無線網路多媒體系統
Wireless Multimedia System

Lecture 6: CDMA & 3G Trend

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Agenda

- Spread Spectrum (Multipath, interferences from other cells)
- W-CDMA
- Evolutions of PCS
- ALL IP Challenges
  - Mobile IP/Cellular IP
  - QoS Provisions: Integrated Service / DiffServ
- Next Week (Mobile IP)

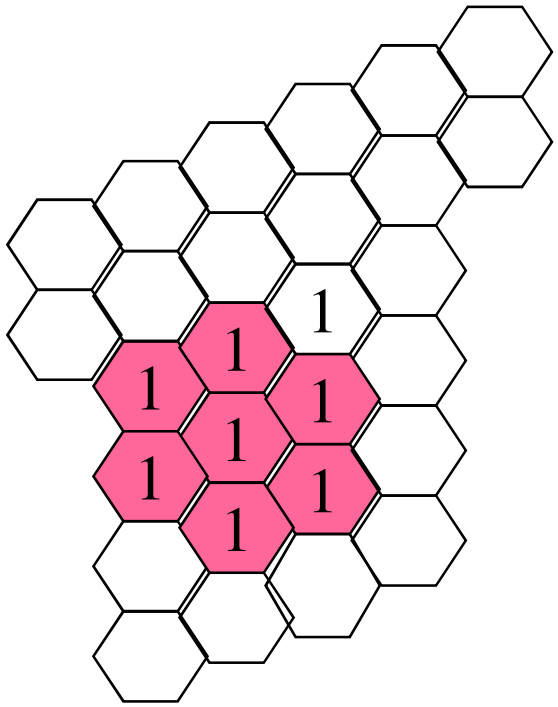
Reading

- [Kohno95]Ryuji Kohno, Reuven Meidan, and Laurence B. Milstein Spread Spectrum Access Methods for Wireless Communications, IEEE Communication Magazine, 1995
- [Dahlman98]Erick Dahlman, Bjorn Gudmundson, Mat Nilsson and Johan Skold, UMTS/IMT-2000 Based on Wideband CDMA, IEEE Communication Magazine 1998
- [Ojanpera98] T. OJanpera, R. Prasad, “An Overview of Third-Generation Wireless Personal Communications: An European Perspective, IEEE Personal Communication Magazine 1998

Code Division, Spread Spectrum

What is Going to Happen in CDMA?

Direct Sequence Cellular

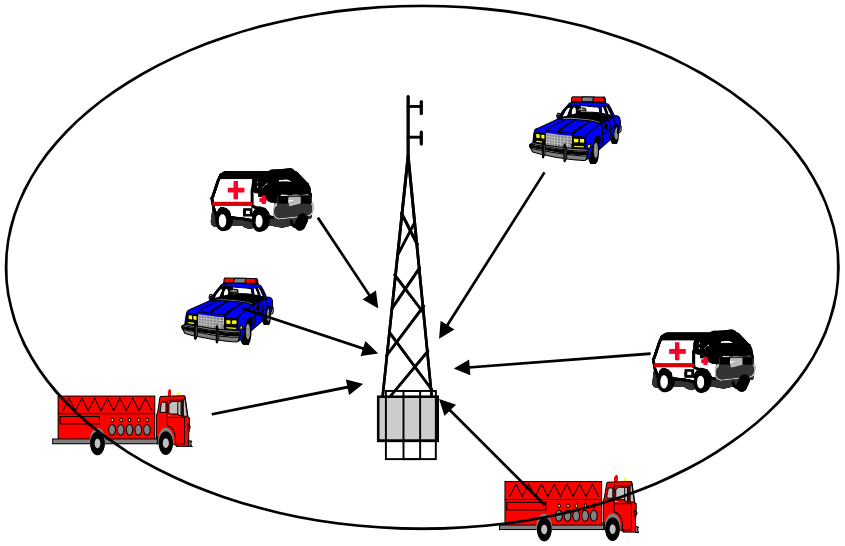


Idealized grid of
Hexagonal cells

- DS spread spectrum signals are generated by linear modulation with wideband PN sequences which are assigned to individual users
- Universal Frequency Reuse: One-cell frequency reuse pattern
- Introduction of a new cell will be less restricted than in the case of either FDMA or TDMA
- (FDD) Frequency Division Duplex Operation: One frequency band is used for the base-to-mobile (forward or down link), one frequency band is used for the mobile-to-base link (the reverse link or uplink)

Power Control (Reverse Link)

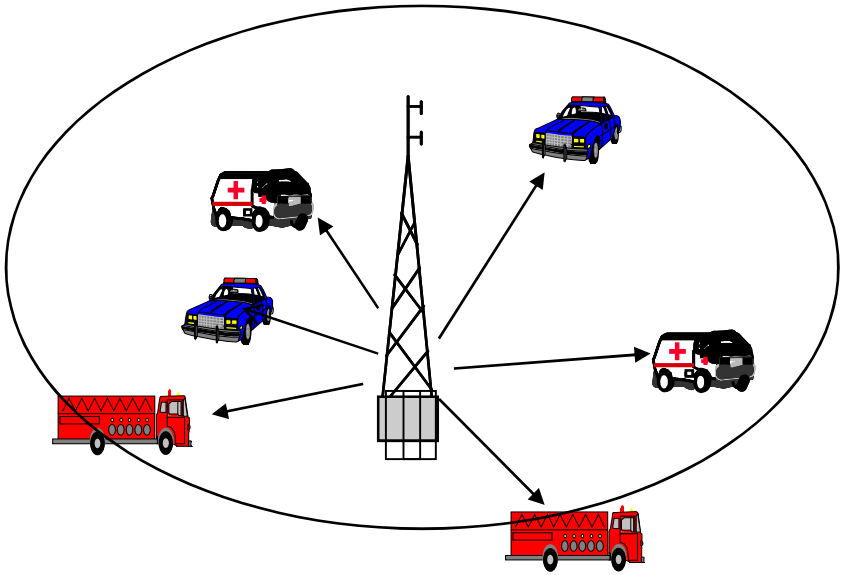
- Reverse Link: asynchronous, asynchronous CDMA system is vulnerable to the “near-far” problem
- Power Control: minimize consumption of the transmitted power, fast enough to compensate for Rayleigh fading
- Capacity is bounded by number of users (MAI Multiple Access interferences)



Everybody has a Code (PN), asynchronous

Power Control (Forward Link)

- Forward Link: the users can be orthogonalized, (however, the orthogonalization is not preserved between different paths of the multipath propagation, nor is it preserved between the forward links of different cells)
- Power Control: Since the cell's signals can be received at the mobile with equal power, the forward link does not suffer from near-far problem
- Cell boundary



Everybody has a Code (PN) synchronous

Cellular Capacity

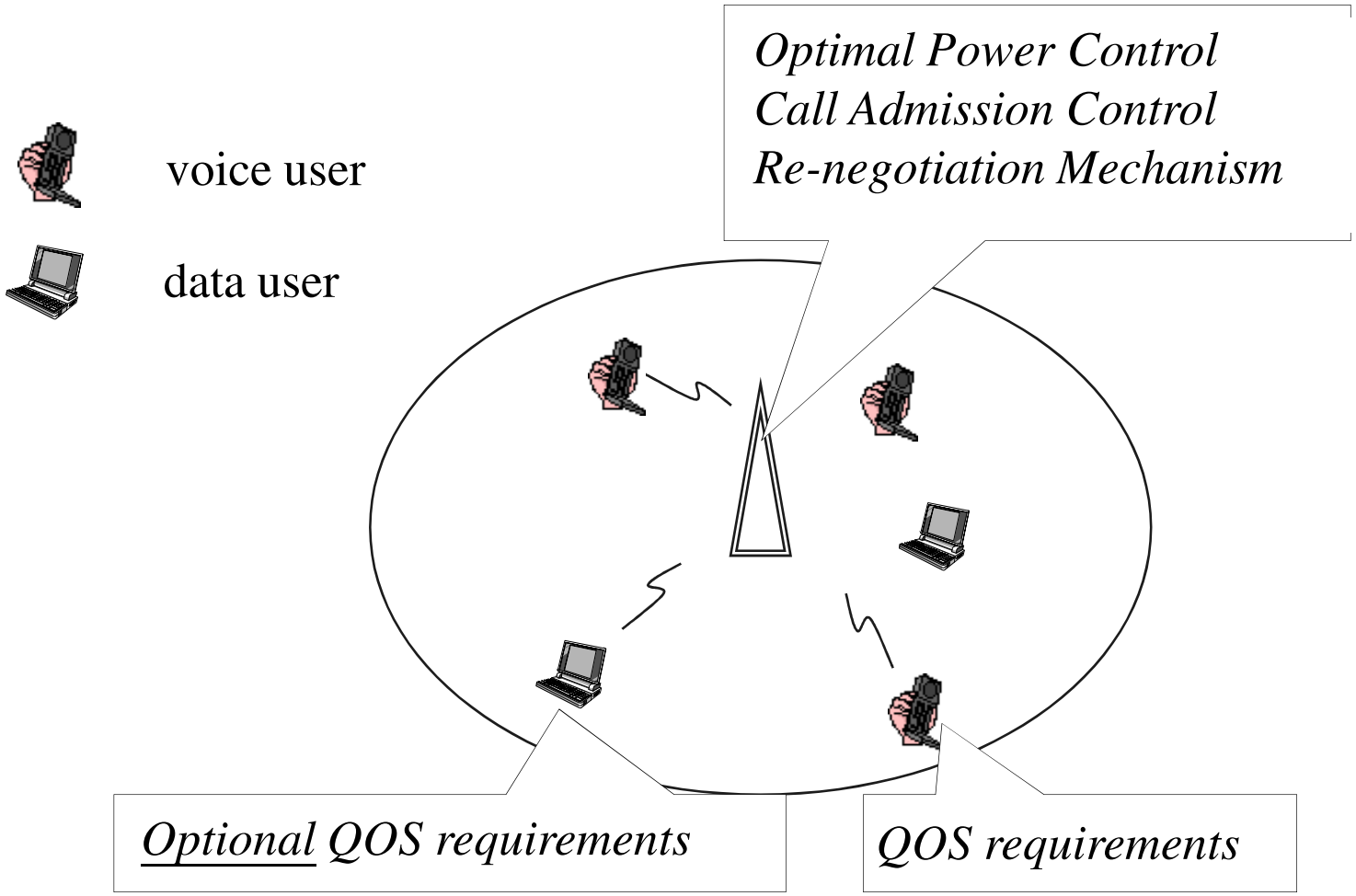
- Capacity of the reverse link
  (typically asynchronous link)

$$\left(\frac{E_b}{\eta_0}\right)_{eff} = \frac{1}{\frac{\eta_0}{E_b} + \frac{2}{3G}(M-1)(1+K)\alpha}$$

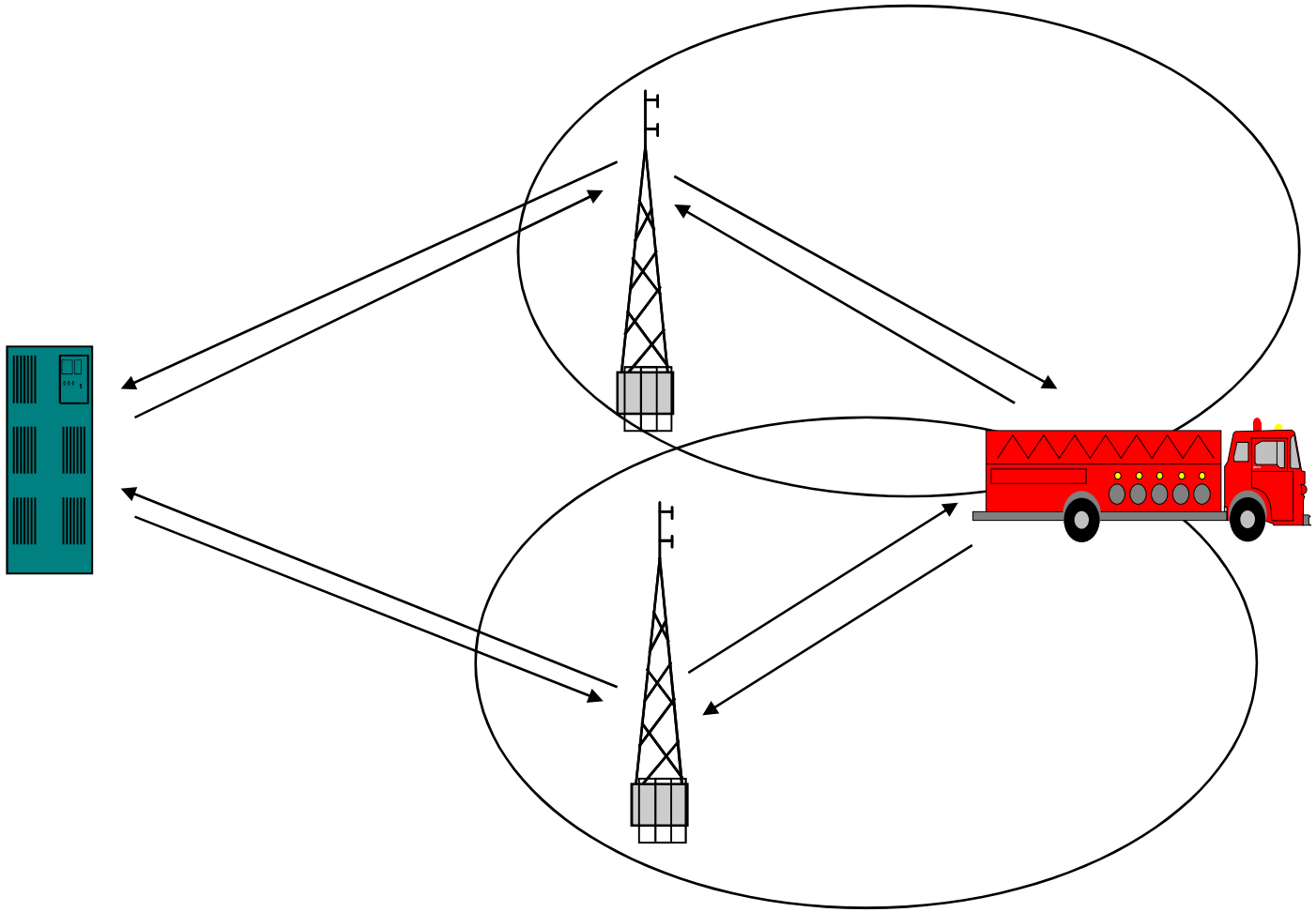
Radio Resource Management

- Power as the common resource makes W-CDMA very flexible
  - Link improvement, less power, more capacity
- Orthogonal variable spreading factor (OVSF) for variable bit rate

