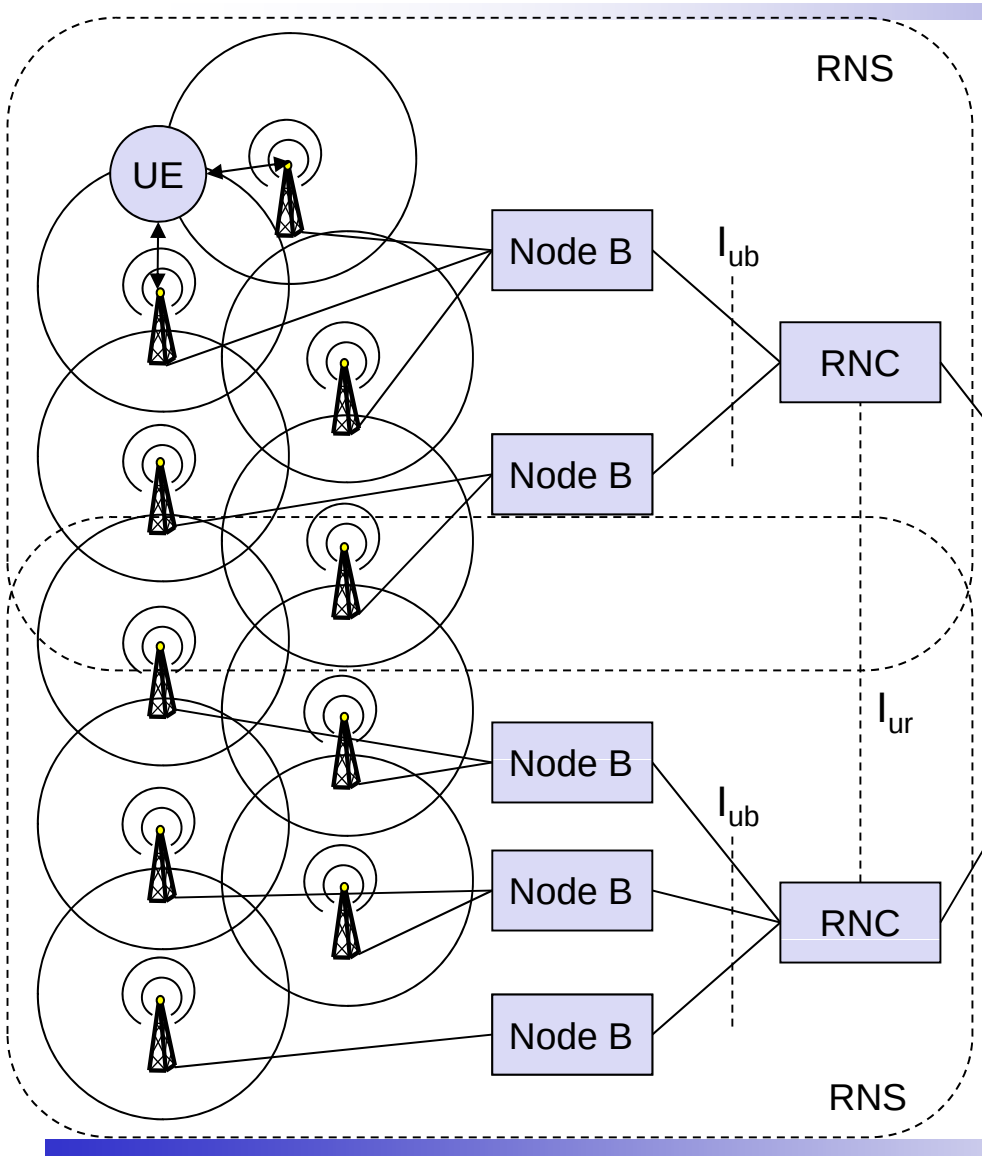
UTRAN comprises several RNSs

Node B can support FDD or TDD or both

RNC is responsible for handover decisions requiring signalingto the UE

Cell offers FDD or TDD

UTRAN architecture



