

無線網路多媒體系統

Wireless Multimedia System

Lecture 6: CDMA & 3G Trend

吳曉光博士

<http://wmlab.csie.ncu.edu.tw/course/wms>

We
provide
無線網路多媒體實驗室
Wireless
Wireless Network & Multimedia Laboratory
Solution

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

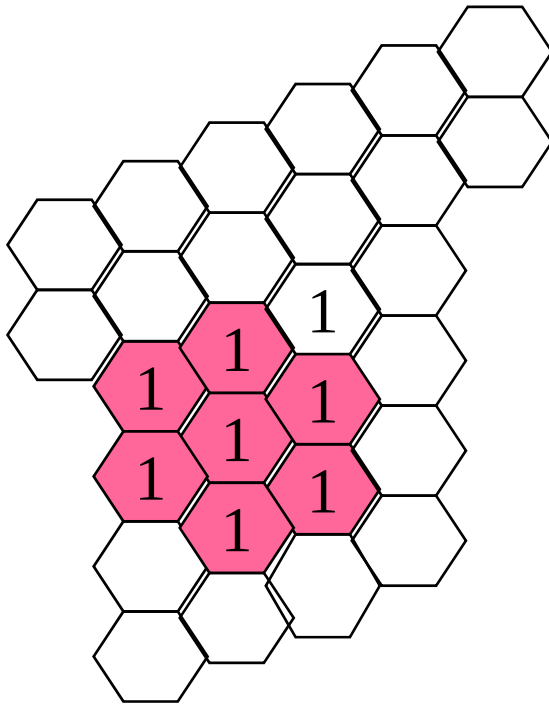


Code Division, Spread Spectrum



**What is Going to Happen
in CDMA?**

Direct Sequence Cellular

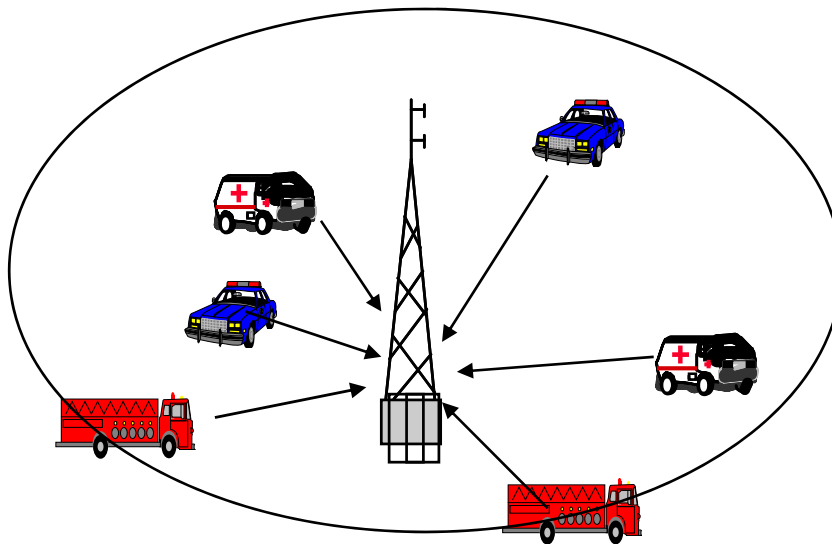


Idealized grid of
Hexagonal cells

- ◆ 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)

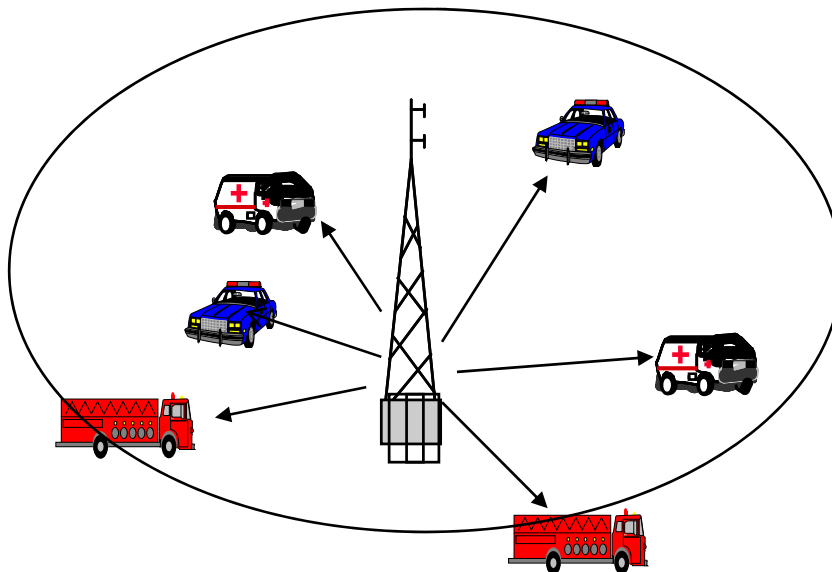


Everybody has a
Code (PN),
asynchronous



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)

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

$$M \sim \frac{2}{3} \frac{G}{\left(\frac{E_b}{\eta_0}\right)} \frac{1}{(1+K)\alpha}$$