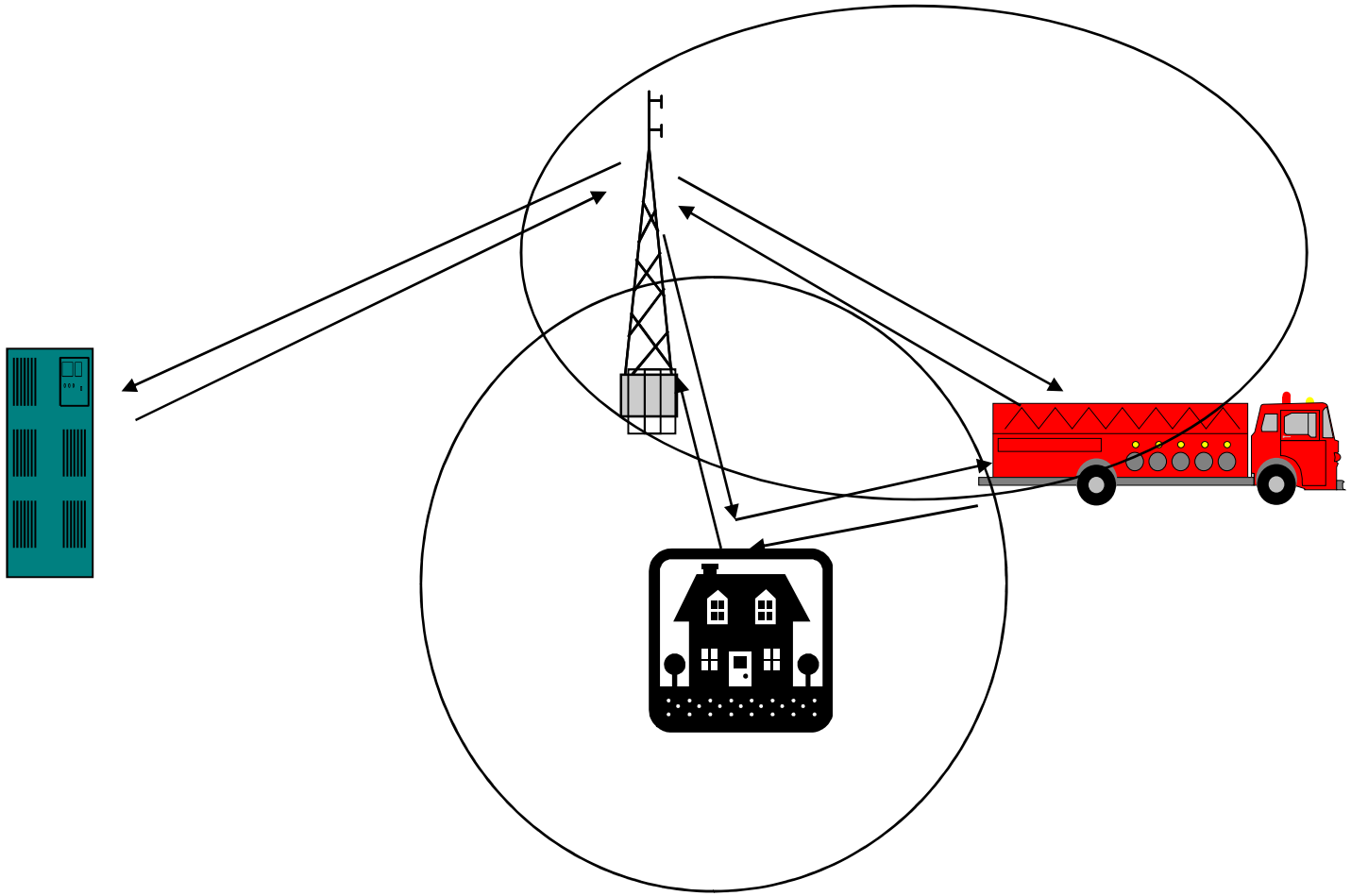
Call Admission Control



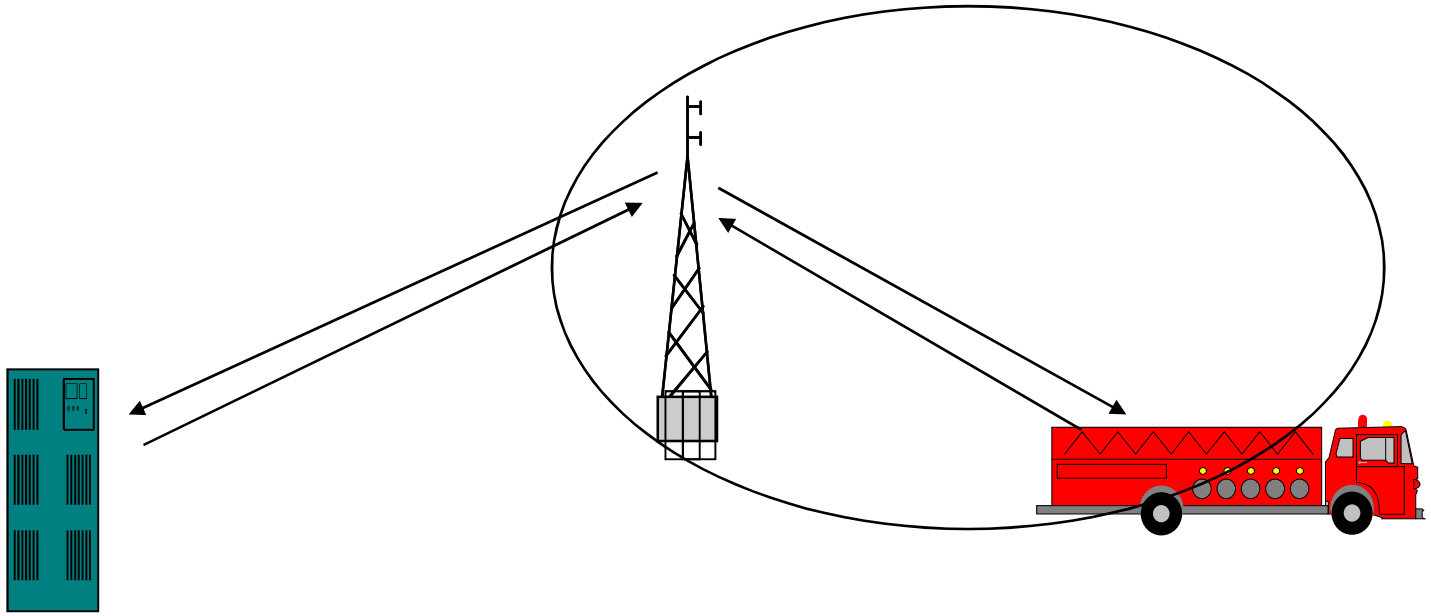
Soft Handovers (Macro Diversity)



Softer Handovers (Space Diversity)

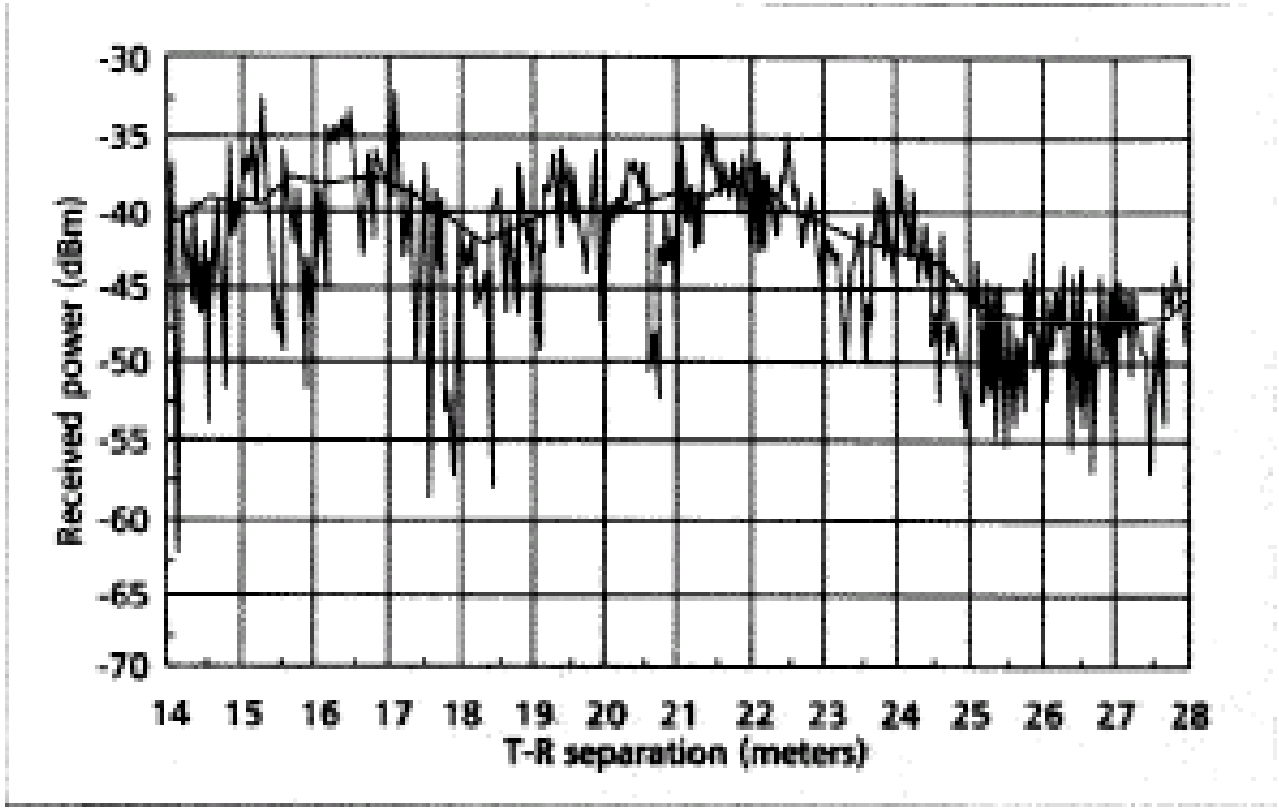


Power Control (Open & Close Loop)



Close-Loop Power Control

- Compensates a fading channe(1500 times per second)

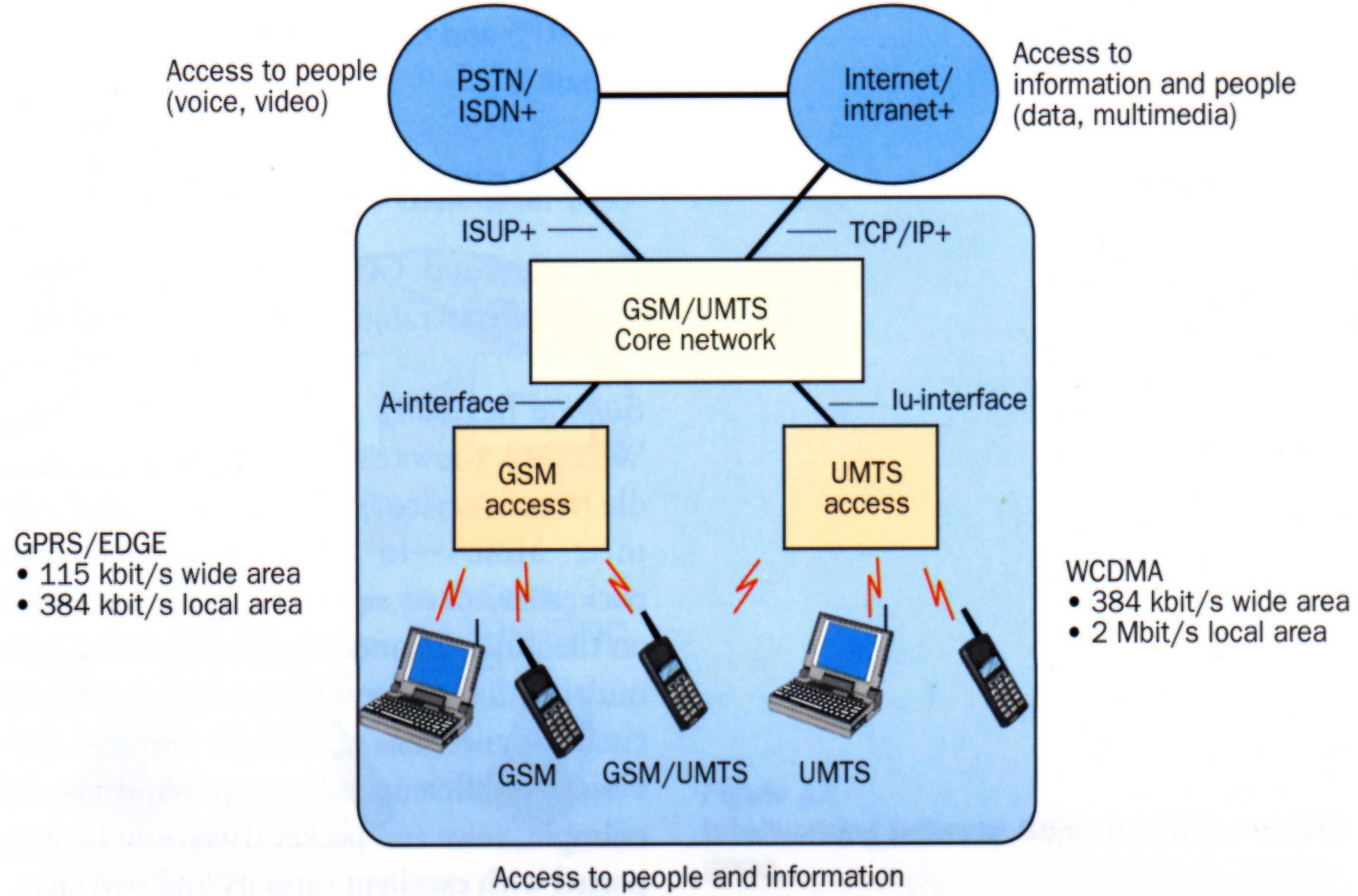


UMTS/IMT-2000
Based on Wideband CDMA

What is going to happen for WCDMA

Application Support in UMTS

- UMTS (Universal Mobile Telecommunication System)
- UTRA (UMTS Terrestrial Radio Access)
- Support:
  - 384 kb/s for wide-area coverage
  - 2 Mb/s for local coverage
- Multimedia Applications Requirements
  - Packet-oriented
  - Variable bit rate
  - Network resources can be available on a shared basis
  - E_b / N_0


Access to people
(voice, video)
PSTN/
ISDN+
Internet/
intranet+
Access to
information and people
(data, multimedia)
ISUP+
TCP/IP+
GSM/UMTS
Core network
A-interface
Iu-interface
GSM
access
UMTS
access
GPRS/EDGE
• 115 kbit/s wide area
• 384 kbit/s local area
WCDMA
• 384 kbit/s wide area
• 2 Mbit/s local area
GSM
GSM/UMTS
UMTS
Access to people and information