RNC: Radio Network Controller

RNS: Radio Network Subsystem

UTRAN comprises several RNSs

Node B can support FDD or TDD or both

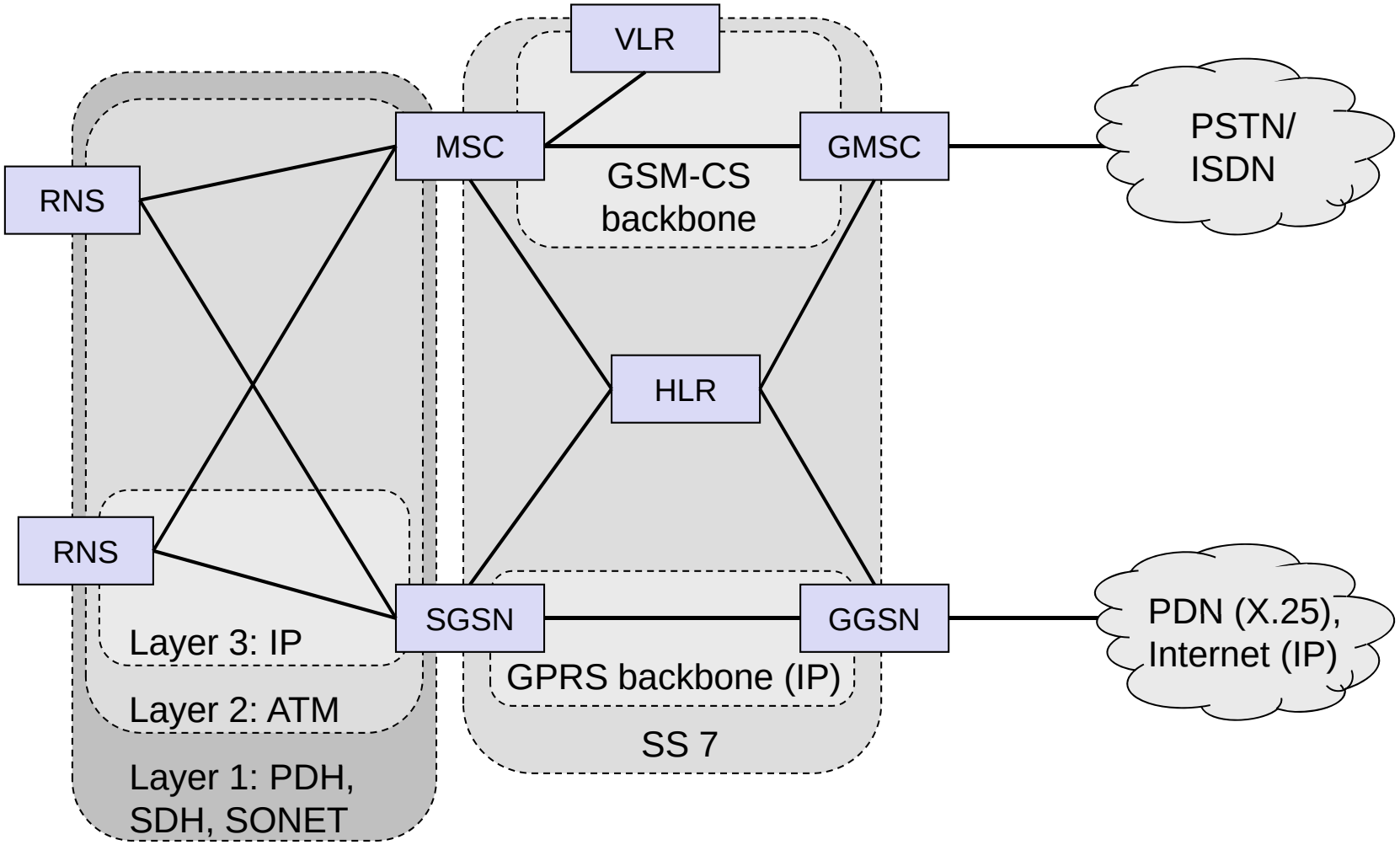
RNC is responsible for handover decisions requiring signaling to the UE