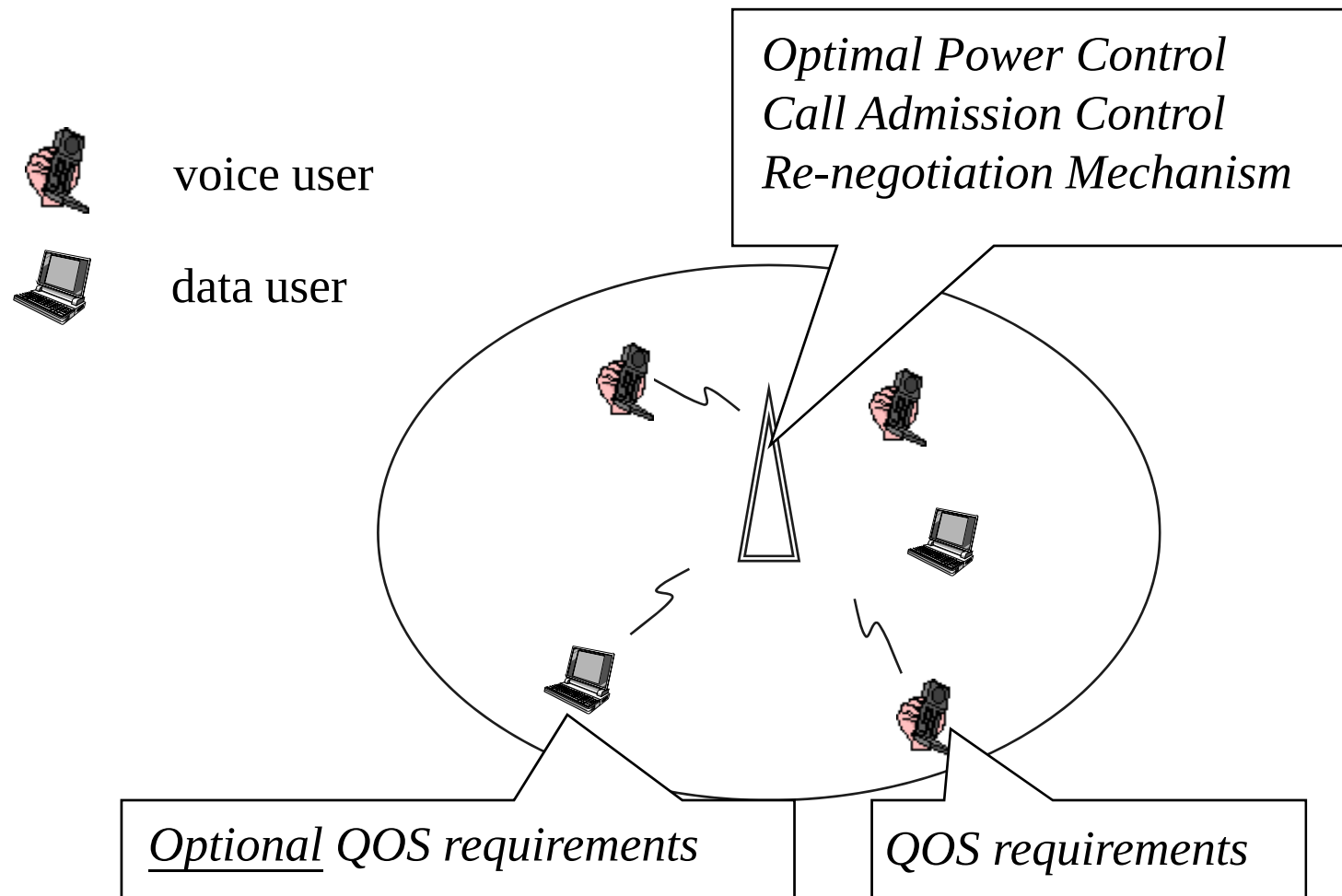


Radio Resource Management

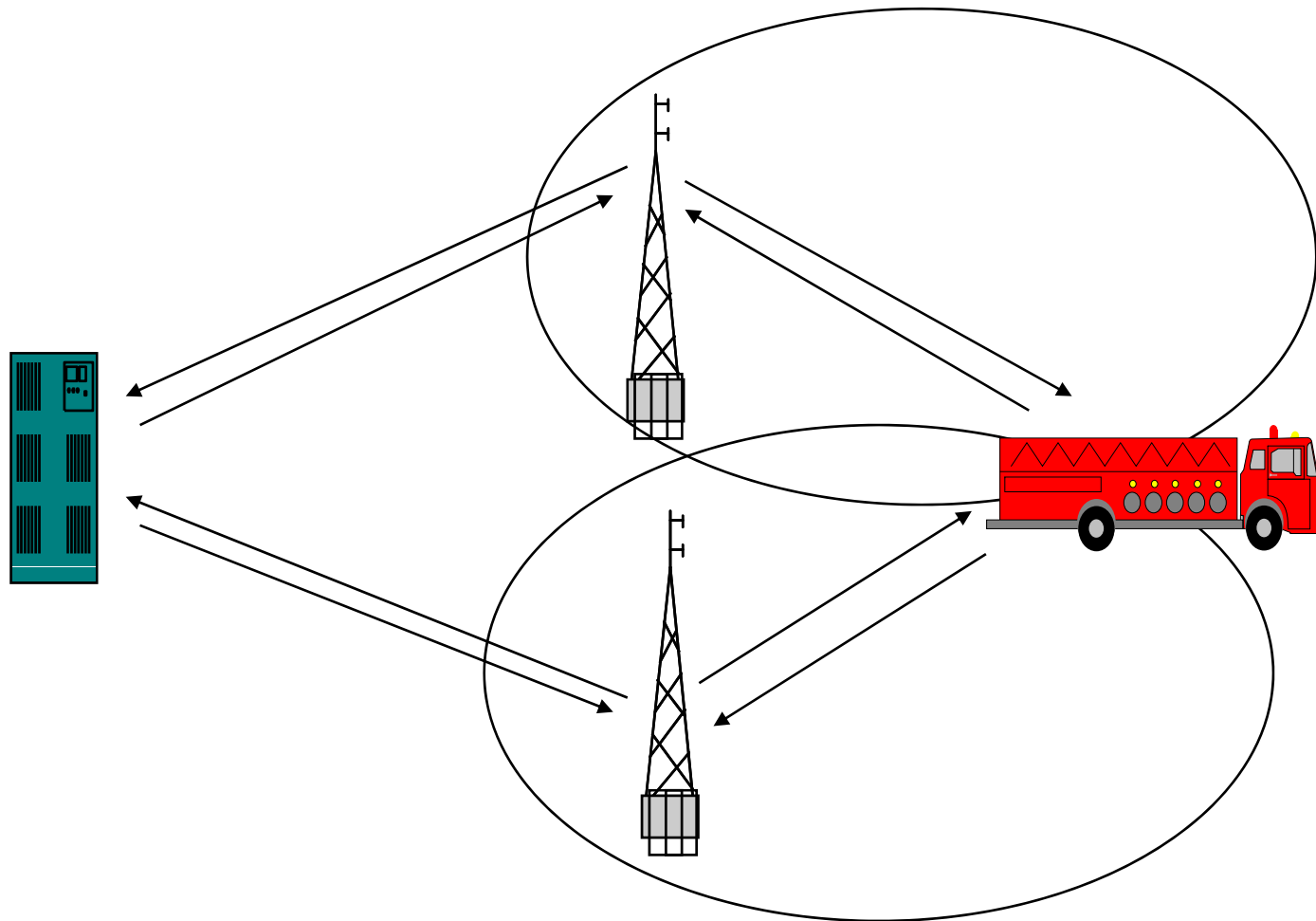
- ◆ Power as the common resource makes W-CDMA very flexible
 - Link improvement, less power, more capacity
- ◆ Orthogonal variable spreading factor (OVSF) for variable bit rate



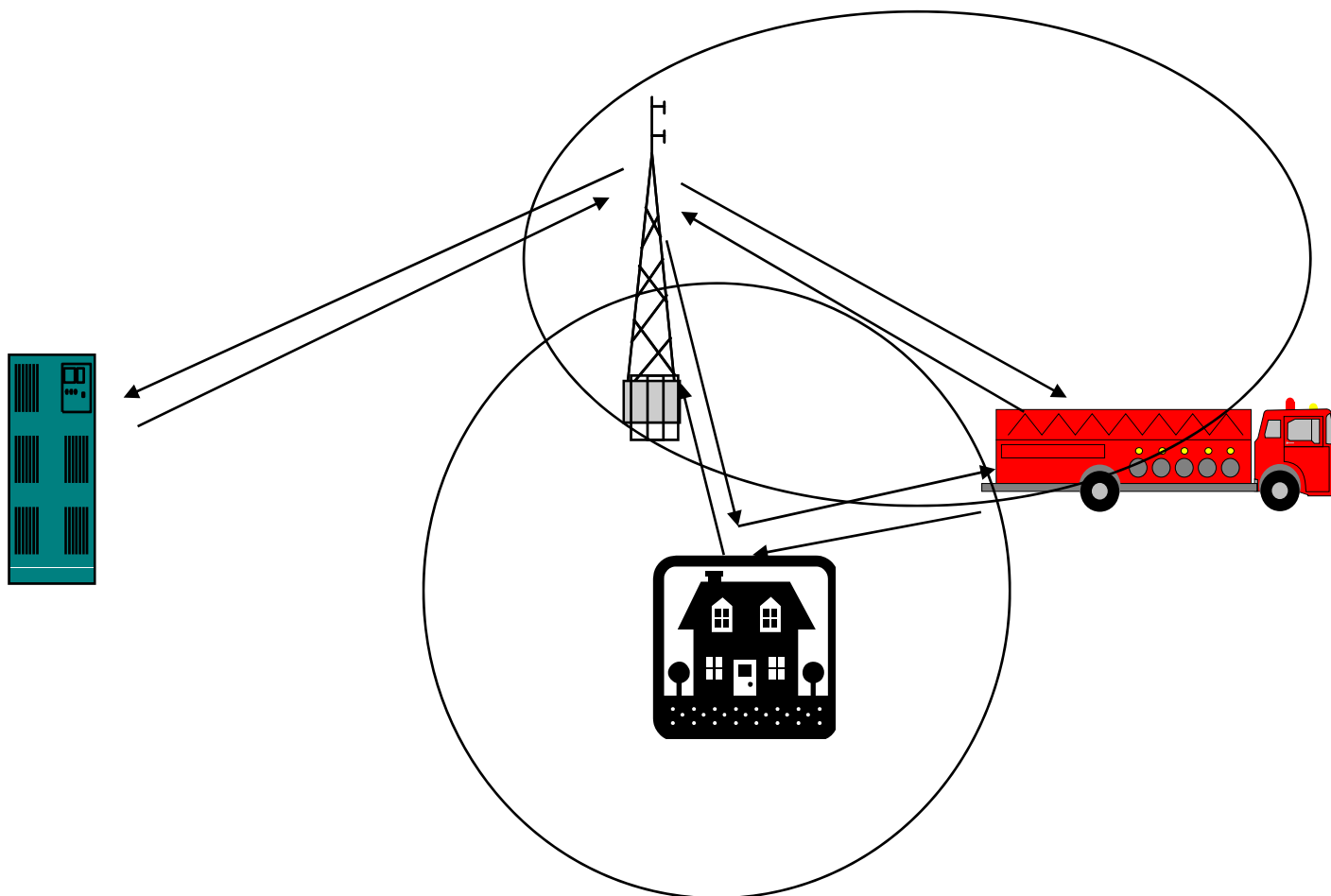
Call Admission Control



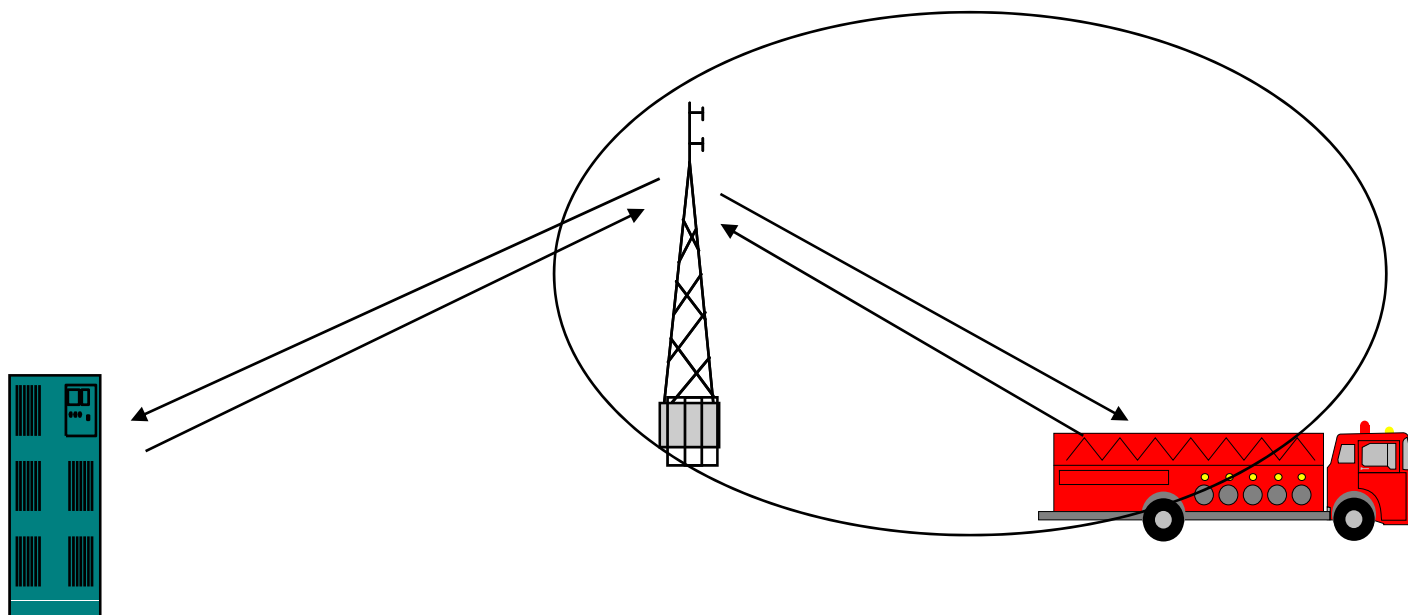
Soft Handovers (Macro Diversity)