RS Spectrum Allocation

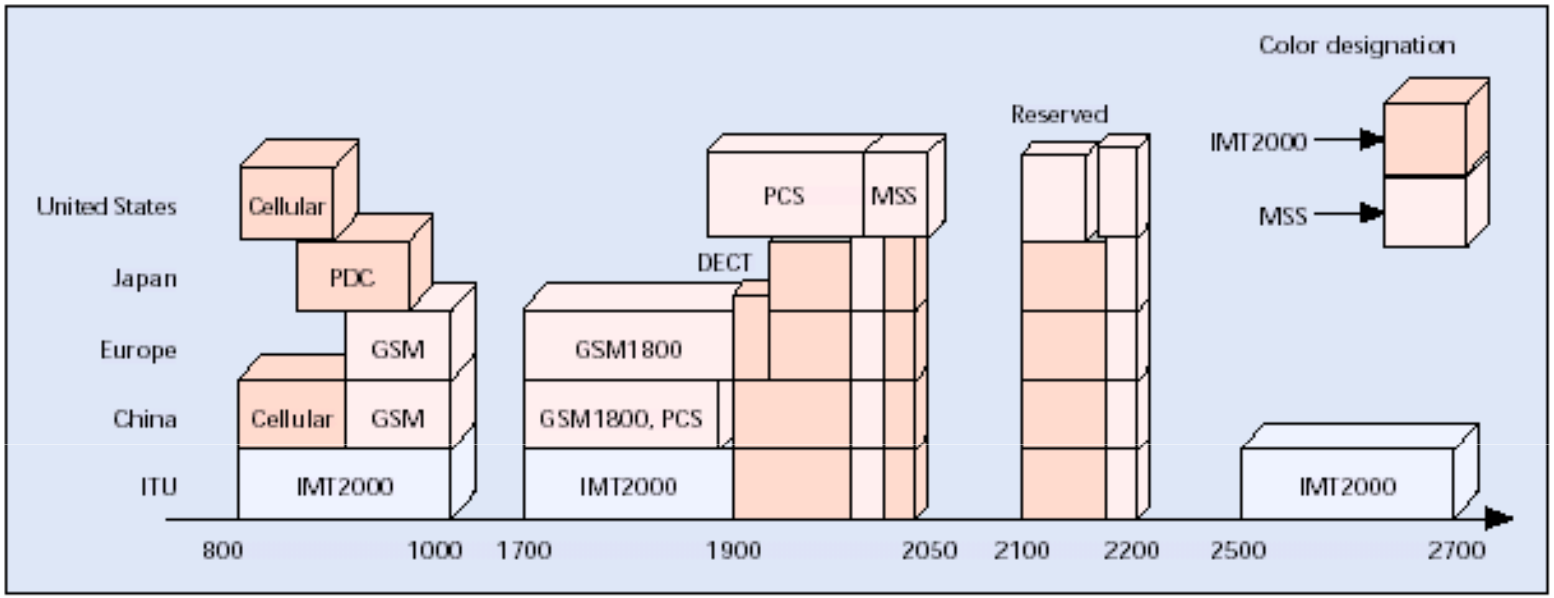
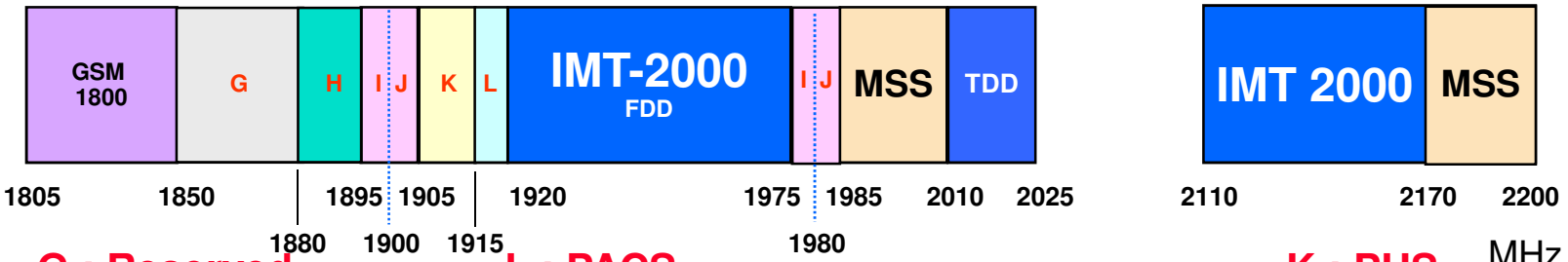


Figure 2. *RF spectrum allocation in major regions.*



G : Reserved
H : DECT
I : PACS
J : PACS (To Be Licensed)
K : PHS
L : Reserved

Wireless Mobile Interface

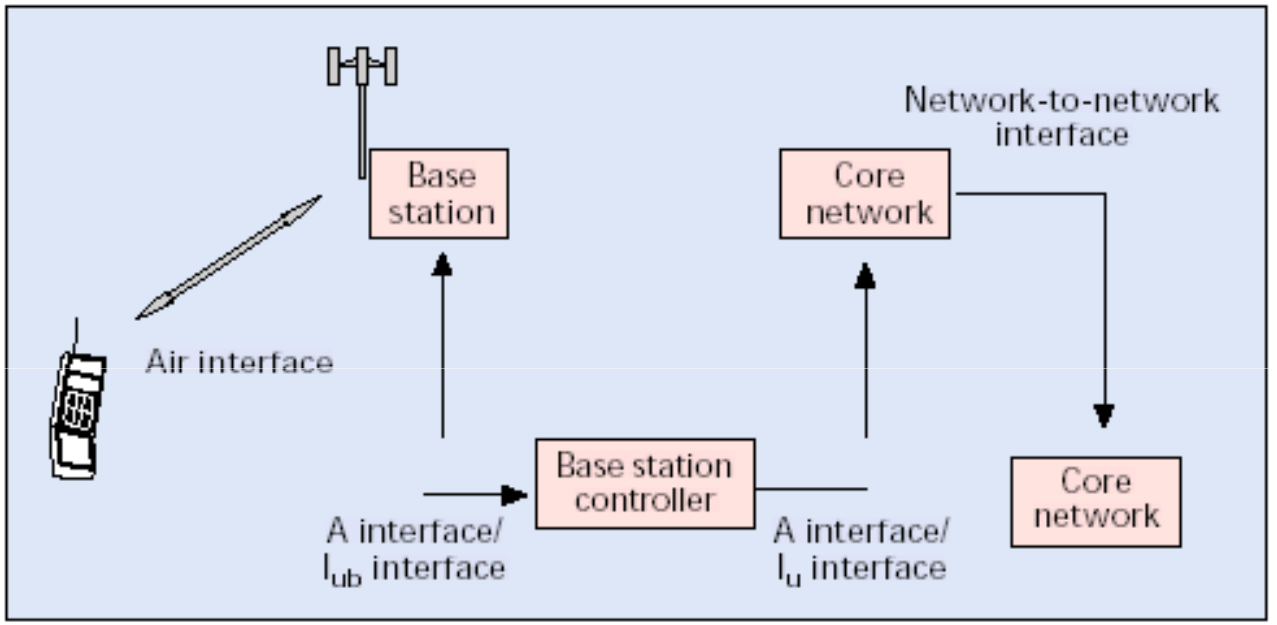
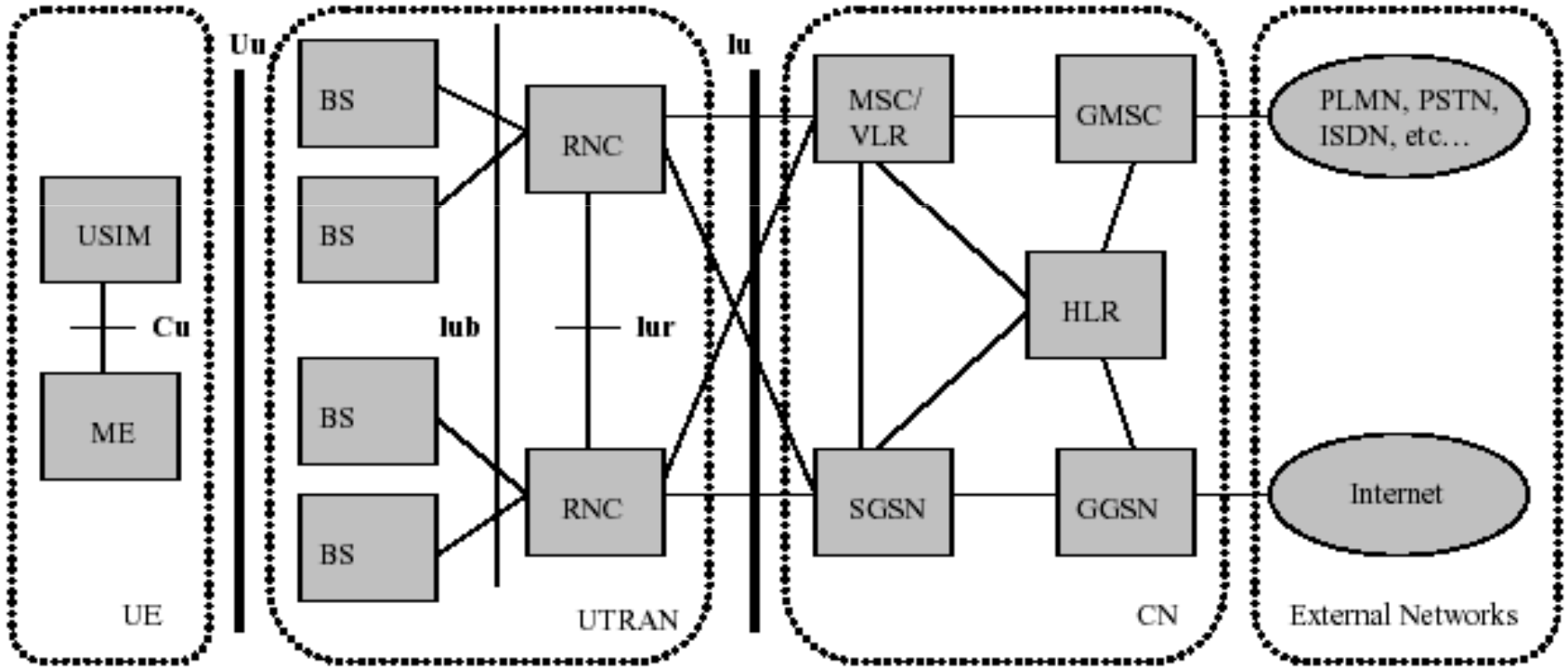
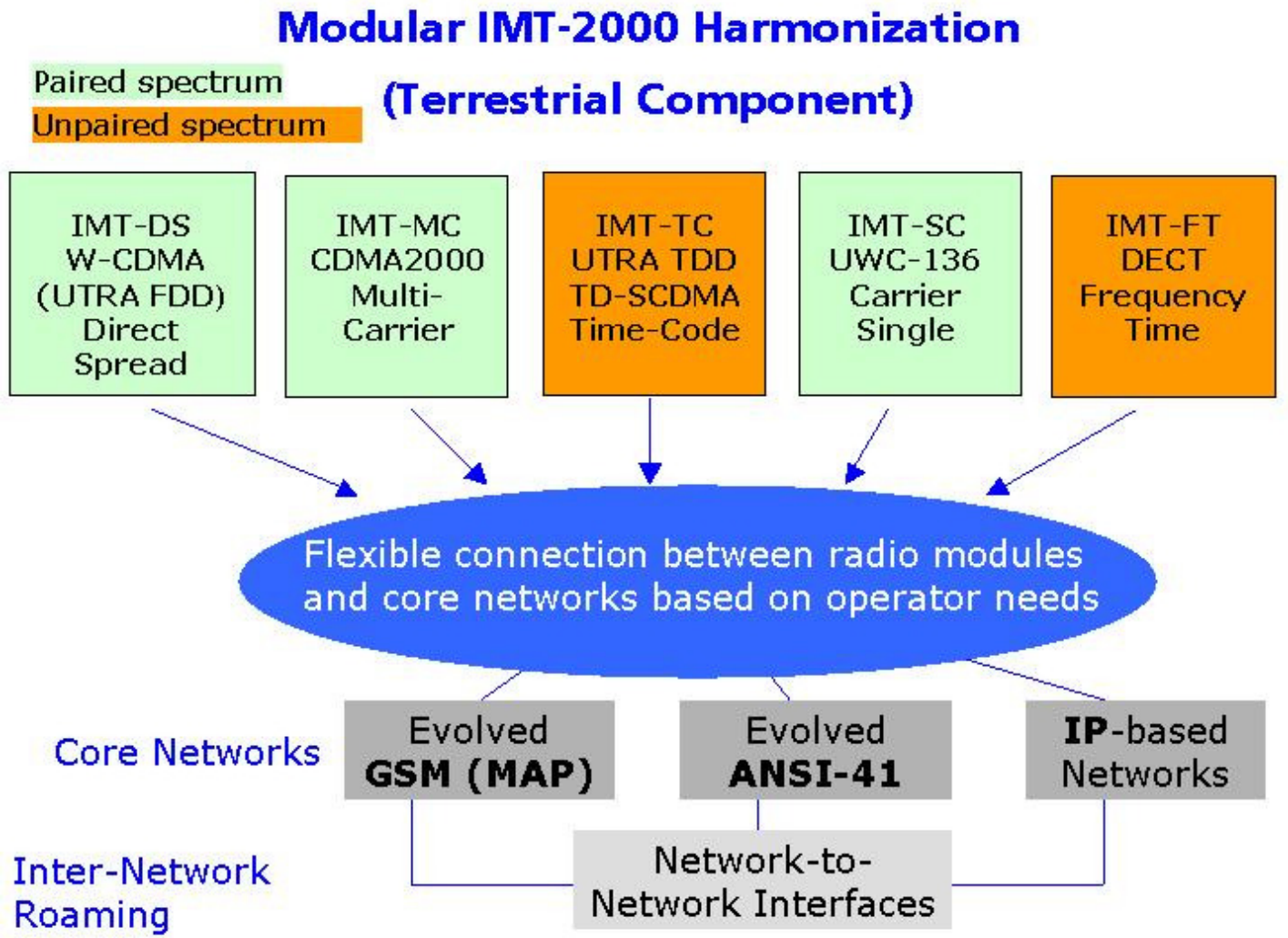