Cell offers FDD or TDD

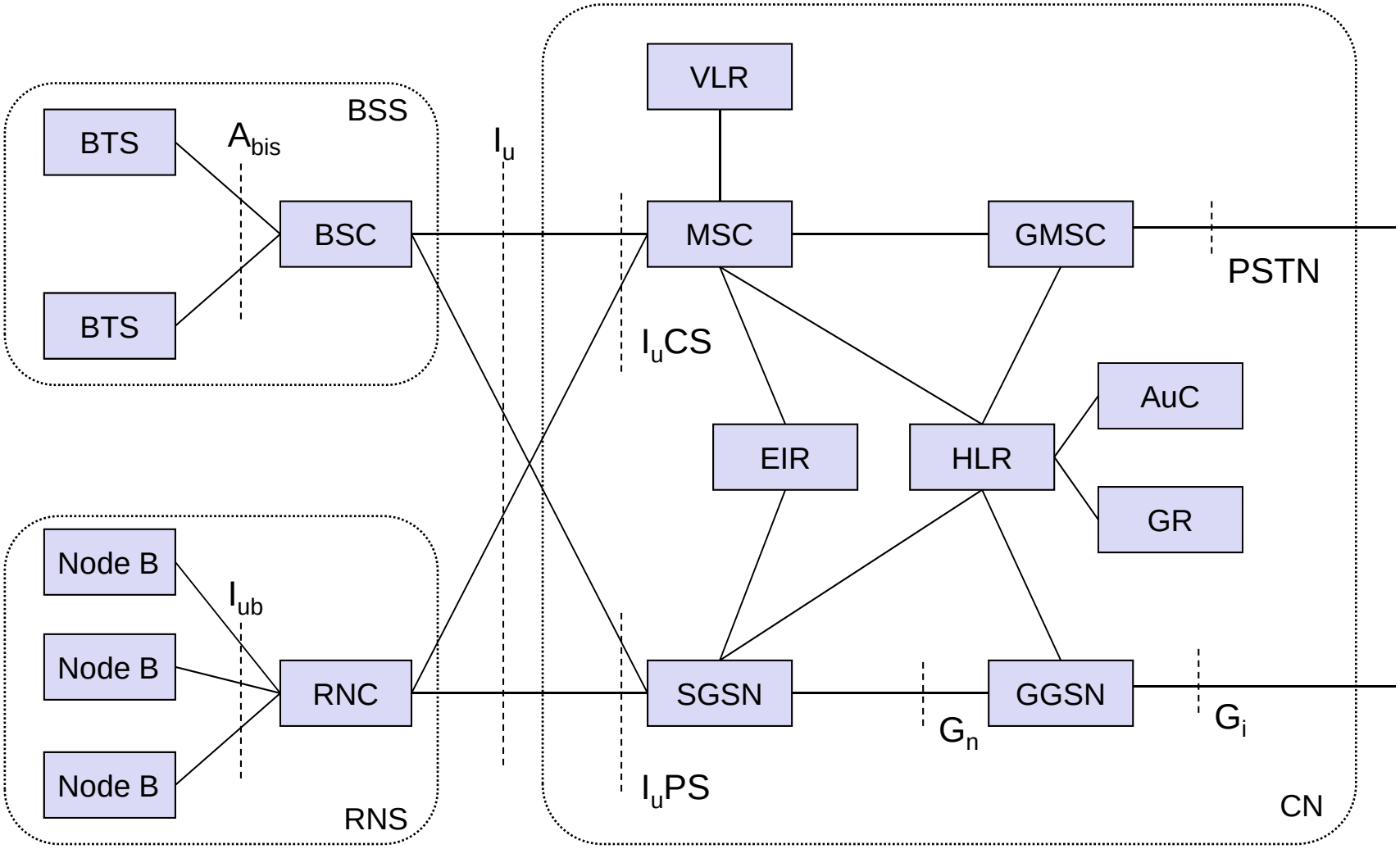
UTRAN functions

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