Softer Handovers (Space Diversity)

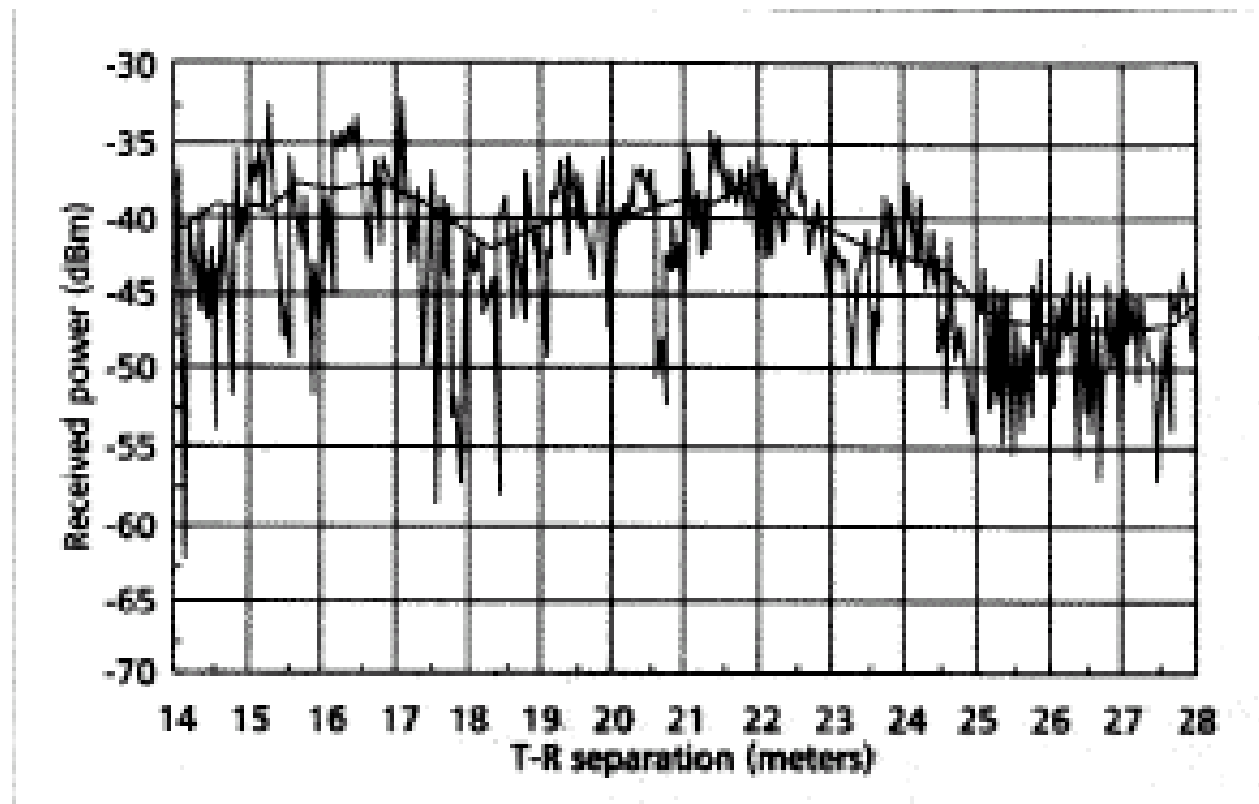


Power Control (Open & Close Loop)



Close-Loop Power Control

- ◆ Compensates a fading channel (1500 times per second)