Figure 4. *Wireless mobile system interface definition.*

Elements of UMTS Architecture



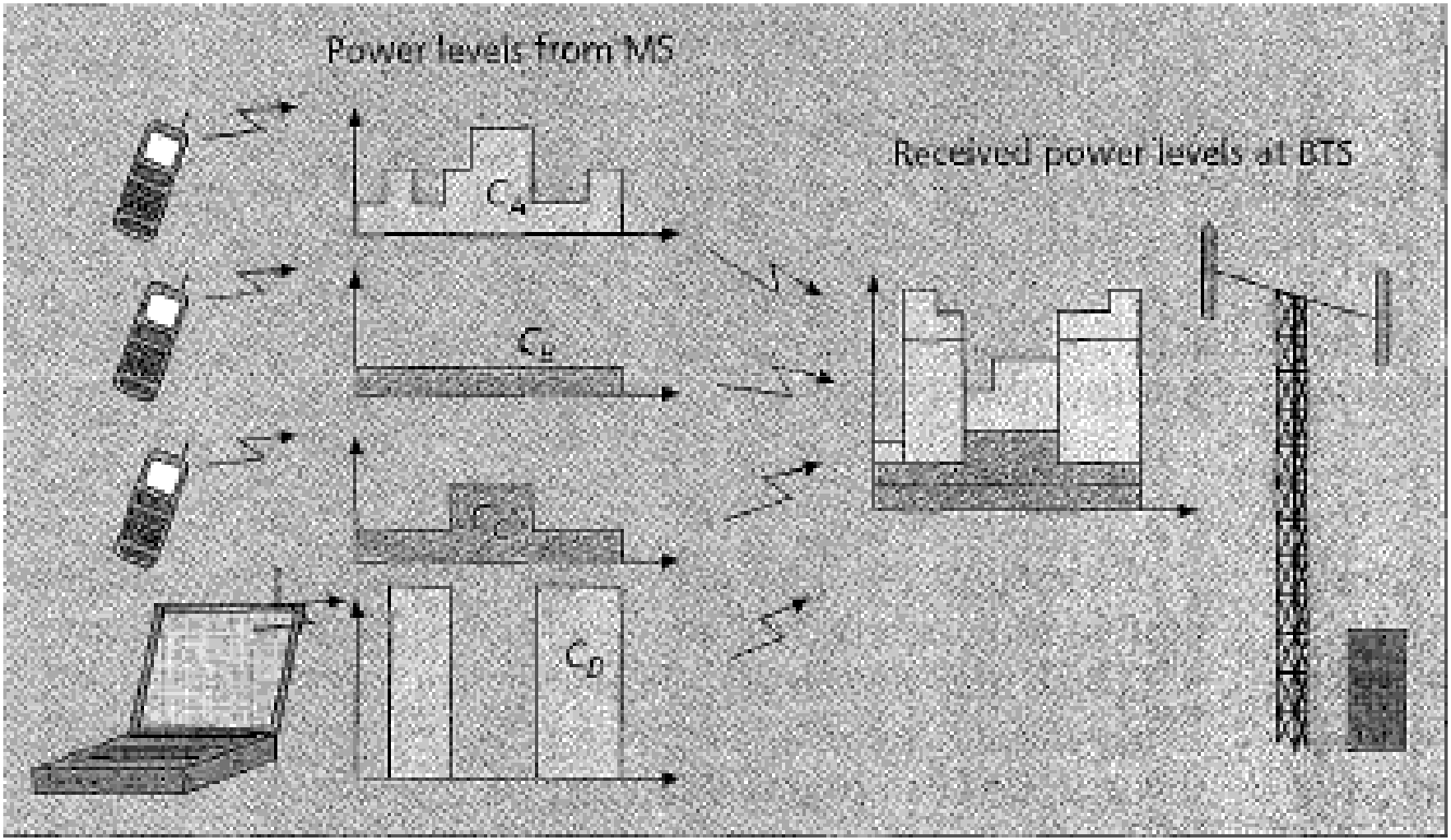
第三代行動電話之技術標準



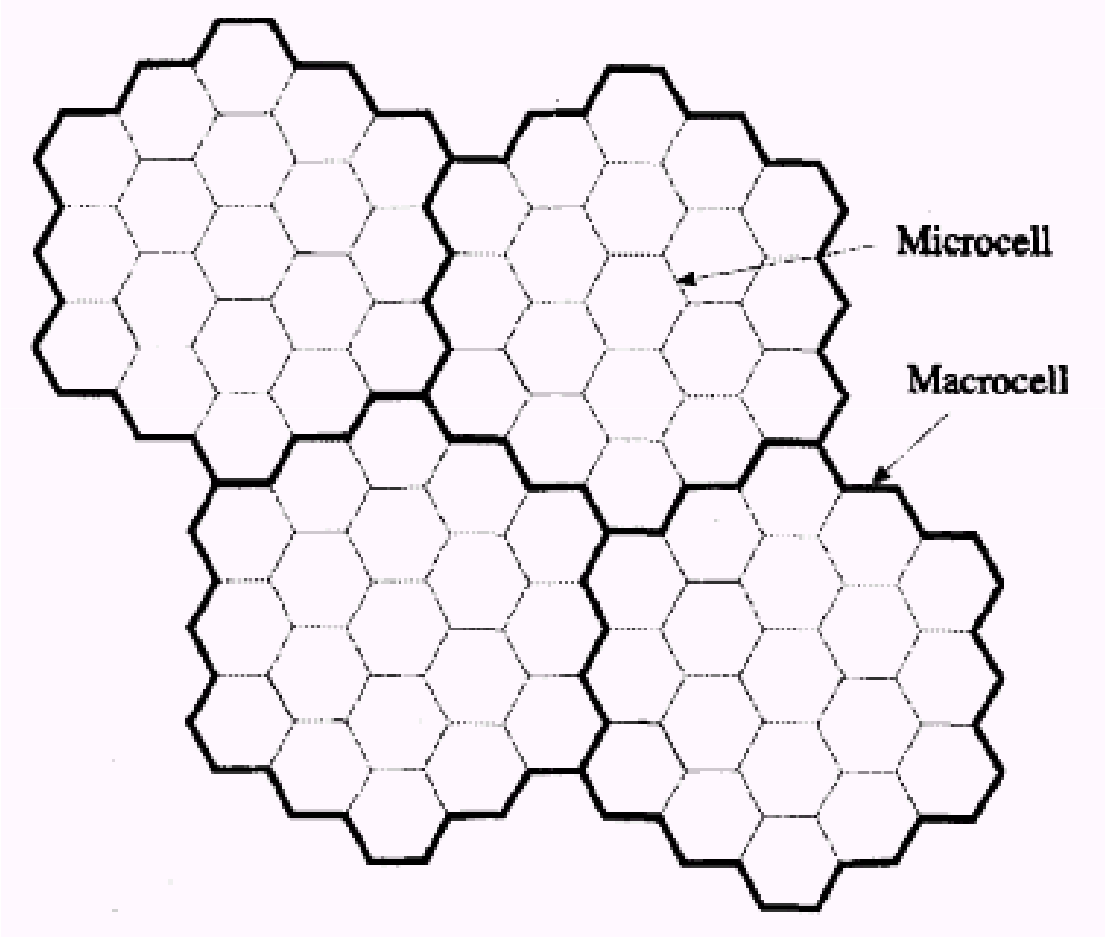
Key W_CDMA Features

- Performance Improvements
  - Capacity Improvements (3 dB, 384 kb/s, 1.9 Mb/s, 130 users)
  - Coverage and Link Budget Improvements (reuse GSM cell, 144 kb/s)
- Service Flexibility
  - Support of a wide range of services with maximum rate of 2 Mb/s, the possibility for multiple parallel services on one connection
  - A fast and efficient packet-access scheme
- Operator Flexibility
  - Support of asynchronous inter-base-station operation
  - Efficient support of different deployment scenarios, HCS, hot-sport
  - Support of evolutionary technologies such as adaptive antenna arrays and multi-user detection
  - A TDD mode designed for efficient operation in uncoordinated environment

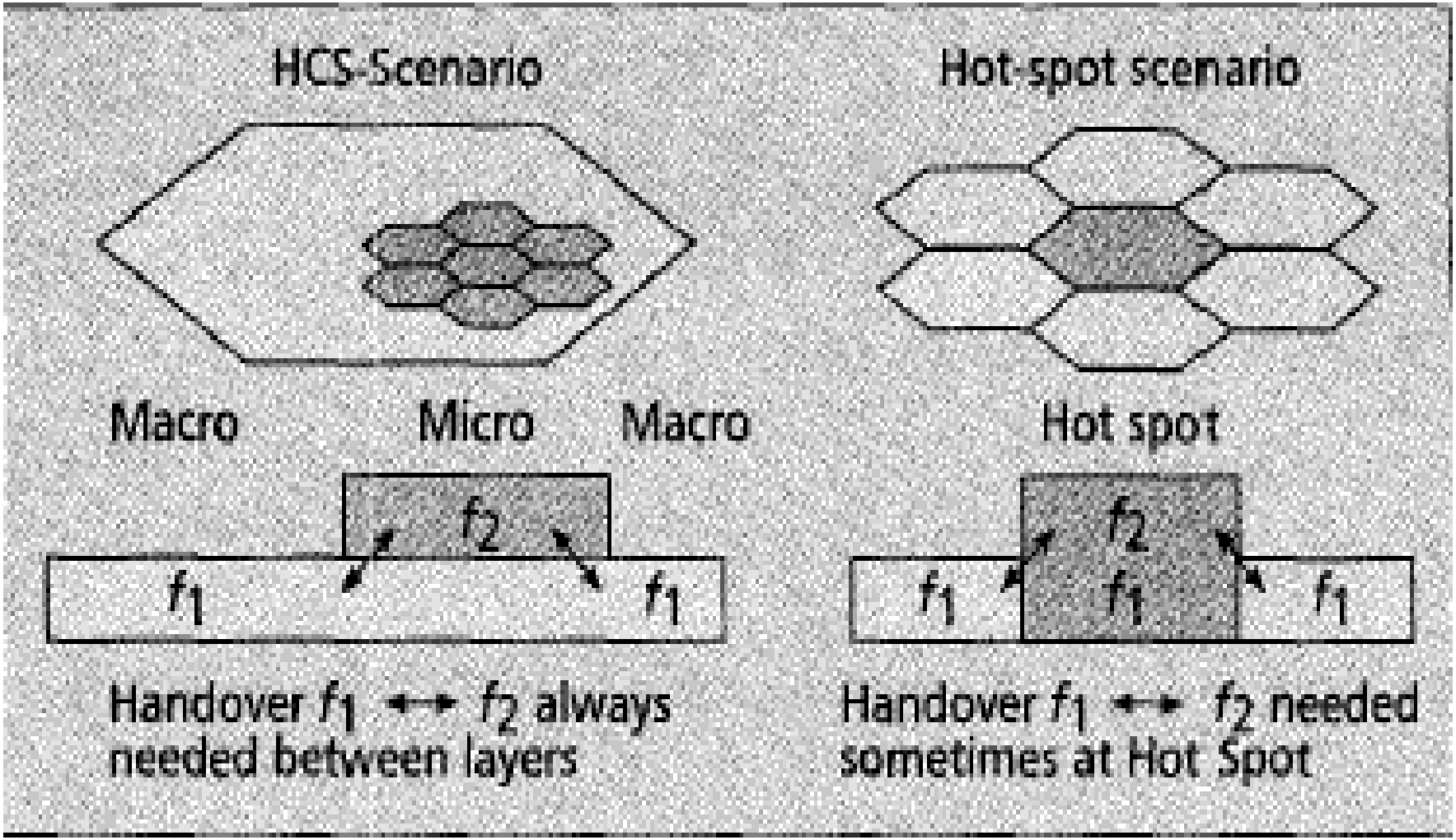
Multiplexing variable bit rate users



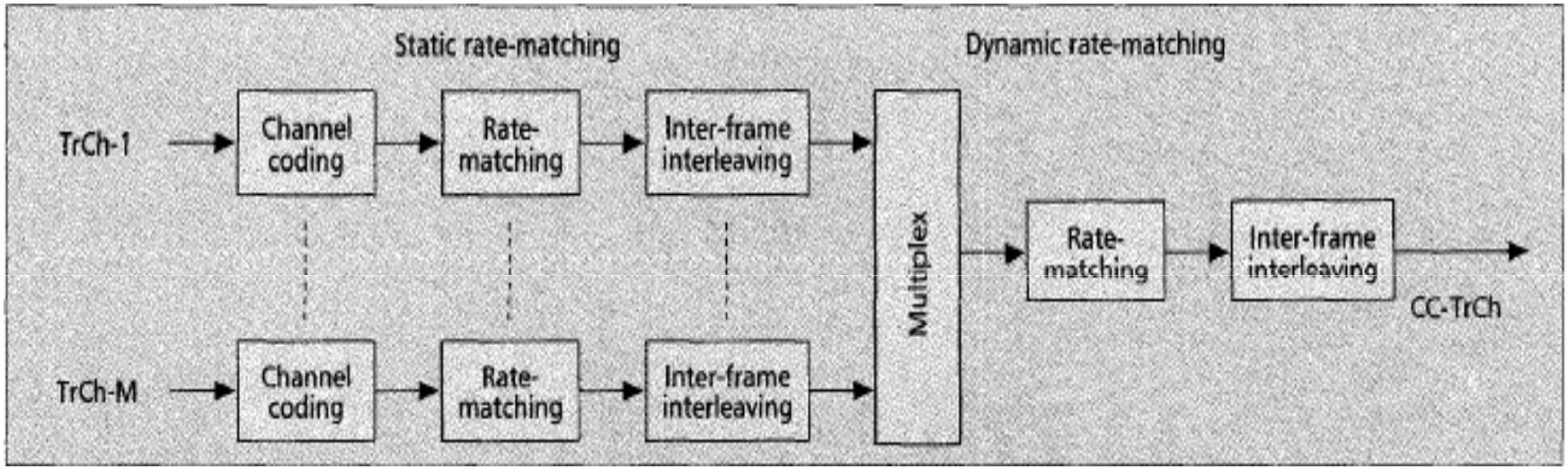
An example of two-tier cellular system



Handoff


HCS-Scenario
Hot-spot scenario
Macro
Micro
Macro
Hot spot
f_2
f_1
f_1
f_2
f_1
f_1
Handover $f_1 \leftrightarrow f_2$ always needed between layers
Handover $f_1 \leftrightarrow f_2$ needed sometimes at Hot Spot