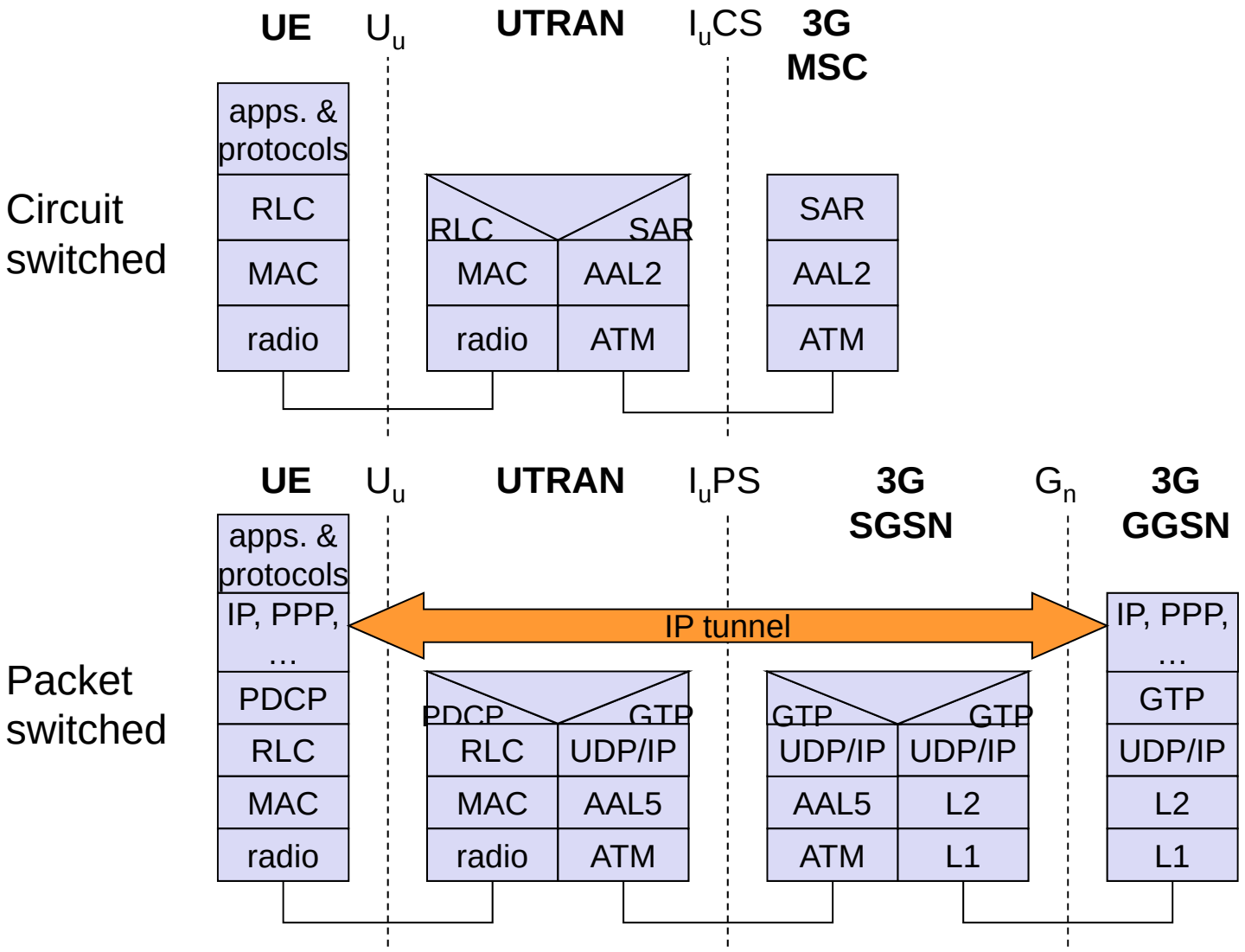
The Core Network (CN) and thus the Interface I_u, too, are separated into two logical domains:

- 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

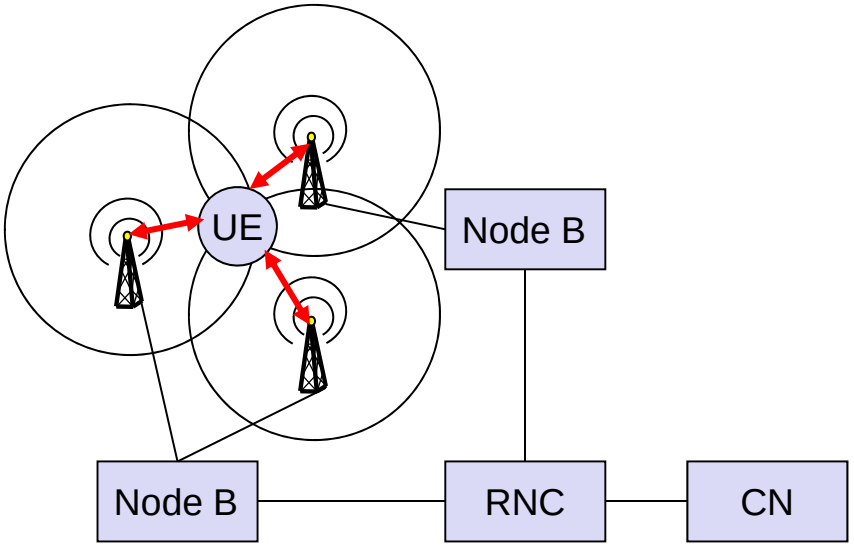
Release 99 uses the GSM/GPRS network and adds a new radio access!

- Helps to save a lot of money …
- Much faster deployment
- Not as flexible as newer releases (5, 6, 8, 10)

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)

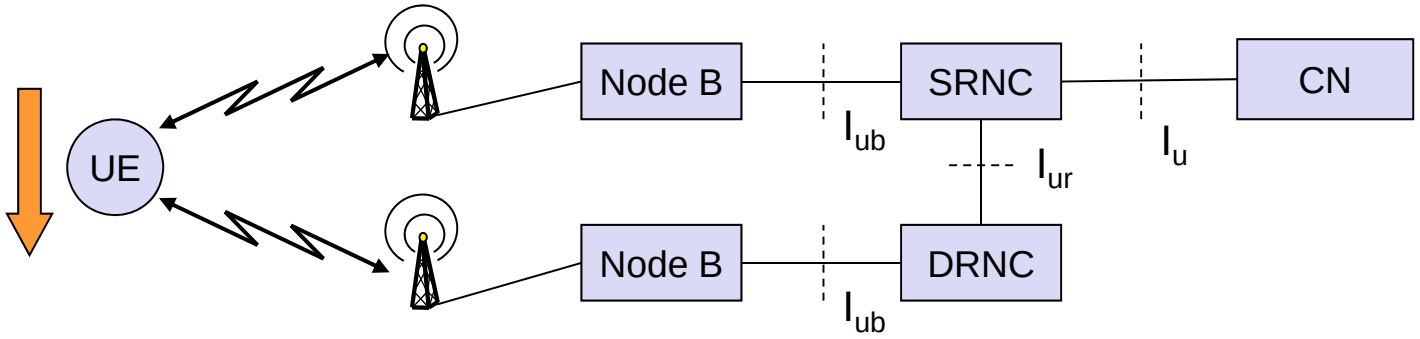
- This is a must as UMTS coverage will be poor in the beginning