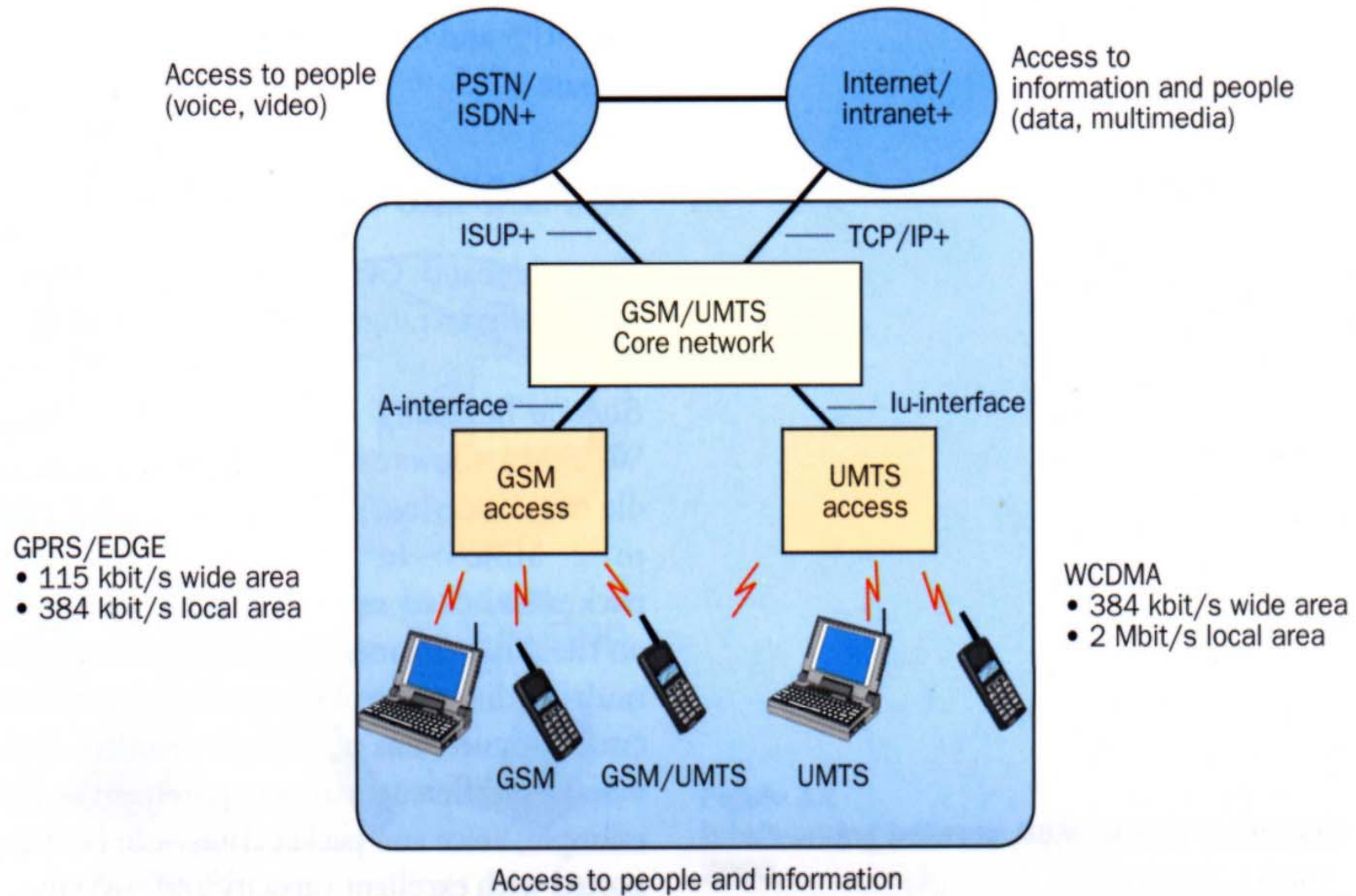
UMTS/IMT-2000 Based on Wideband CDMA



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



RS Spectrum Allocation

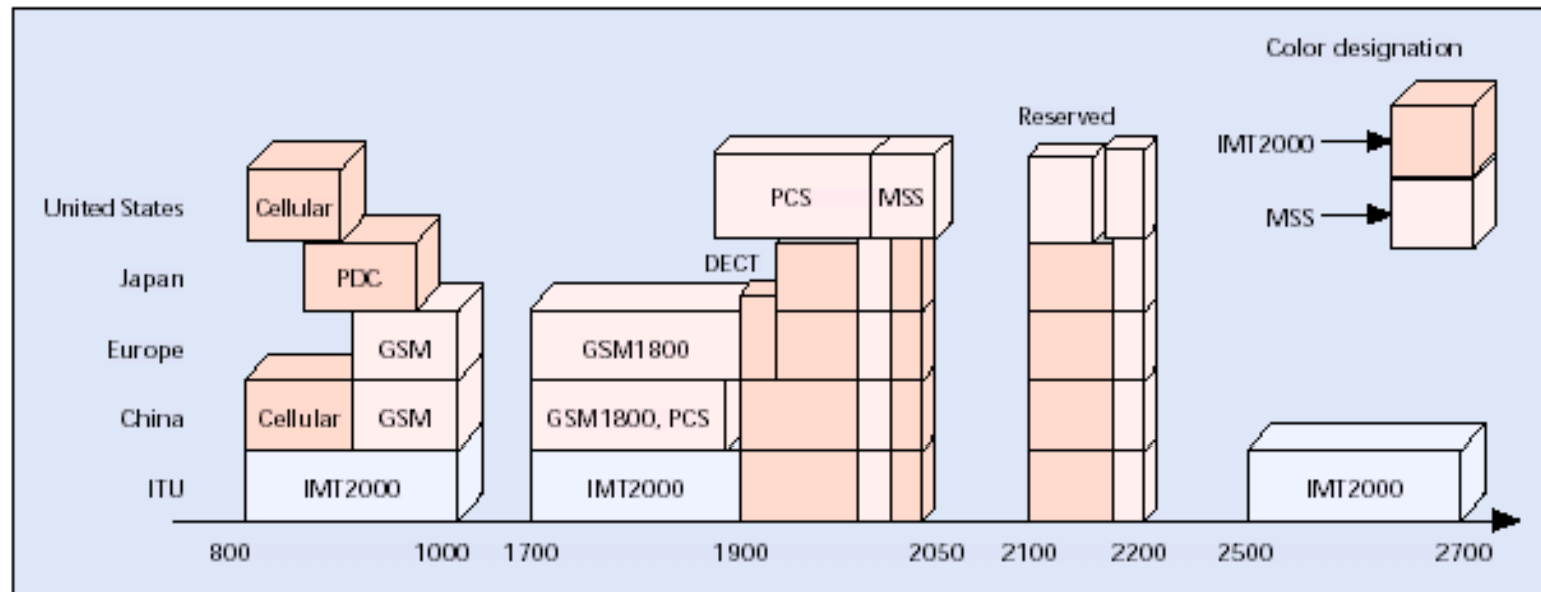
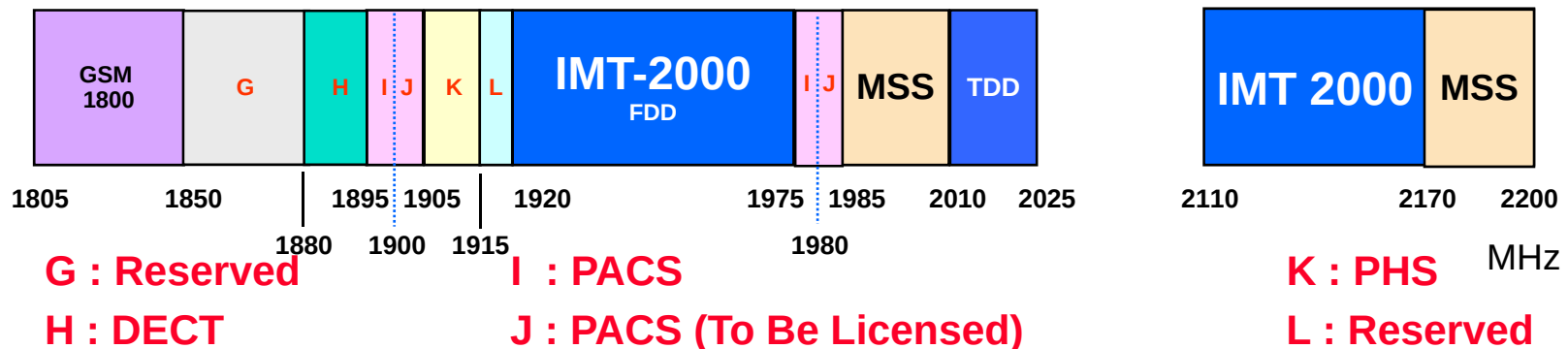
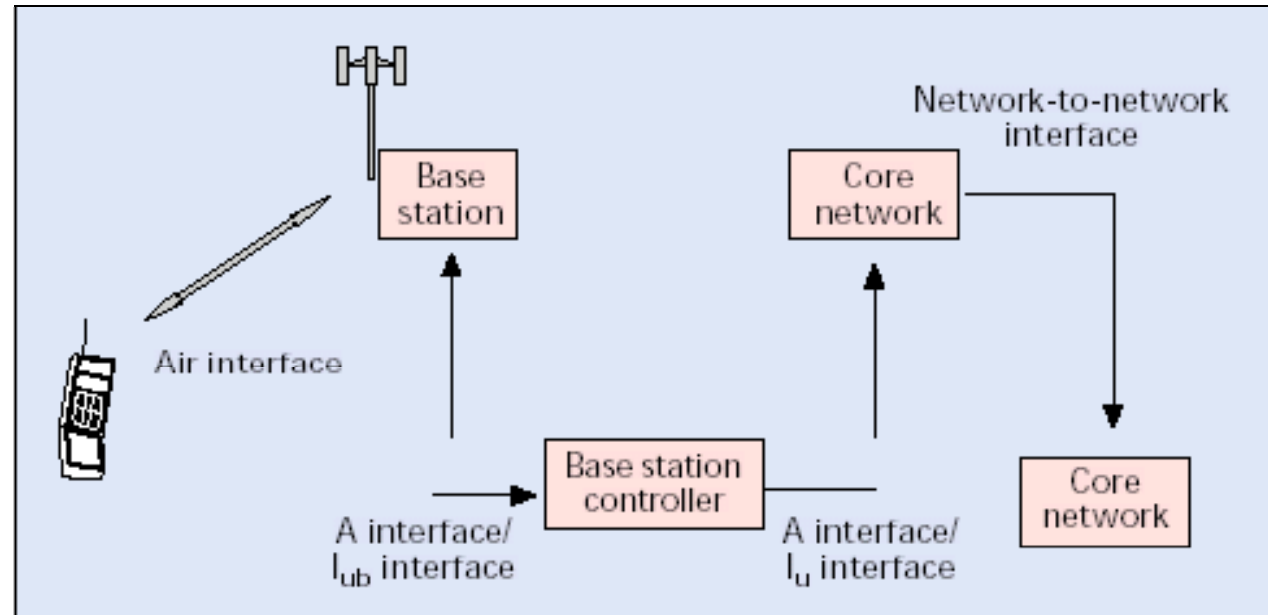


Figure 2. RF spectrum allocation in major regions.

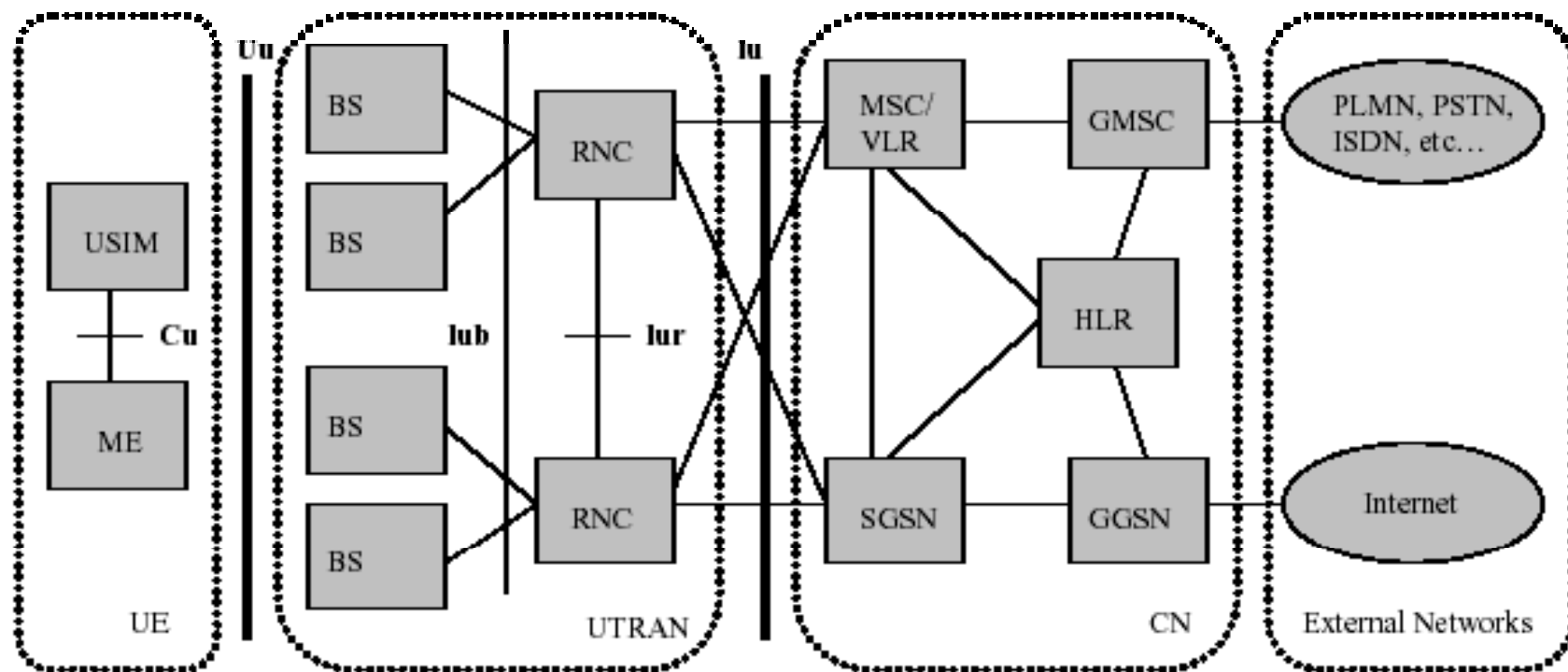


Wireless Mobile Interface



■ Figure 4. Wireless mobile system interface definition.