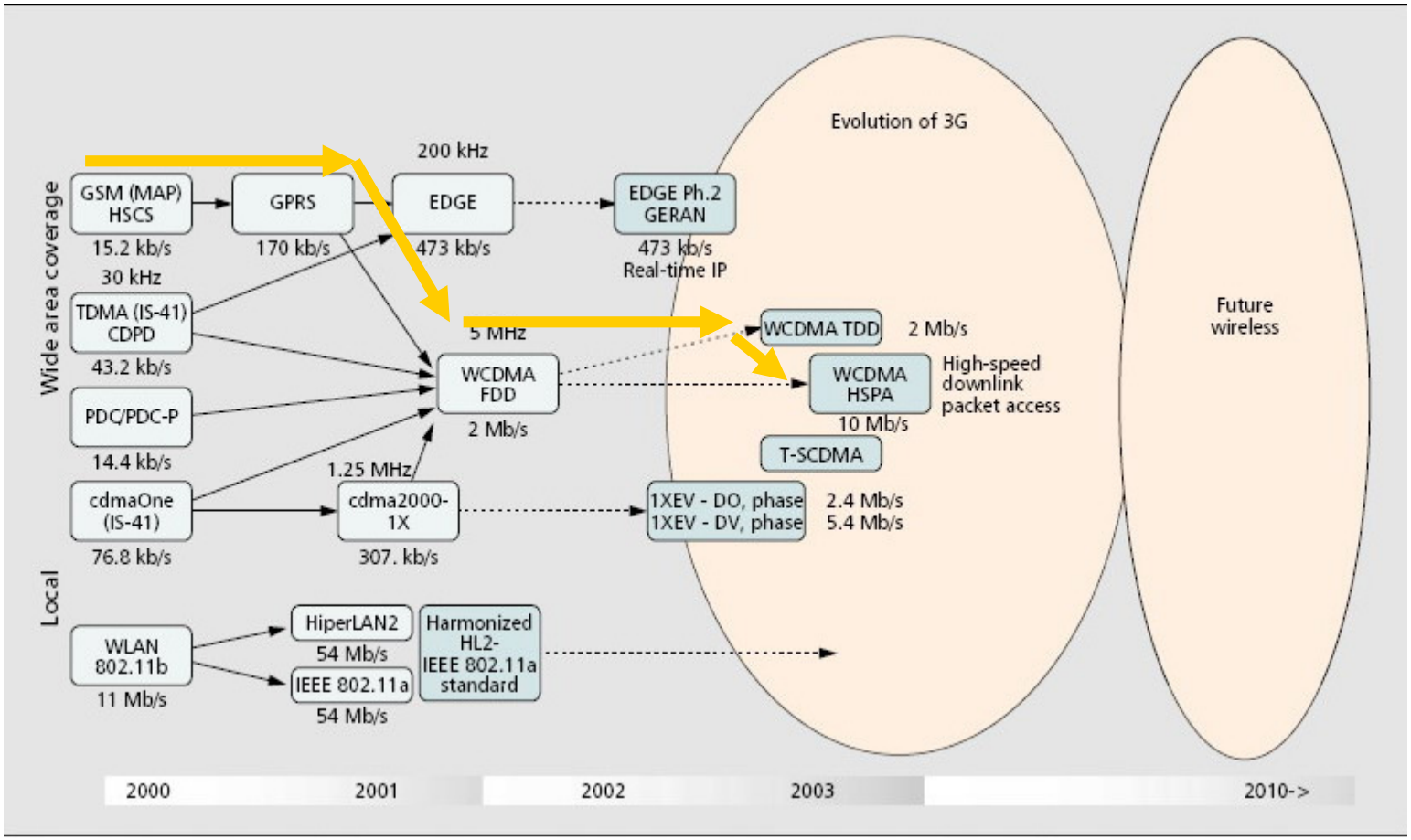
Transport of the channel



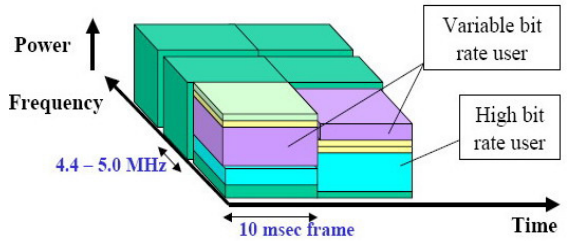
About 3G

- Organization：
  - 3GPP (3rd Generation Partnership Project)
  - 3GPP2 is the standardization group for IS-95 (CDMA)
- IMT-2000 (International Mobile Telephony 2000)
  - global standard proposed by the **ITU**
- IMT-2000 3G standards：
  - TD-SCDMA
  - CDMA2000
  - W-CDMA

Development : 2G to 3G



WCDMA

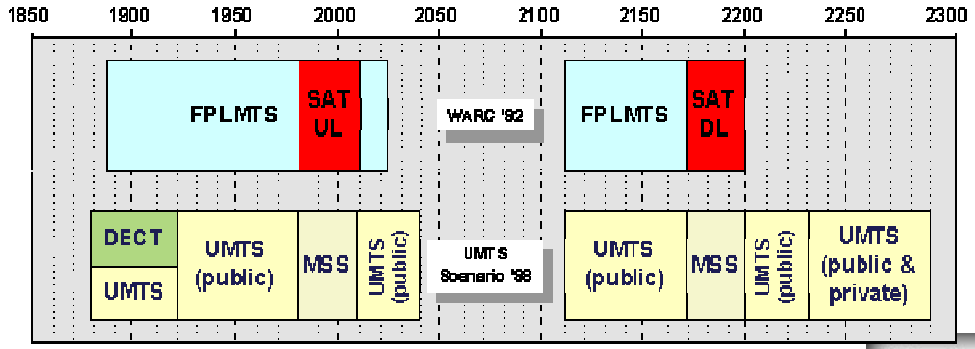


- Wideband CDMA
  - DS-CDMA
  - Use spreading factors 4 - 512 to spread the base band data over ~5MHz band.

Multiple access method	DS-CDMA (Direct-Sequence - CDMA)
Duplex method	FDD / TDD
Chip rate	3.84 Mcps
Frame length	10 msec
Base station frequency	Asynchronous operation
Service multiplexing	Multiple services with different quality of service requirements multiplexed on one connection
Multi-rate concept	Variable spreading factor and multi-code

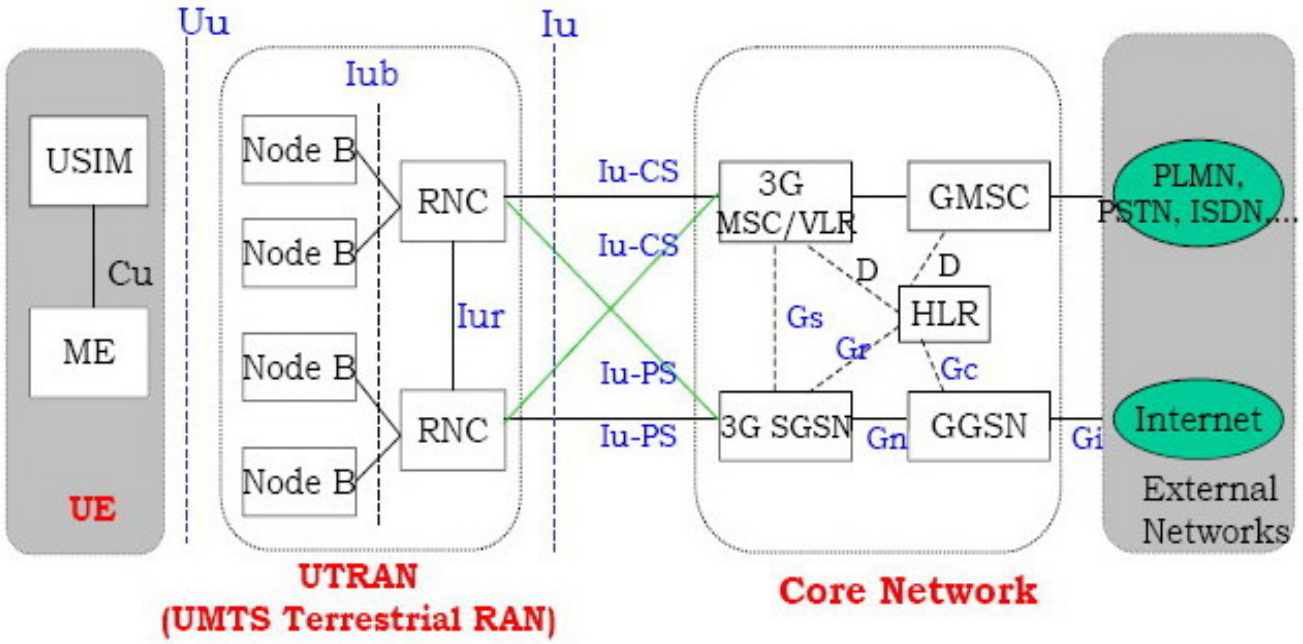
UMTS/WCDMA Features

- Speed：
  - UMTS 384Kbps up to 2Mbps
- Bands：
  - Asia & Europe 2100MHz North America 800 & 1900MHz
- Applications：
  - Email, internet, fax, music, image, video…etc
- Global Access：
  - Users can move between GSM, GPRS and UMTS coverage areas without dropping connections or losing access to their network.



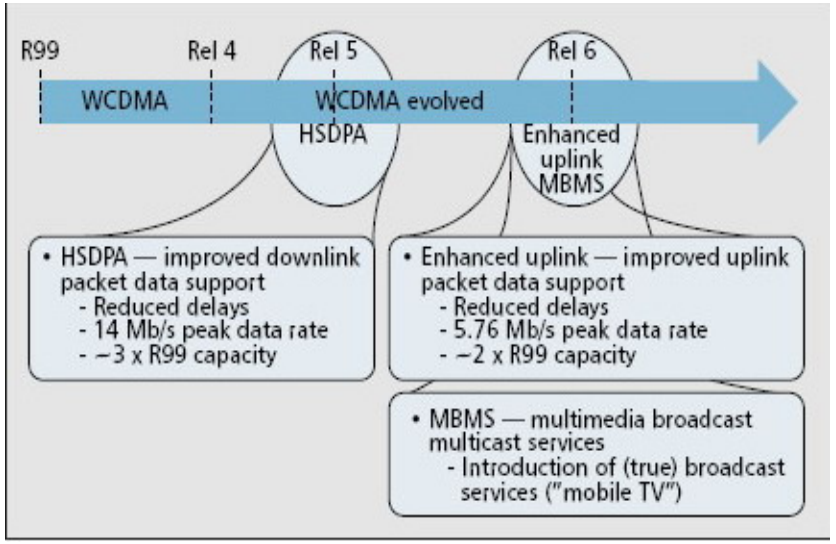
UMTS Architecture

- Core Network ：Connection with External Networks
- UTRAN：Functions about Radio
- UE：communication between air interface and users.

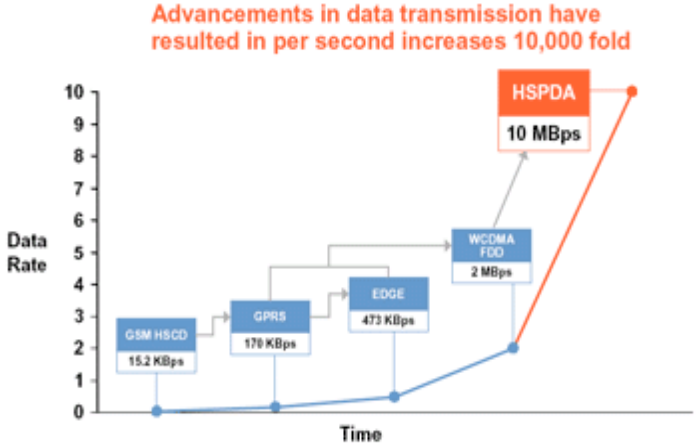


First Step of HSPA - HSDPA

- WCDMA R5
  - Proposed by 3GPP on 2001
  - HSDPA Technique

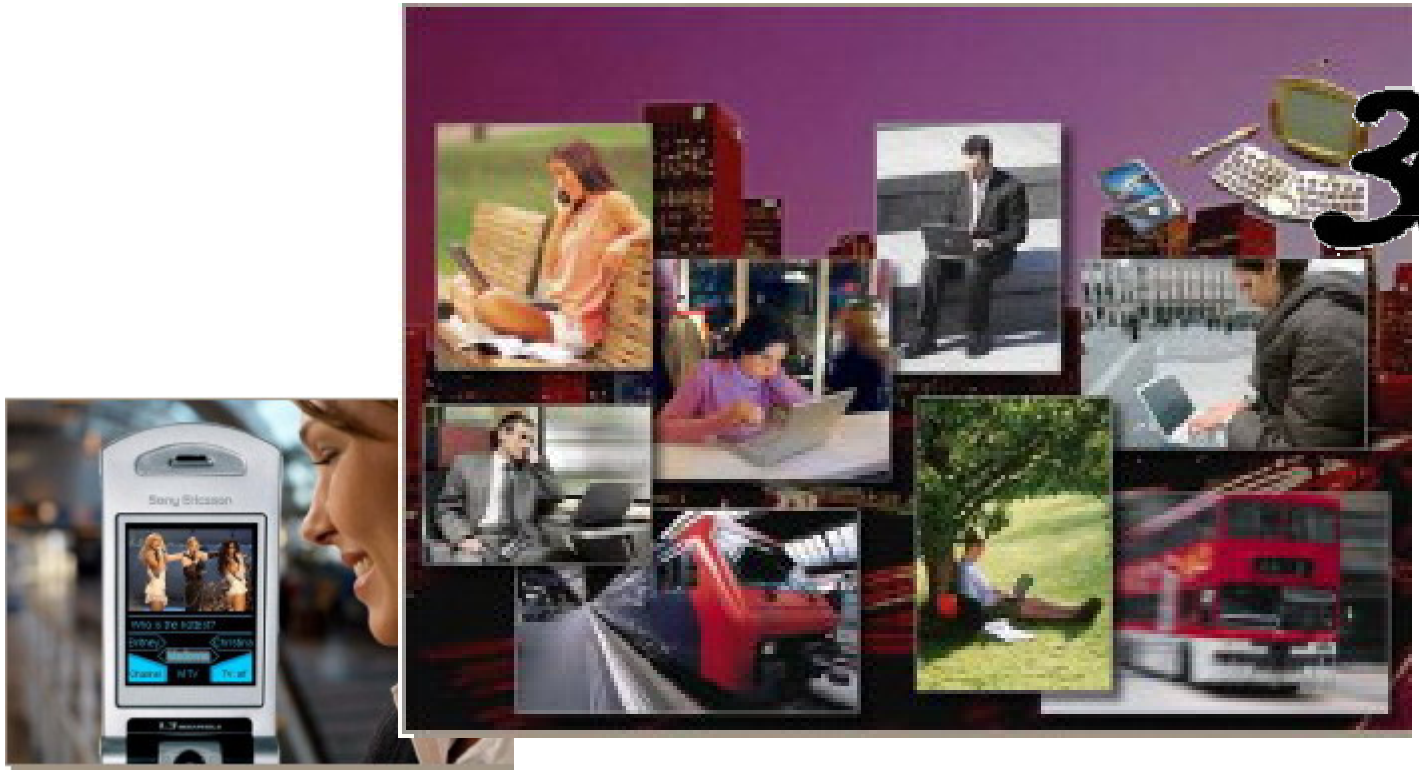


- HSDPA (High Speed Downlink Packet Access)
  - Data rate 3Mbps up to 14Mbps
  - 3 times Capacity
  - Backward compatible with WCDMA