RNS controlling the connection is called SRNS (Serving RNS)

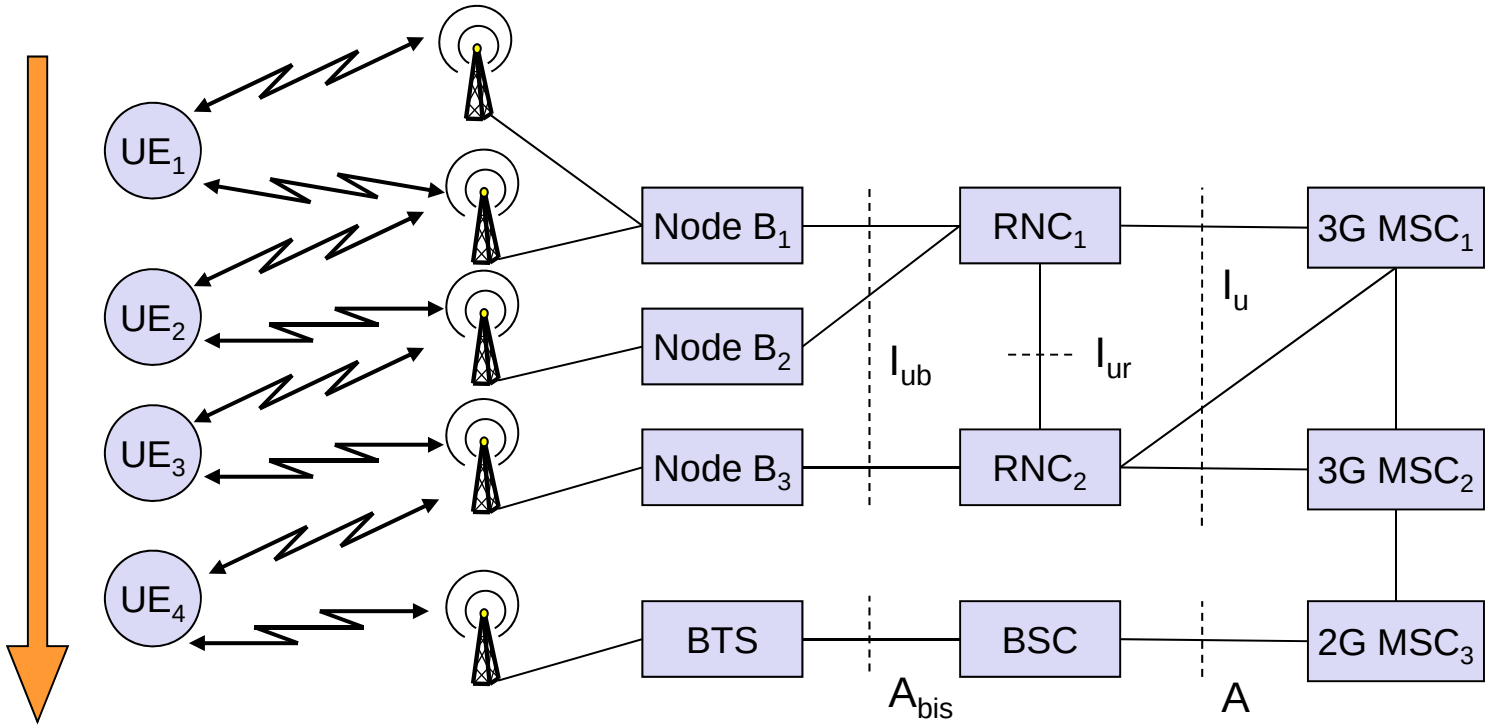
RNS offering additional resources (e.g., for soft handover) is called Drift RNS (DRNS)

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



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

Homework #6:

1. What's the OSVF coding ?
2. What's the core network: architecture of UTRAN ?