Elements of UMTS Architecture



第三代行動電話之技術標準

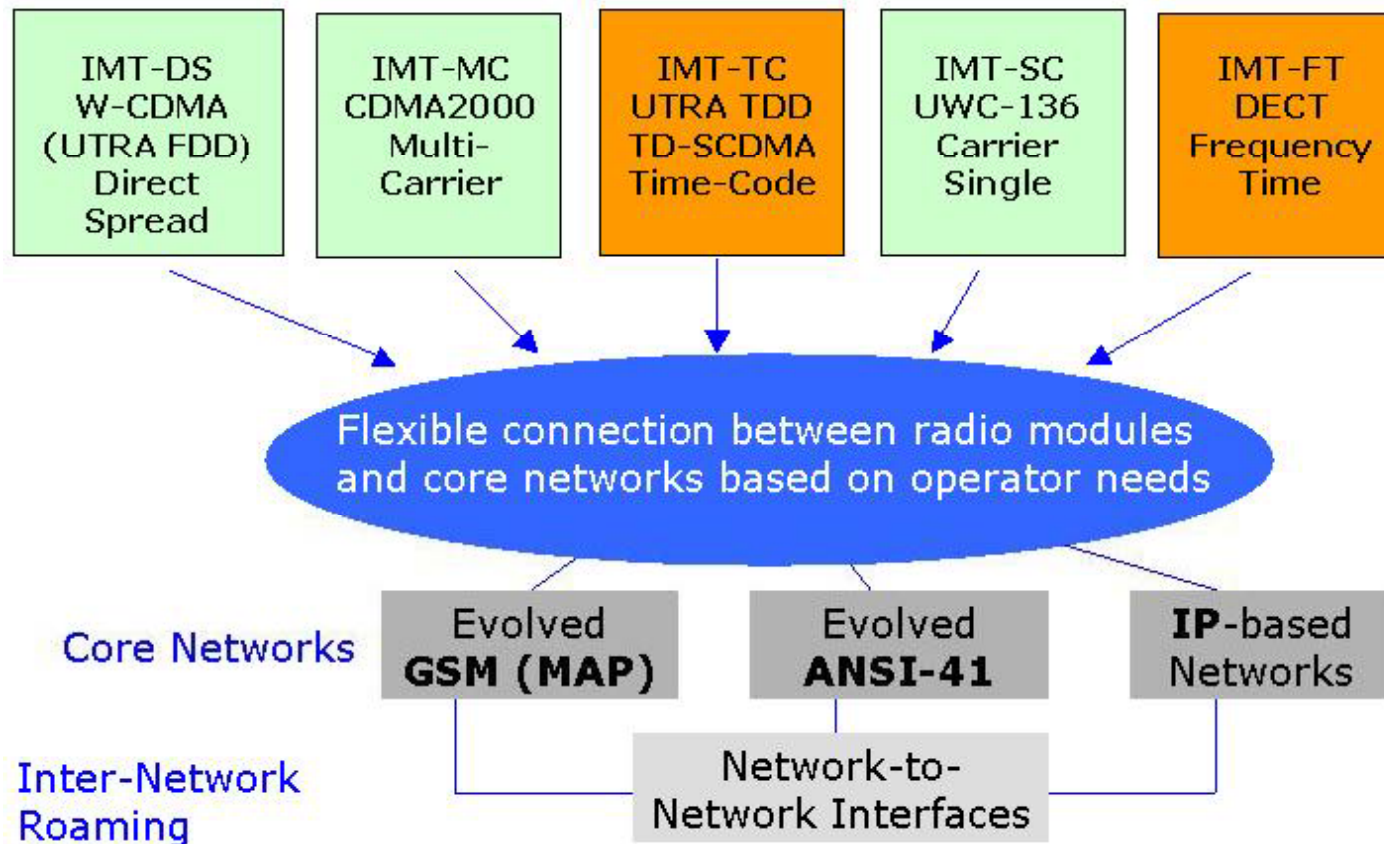


Modular IMT-2000 Harmonization

Paired spectrum

Unpaired spectrum

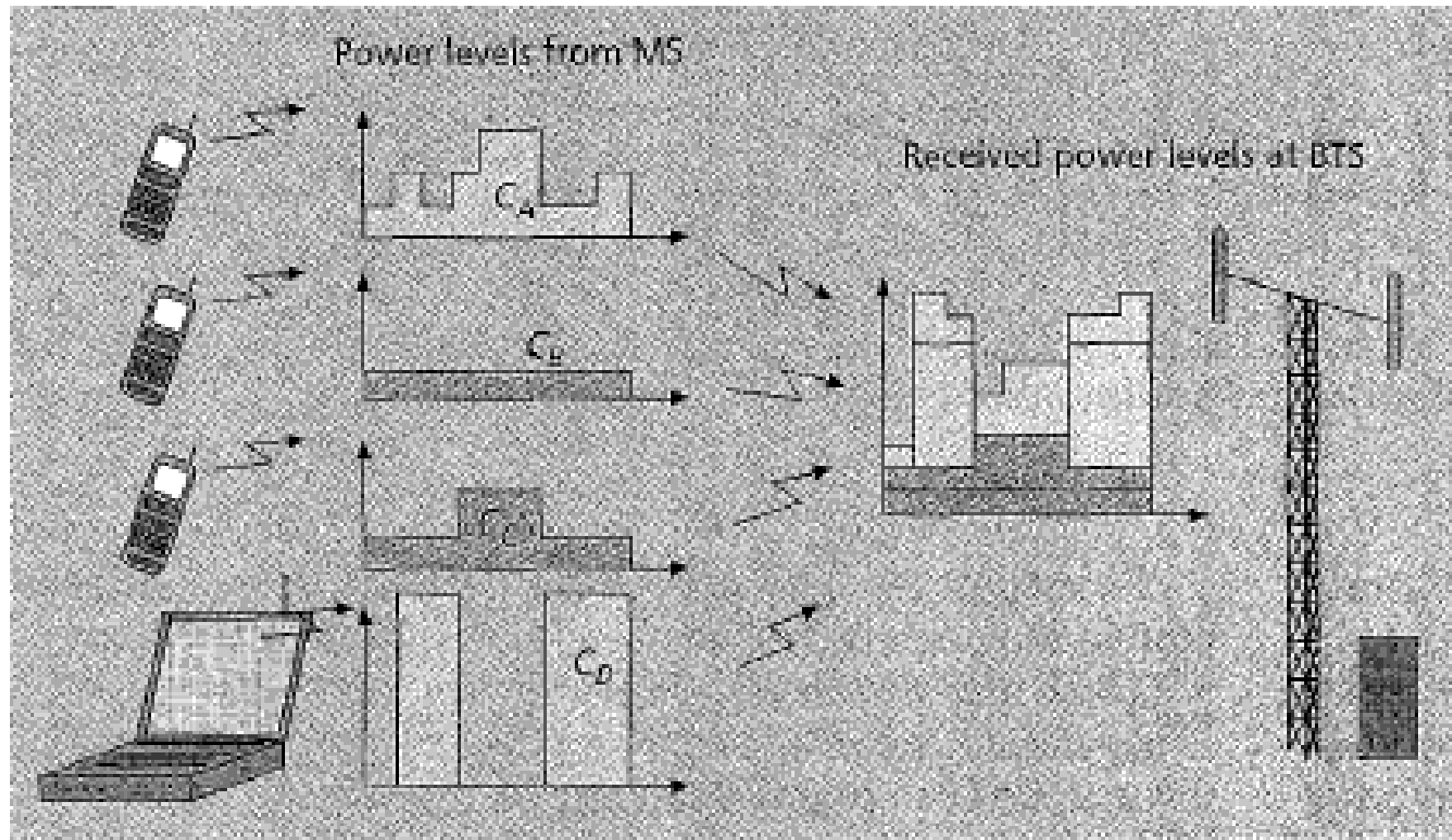
(Terrestrial Component)