Enhanced WCDMA - 3.5G HSDPA

- Defined in 3GPP Release 5.
- Higher data rate：2Mbps~14Mbps

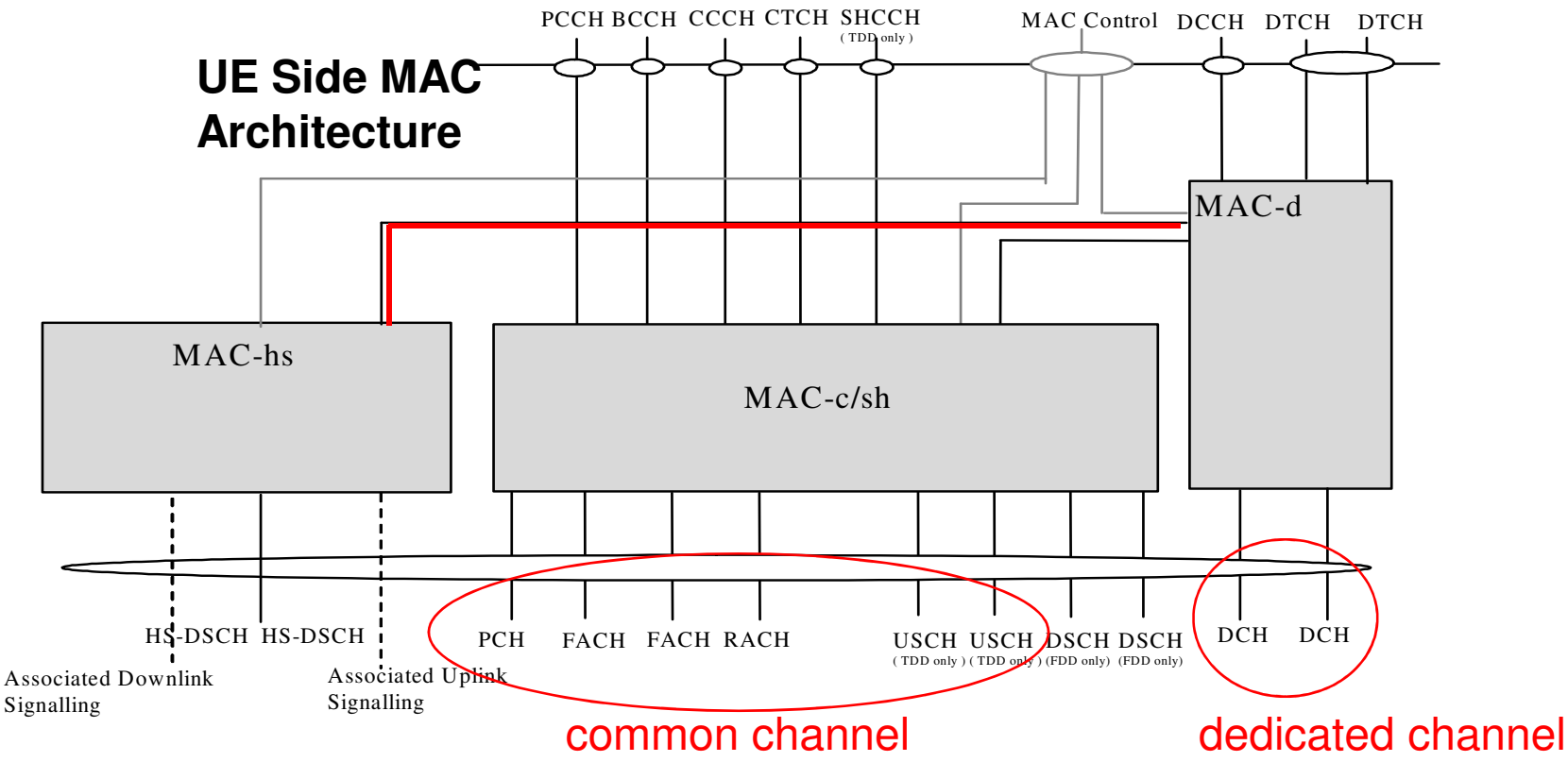


HSDPA Characteristic

- New Transport Channel
  - HS-DSCH
- Short TTI
  - 2ms
- AMC
  - Modulation：
    QPSK(2bits/symbol)
    16QAM(4bits/symbol)
  - Channelized code 1~15
- HARQ
  - SAW HARQ (simplest and little overhead)
- Fast Scheduling
  - Do packet Scheduling and retransmission in Node B

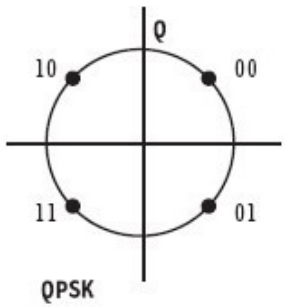
MAC Architecture

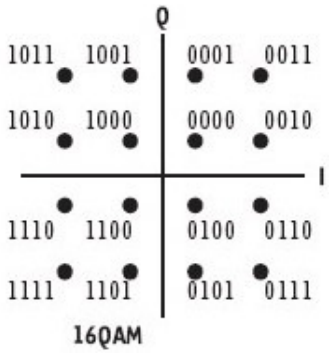
- UTRAN Side MAC entity is similar to the UE side except that there will be one MAC-d for each UE.



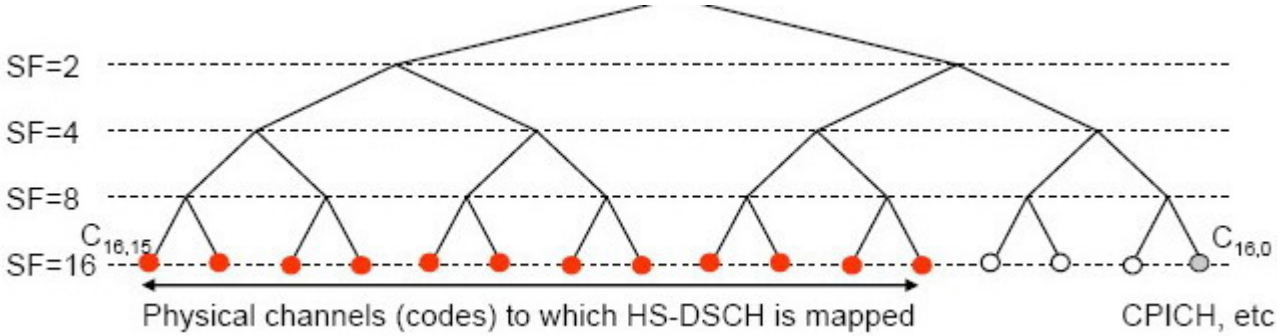
SF and Modulation

- QPSK can show 2 bits per symbol, and 16QAM can show 4 bits per symbol.



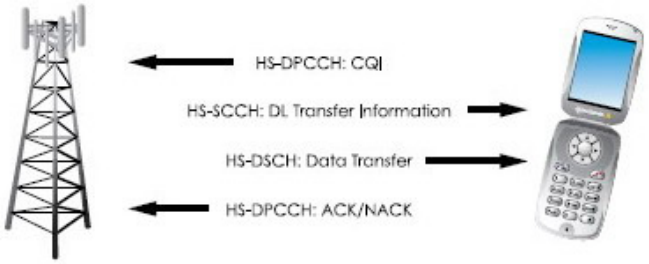


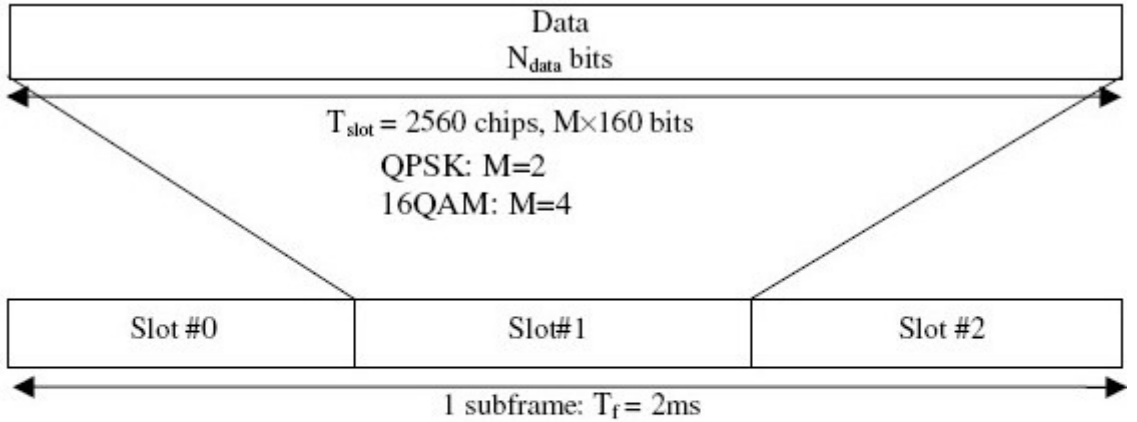
- Channelization code at a fixed SF = 16.



HS-PDSCH

- HS-PDSCH carries the data traffic in terms of MAC-hs PDU.
- Fixed SF=16; up to 15 parallel channels
- 14Mbps = 960 x 15 ~= 14400 kbps

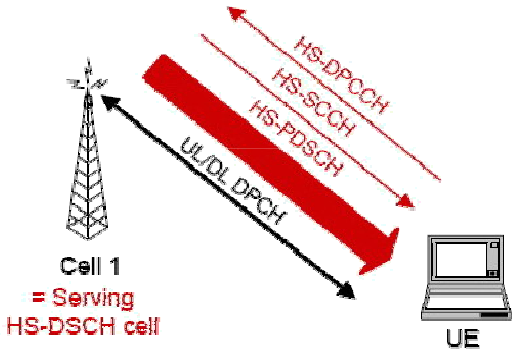


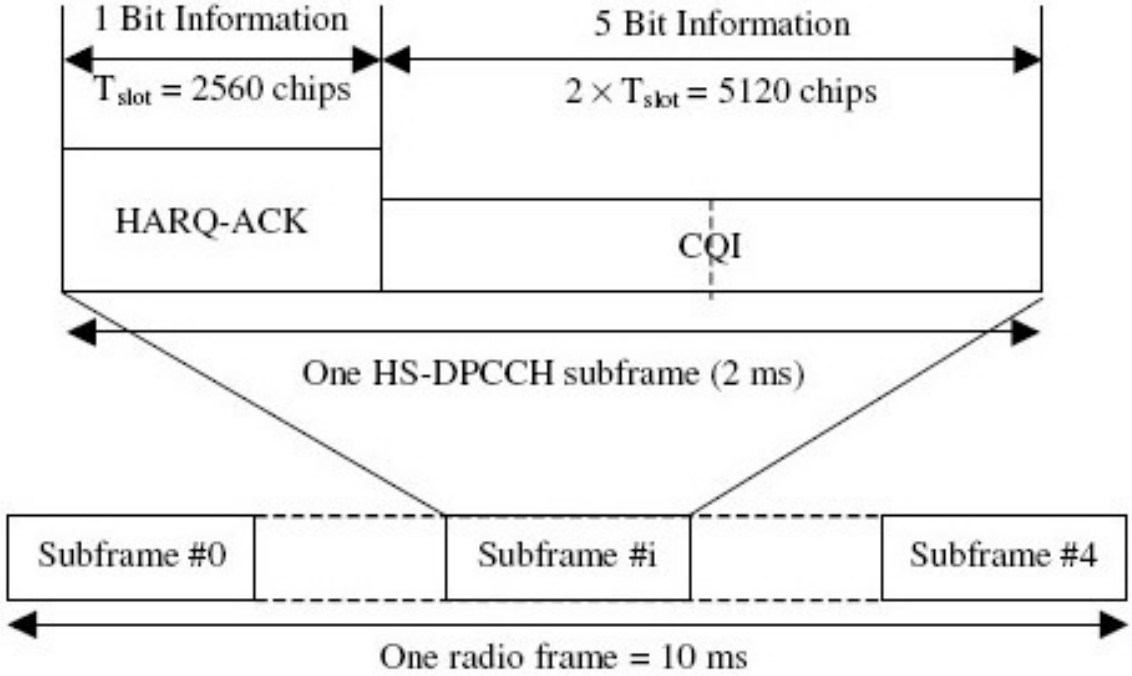


Slot format #I	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ HS-DSCH subframe	N_{data}
0(QPSK)	480	240	16	960	320
1(16QAM)	960	240	16	1920	640

HS-DPCCH

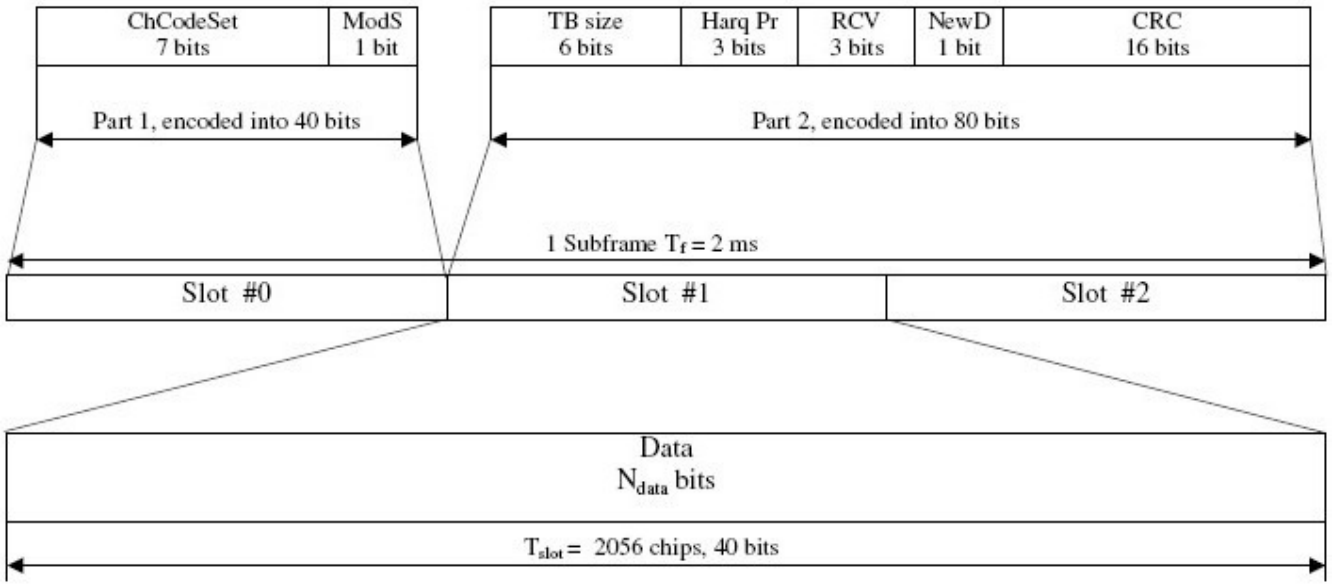
- HS-DPCCH feedbacks ACK/NACK and channel quality information (CQI).
- Fixed SF=256.





HS-SCCH

- Fixed SF=128：UE can monitor up to 4 HS-SCCH simultaneously.
- HS-SCCH signals the configuration to be used next.