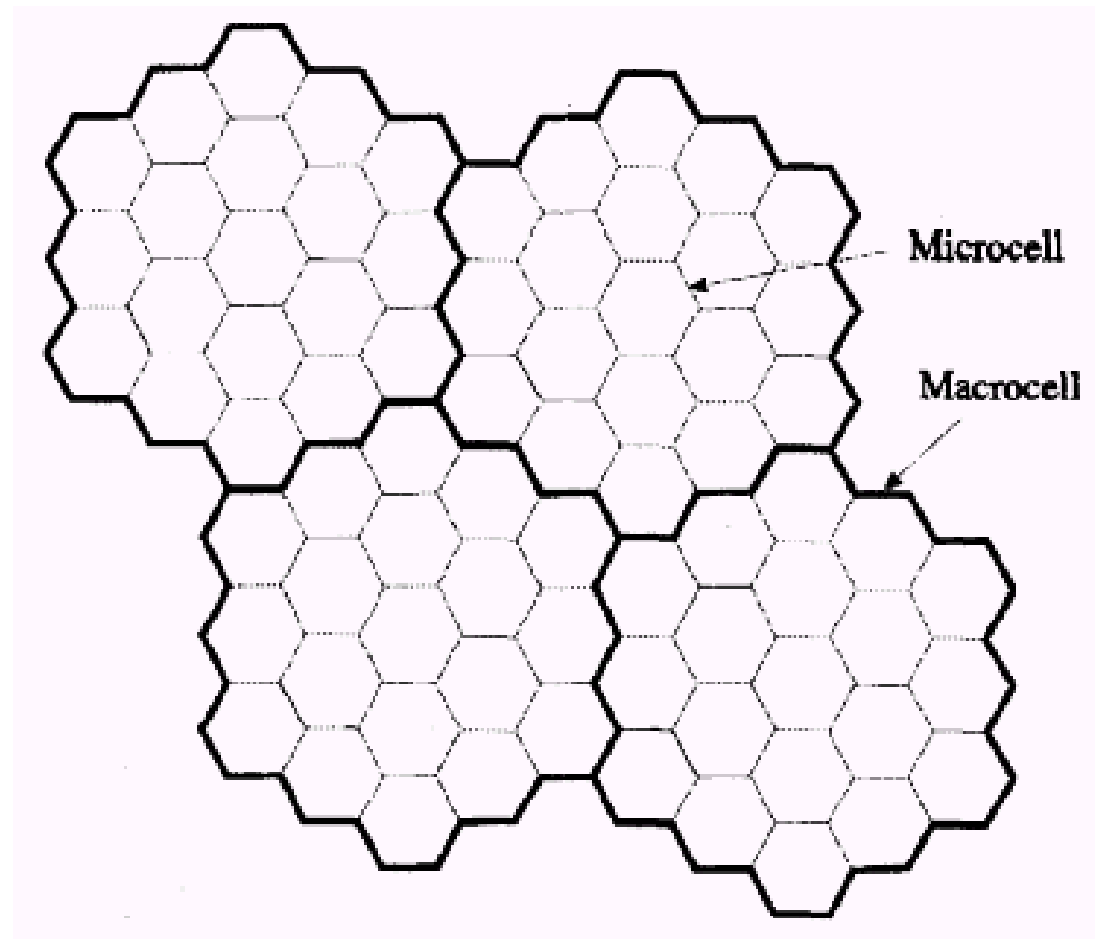
Key W_CDMA Features

- ◆ 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-spot
 - Support of evolutionary technologies such as adaptive antenna arrays and multi-user detection
 - A TDD mode designed for efficient operation in uncoordinated environment

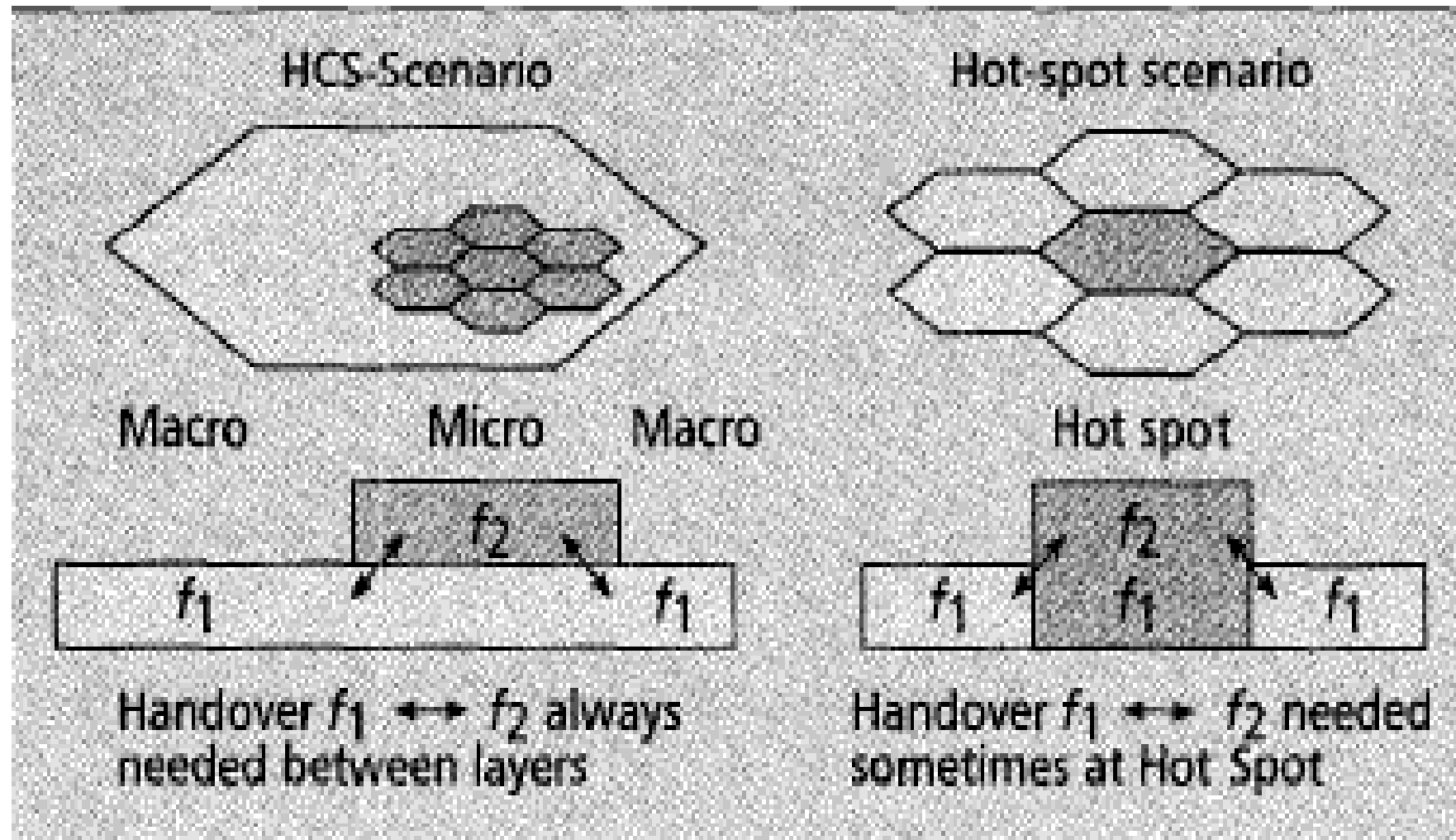
Multiplexing variable bit rate users



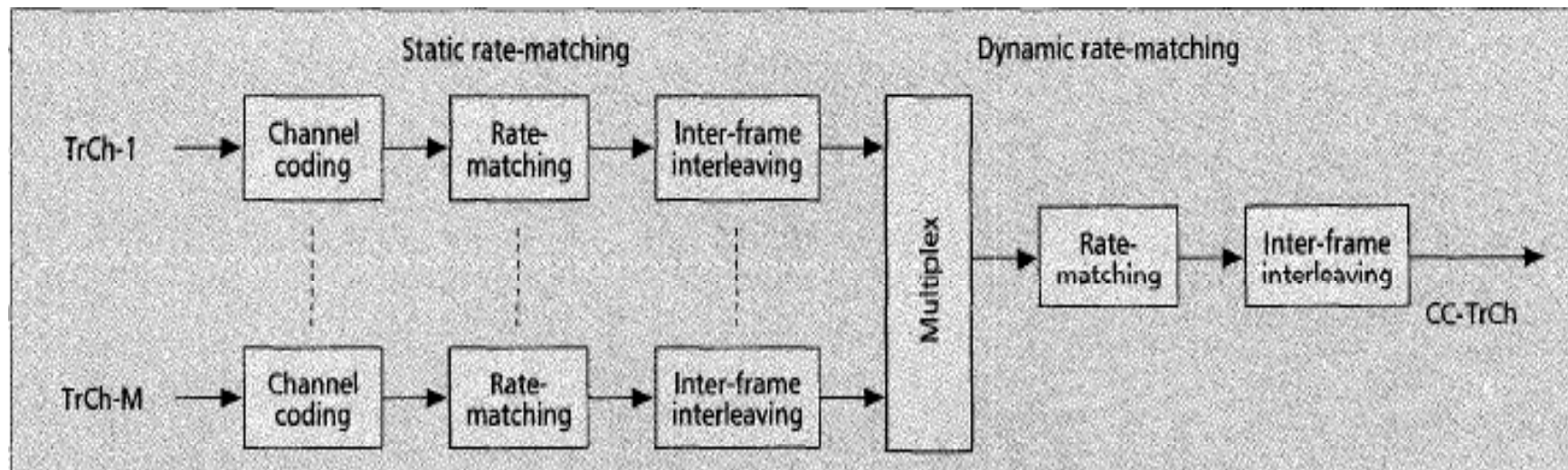
An example of two-tier cellular system



Handoff



Transport of the channel



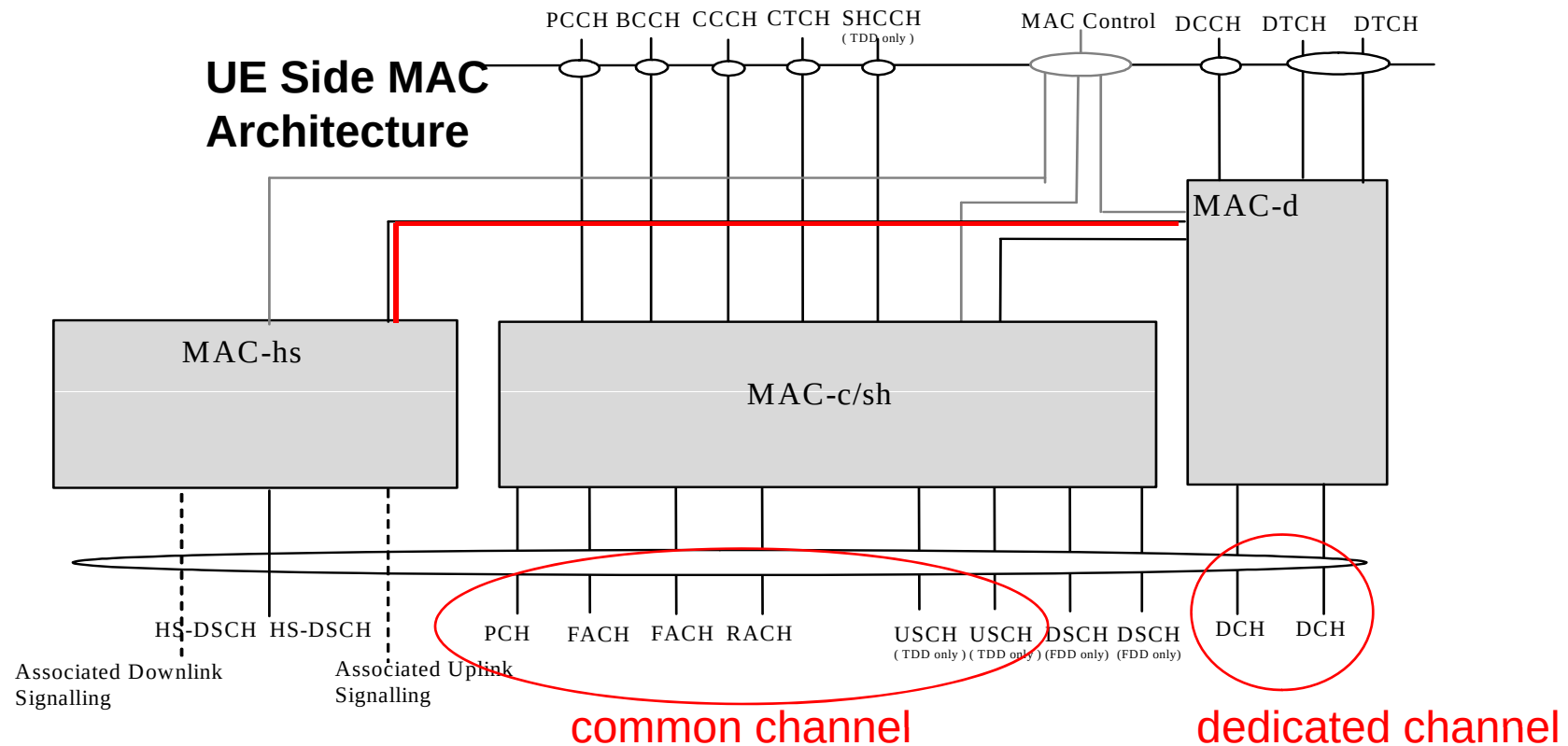
HSDPA Characteristic

- ◆ 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



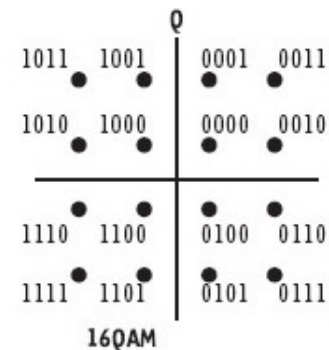
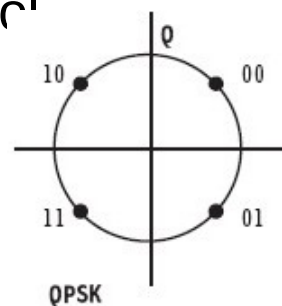
MAC Architecture

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

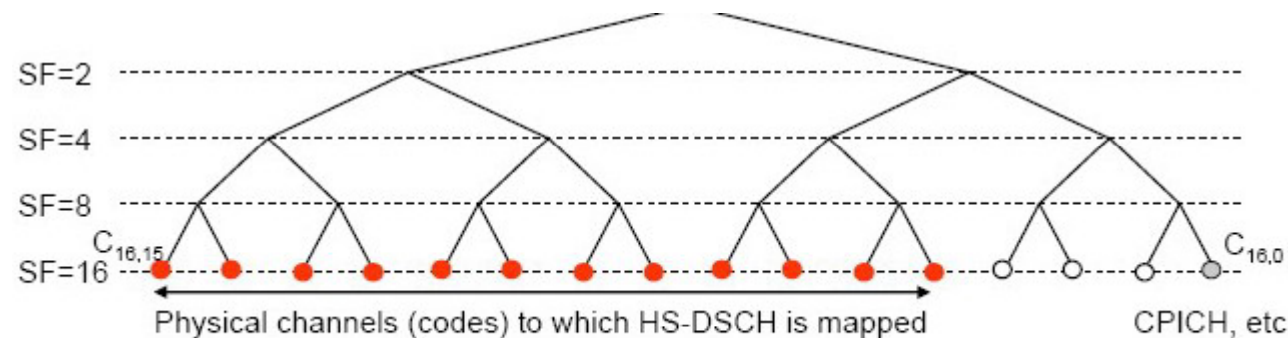


SF and Modulation

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

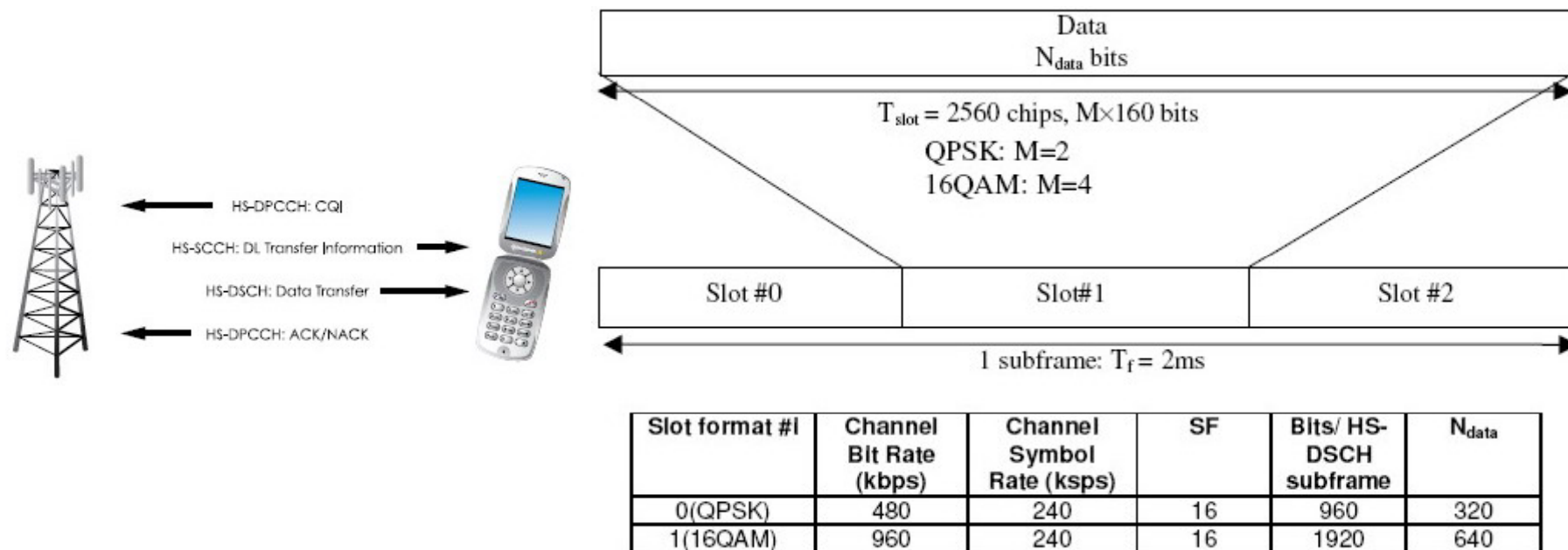


- ◆ Channelization code at a fixed SF = 16.