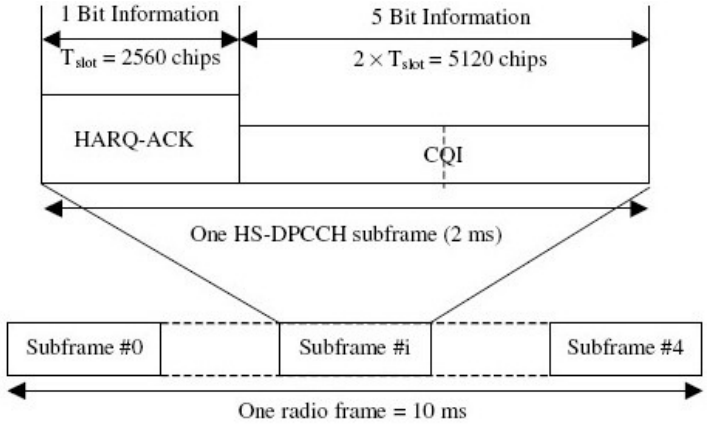


DCH, DSCH and HS-DSCH

Feature	DCH	DSCH	HS-DSCH
Variable SF	Yes (4 ~ 512)	Yes (4 ~ 256)	No (16)
Fast power control	Yes	Yes	No
Modulation	QPSK	QPSK	Adaptive using QPSK ,16QAM
HARQ	No	No	Yes
TTI	10 to 80 ms	10 or 20 ms	2 ms
Multi-Code operation	Yes (up to 6)	Yes (up to 6)	Yes (extended to 15)
Mac Processing	RNC	RNC	Node B

CQI (Channel Quality Indicator)

- Estimate the channel quality from CPICH and feedback CQI via HS-DPCCH cyclically. (In Spec25.331 k = 0,2,4,8,10,20,40,80,160)
- Delay and error of bits affect the accuracy of estimation.
- $$CQI = \begin{cases} 0 & SNR <= -16 \\ \left\lfloor \frac{SNR}{1.02} + 16.62 \right\rfloor & -16 < SNR < 14 \\ 30 & 14 <= SNR \end{cases}.$$



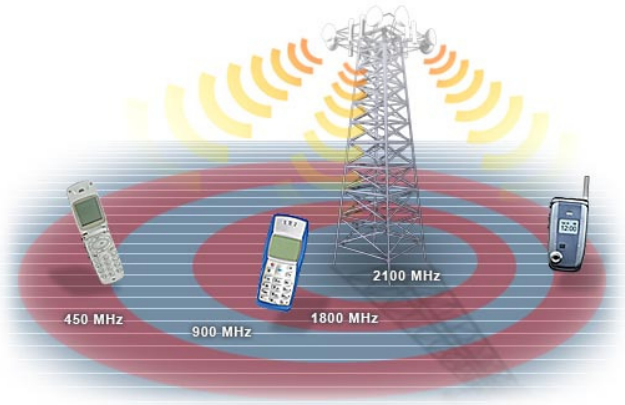
UE Category

- Classify the UE category base on the capability of UE.

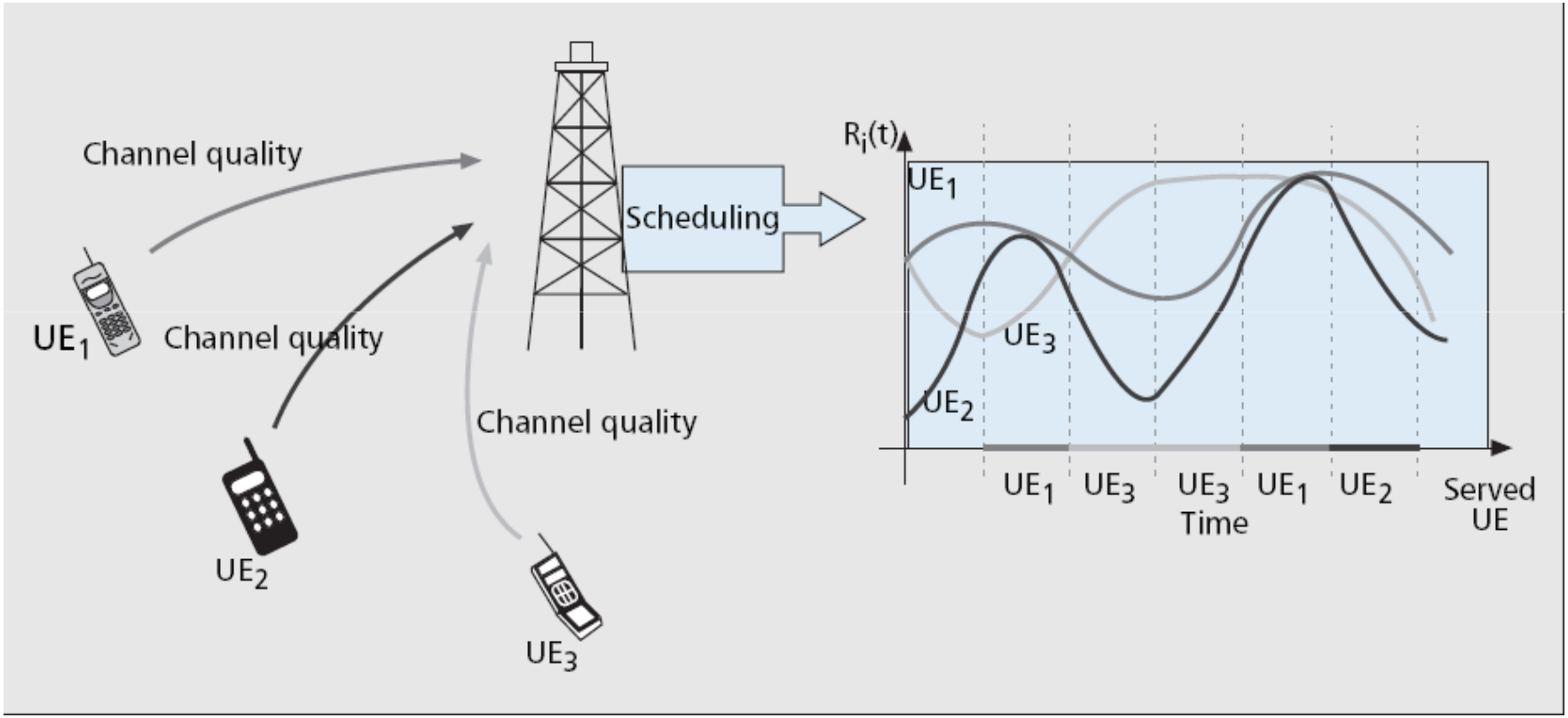
Category	Codes	Inter-TT1	TB Size	Total # of Soft Bits	Modulation	Data Rate
1	5	3	7300	19200	QPSK/16QAM	1.2 Mbps
2	5	3	7300	28800	QPSK/16QAM	1.2 Mbps
3	5	2	7300	28800	QPSK/16QAM	1.8 Mbps
4	5	2	7300	38400	QPSK/16QAM	1.8 Mbps
5	5	1	7300	57600	QPSK/16QAM	3.6 Mbps
6	5	1	7300	67200	QPSK/16QAM	3.6 Mbps
7	10	1	14600	115200	QPSK/16QAM	7.2 Mbps
8	10	1	14600	134400	QPSK/16QAM	7.2 Mbps
9	15	1	20432	172800	QPSK/16QAM	10.2 Mbps
10	15	1	28776	172800	QPSK/16QAM	14.4 Mbps
11	5	2	3650	14400	QPSK only	0.9 Mbps
12	5	1	3650		QPSK only	1.8 Mbps

UE Category 1~6 CQI table

CQI value	Transport Block Size	Number of HS-PDSCH	Modulation	Reference power adjustment Δ	N_{IR}	X_{RV}
0	N/A	Out of range				
1	137	1	QPSK	0	9600	0
2	173	1	QPSK	0		
3	233	1	QPSK	0		
4	317	1	QPSK	0		
5	377	1	QPSK	0		
6	461	1	QPSK	0		
7	650	2	QPSK	0		
8	792	2	QPSK	0		
9	931	2	QPSK	0		
10	1262	3	QPSK	0		
11	1483	3	QPSK	0		
12	1742	3	QPSK	0		
⋮						
20	5887	5	16-QAM	0		
21	6554	5	16-QAM	0		
22	7168	5	16-QAM	0		
23	7168	5	16-QAM	-1		
24	7168	5	16-QAM	-2		
25	7168	5	16-QAM	-3		
26	7168	5	16-QAM	-4		
27	7168	5	16-QAM	-5		
28	7168	5	16-QAM	-6		
29	7168	5	16-QAM	-7		
30	7168	5	16-QAM	-8		



Scheduling based on User Channel Quality (CQI),IEEE Network 2007



Round Robin vs. Proportional Fair Scheduler

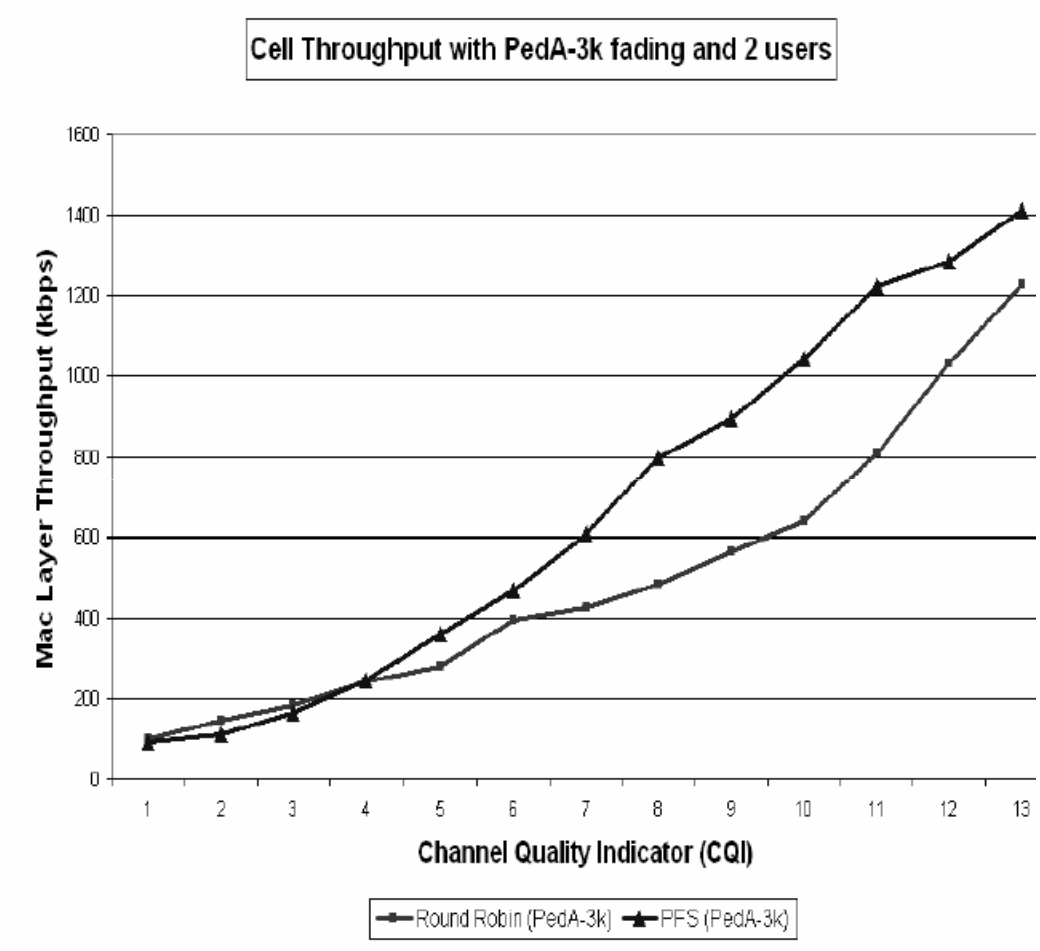
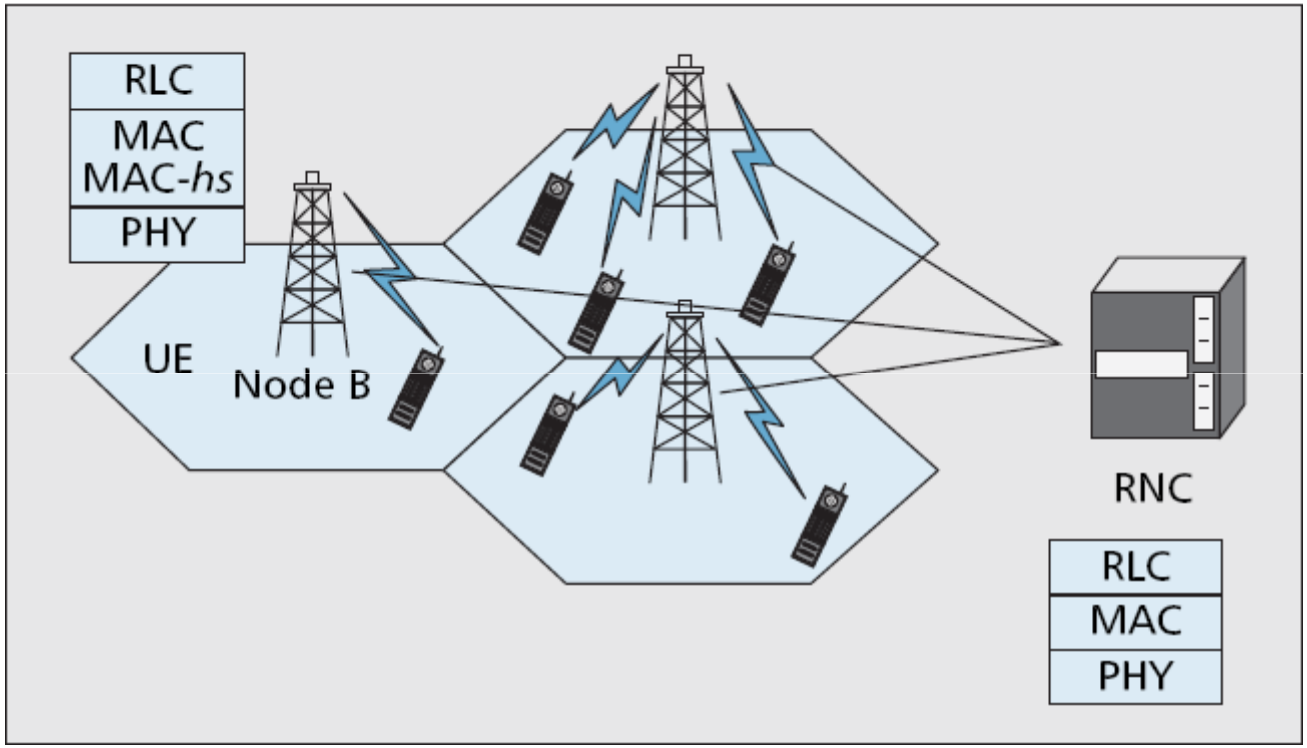
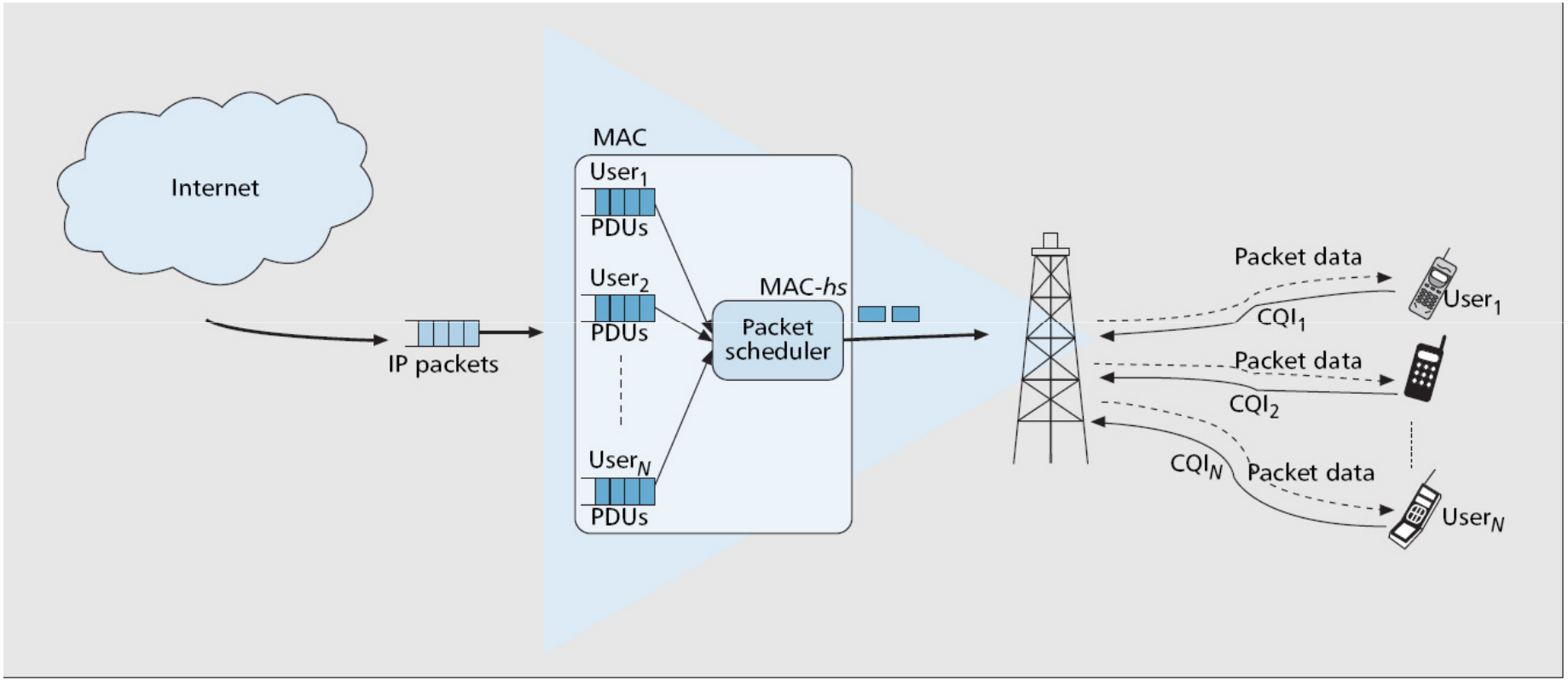


Fig. 1. Performance comparison between Proportional Fair Scheduler and Round Robin in lab, in a low mobility scenario (Ped A)

Scheduling from RNC to Basestation (Node B)



Packet Scheduler Model in HSDPA



Performance of HSDPA, IEEE VTJ 2007

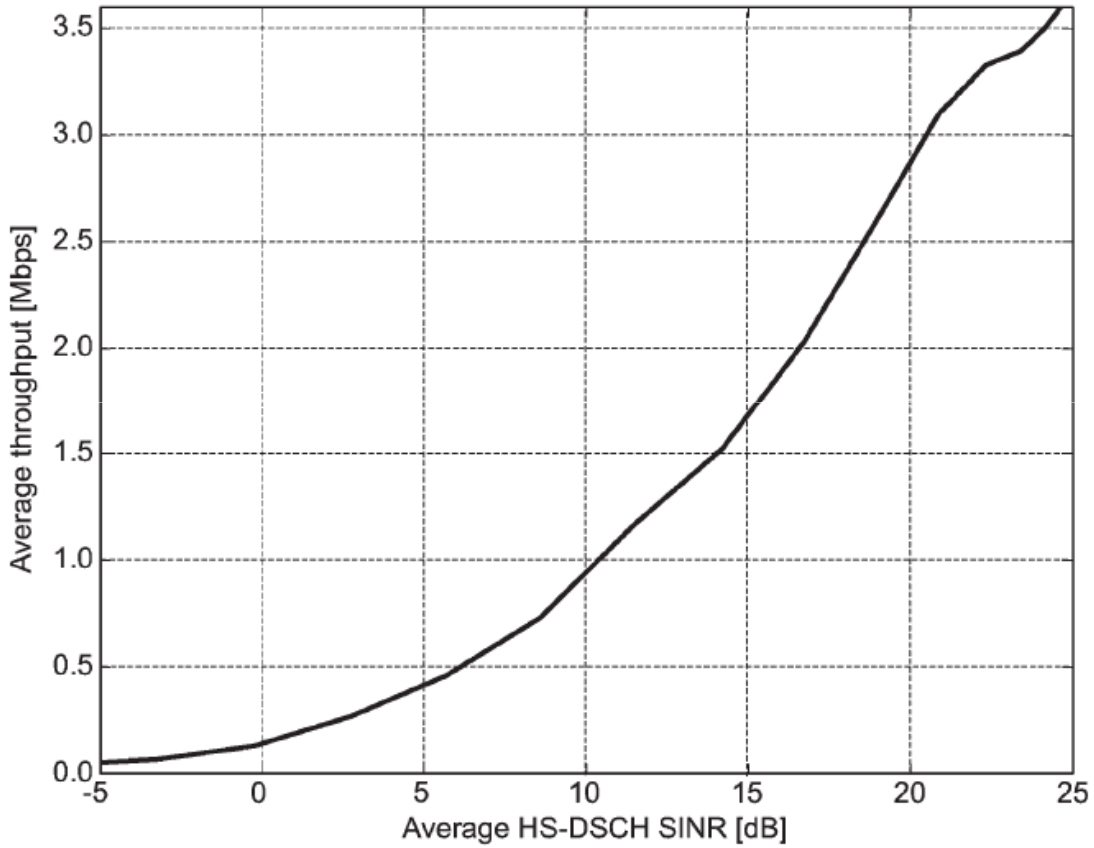


Fig. 5. Single-user HSDPA throughput as a function of the average HS-DSCH SINR.

DCH vs HSPDA

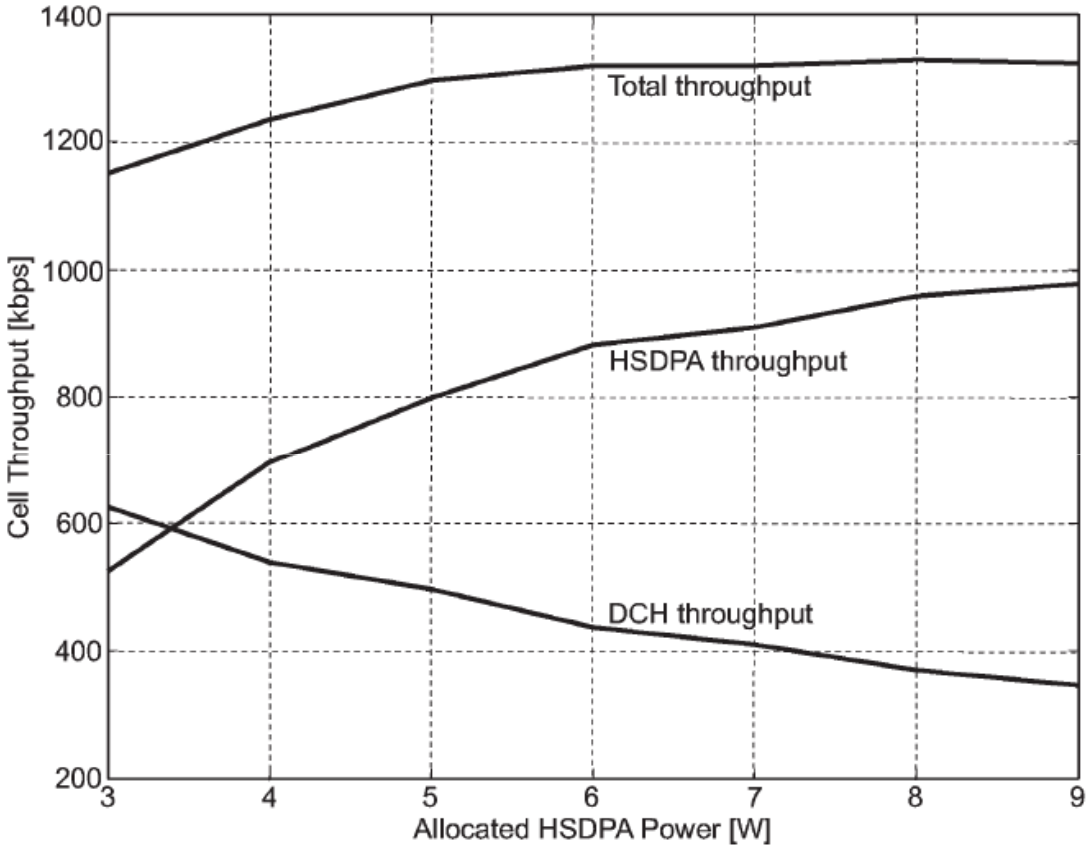


Fig. 7. Average cell throughput versus the allocated HSDPA power. PF scheduling is assumed, with five HS-PDSCH codes and six HSDPA users per cell.

System Architecture

Teacher

teaching material

children

interactive

parents

monitor

PCB layout

接收傳送模組

Bluetooth

mic

Speaker

3G監控模組

SPCE061A

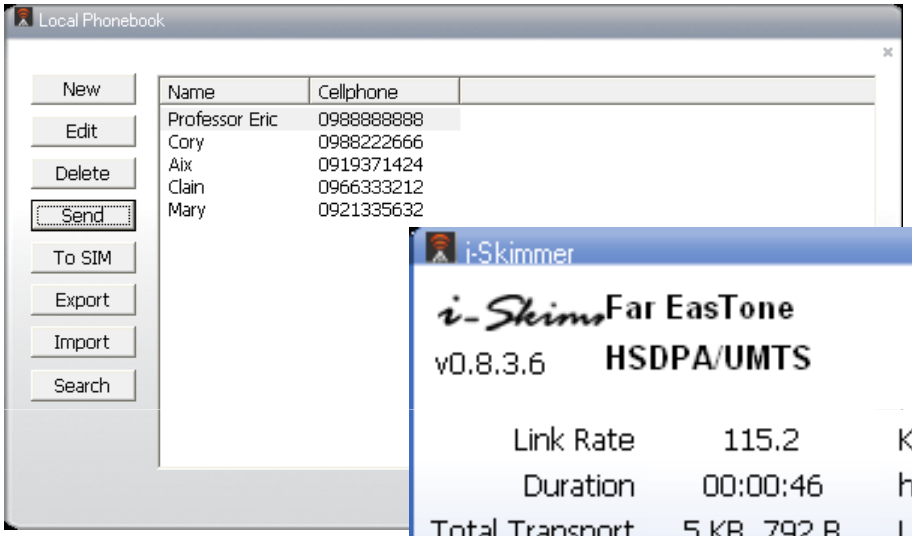
互動模組

語音辨識

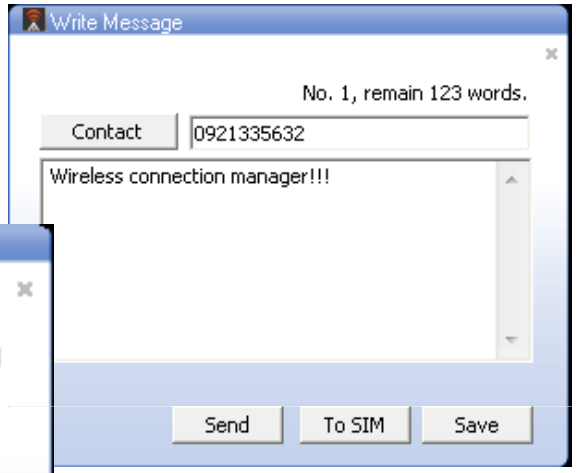
Wii remote

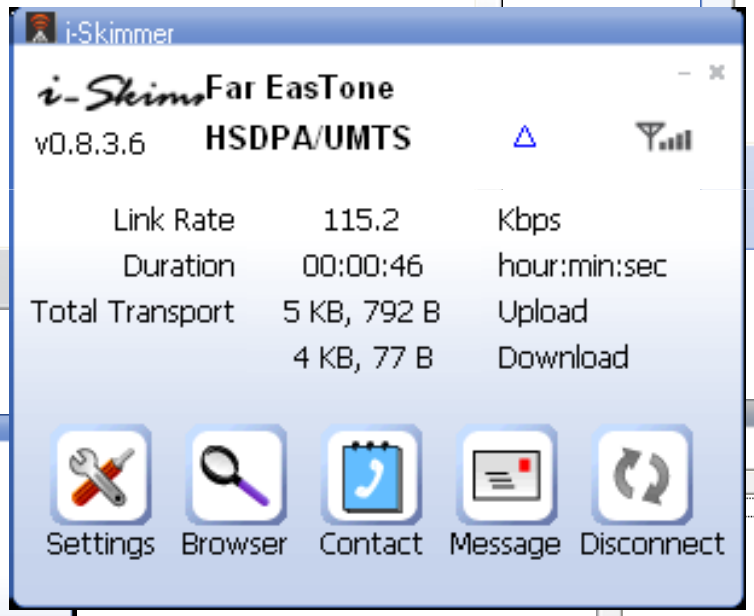
Interface and Use Scenario

Contacts

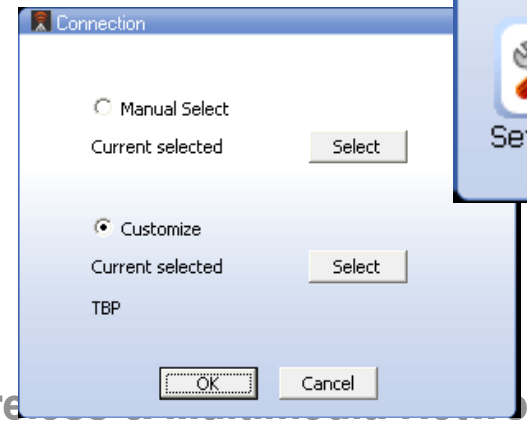


Writing SMS

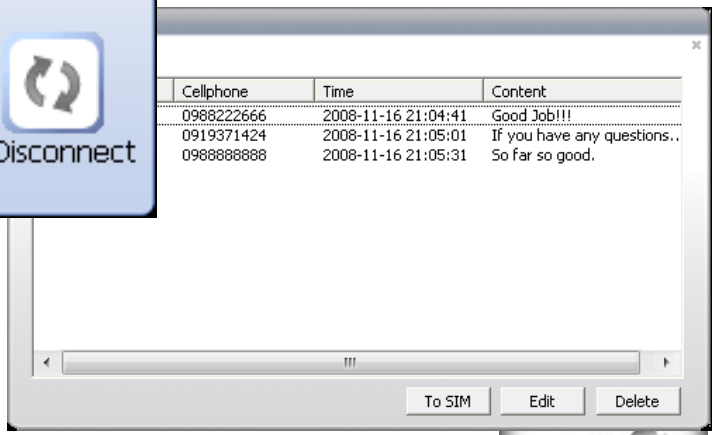




Connection Setting



Reading SMS



Interface and Use Scenario

login

Contacts

Message box

Writing MMS

VoIP call