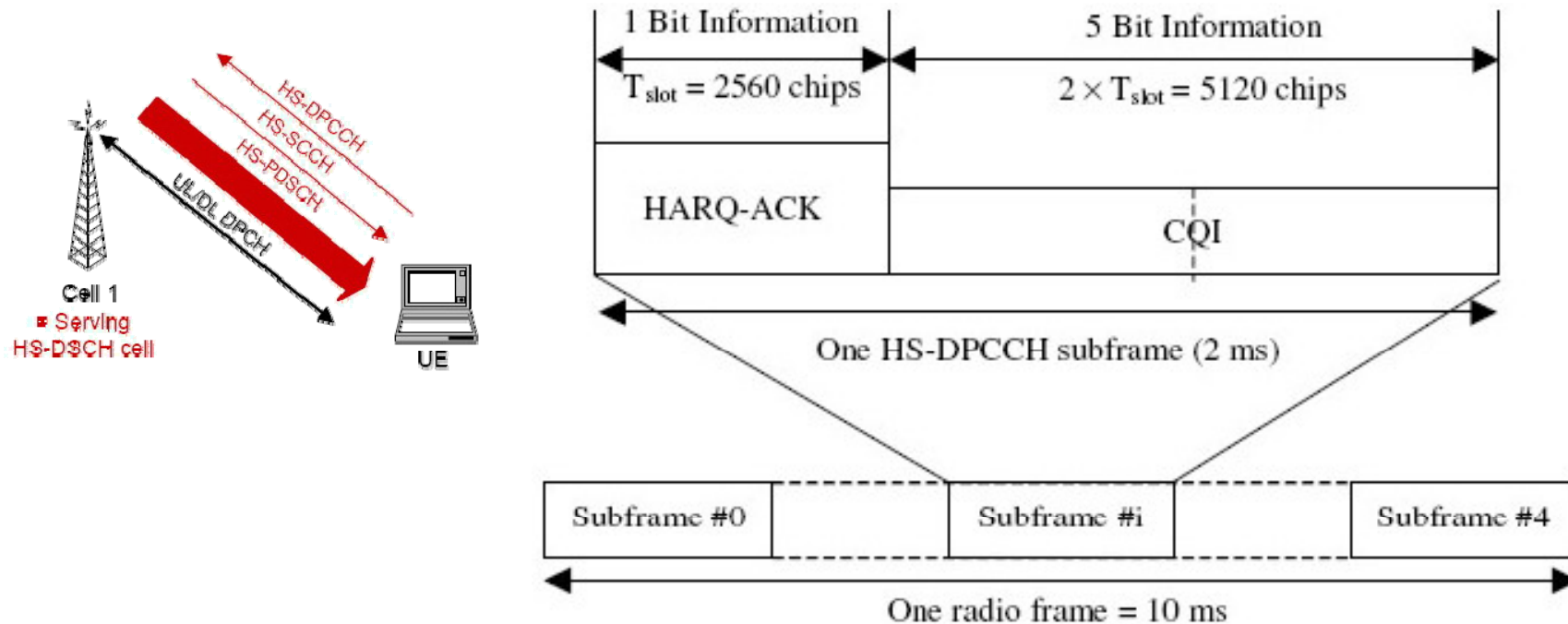
HS-PDSCH

- ◆ HS-PDSCH carries the data traffic in terms of MAC-hs PDU.
- ◆ Fixed **SF=16**; up to **15** parallel channels
- ◆ 14Mbps = $960 \times 15 \approx 14400$ kbps



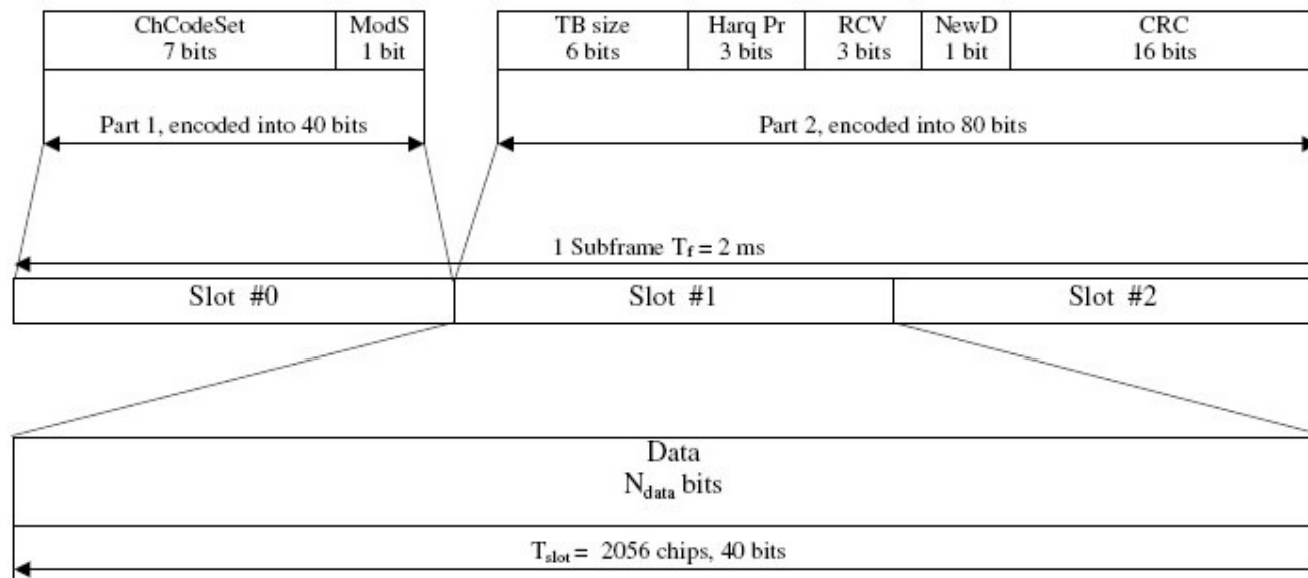
HS-DPCCH

- ◆ 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.



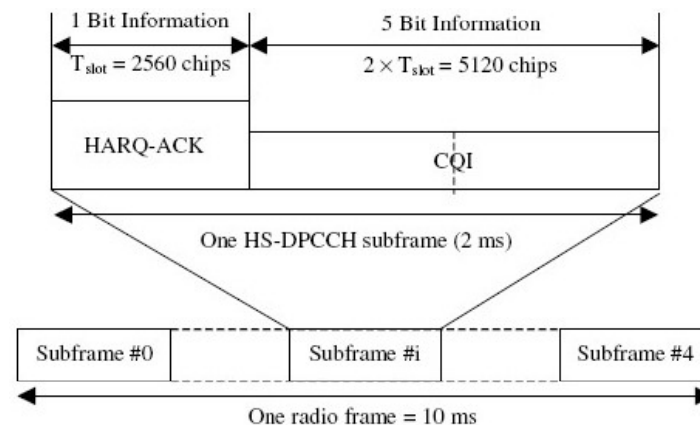
DCH, DSCH and HS-DSCH

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.

$$CQI = \begin{cases} 0 & SNR \leq -16 \\ \left\lfloor \frac{SNR}{1.02} + 16.62 \right\rfloor & -16 < SNR < 14 \\ 30 & 14 \leq SNR \end{cases}$$



UE Category

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

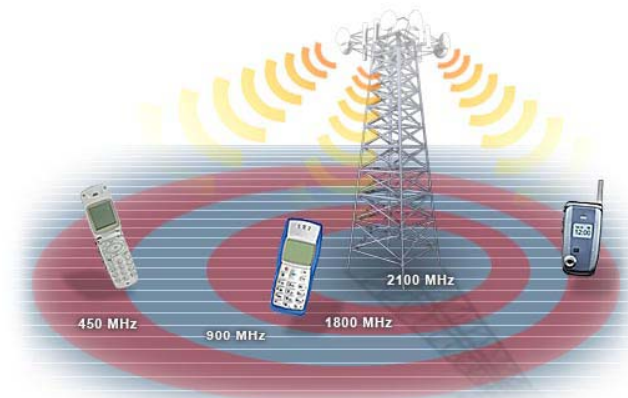
Category	Codes	Inter-TT1	TB Size	Total # of Soft Bits	Modulation	Data Rate
1	5	3	7300	19200	QPSK/16QAM	1.2 Mbps
2	5	3	7300	28800	QPSK/16QAM	1.2 Mbps
3	5	2	7300	28800	QPSK/16QAM	1.8 Mbps
4	5	2	7300	38400	QPSK/16QAM	1.8 Mbps
5	5	1	7300	57600	QPSK/16QAM	3.6 Mbps
6	5	1	7300	67200	QPSK/16QAM	3.6 Mbps
7	10	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 _s	Number of HS-PDSCH	Modulation	Reference power adjustment Δ_s	$H_{IR,s}$	$X_{RV,s}$
0 _s	N/A _s	Out of range _s				
1 _s	137 _s	1 _s	QPSK _s	0 _s	9600 _s	0 _s
2 _s	173 _s	1 _s	QPSK _s	0 _s		
3 _s	233 _s	1 _s	QPSK _s	0 _s		
4 _s	317 _s	1 _s	QPSK _s	0 _s		
5 _s	377 _s	1 _s	QPSK _s	0 _s		
6 _s	461 _s	1 _s	QPSK _s	0 _s		
7 _s	650 _s	2 _s	QPSK _s	0 _s		
8 _s	792 _s	2 _s	QPSK _s	0 _s		
9 _s	931 _s	2 _s	QPSK _s	0 _s		
10 _s	1262 _s	3 _s	QPSK _s	0 _s		
11 _s	1483 _s	3 _s	QPSK _s	0 _s		
12 _s	1742 _s	3 _s	QPSK _s	0 _s		

⋮

20 _s	5887 _s	5 _s	16-QAM _s	0 _s		
21 _s	6554 _s	5 _s	16-QAM _s	0 _s		
22 _s	7168 _s	5 _s	16-QAM _s	0 _s		
23 _s	7168 _s	5 _s	16-QAM _s	-1 _s		
24 _s	7168 _s	5 _s	16-QAM _s	-2 _s		
25 _s	7168 _s	5 _s	16-QAM _s	-3 _s		
26 _s	7168 _s	5 _s	16-QAM _s	-4 _s		
27 _s	7168 _s	5 _s	16-QAM _s	-5 _s		
28 _s	7168 _s	5 _s	16-QAM _s	-6 _s		
29 _s	7168 _s	5 _s	16-QAM _s	-7 _s		
30 _s	7168 _s	5 _s	16-QAM _s	-8 _s		

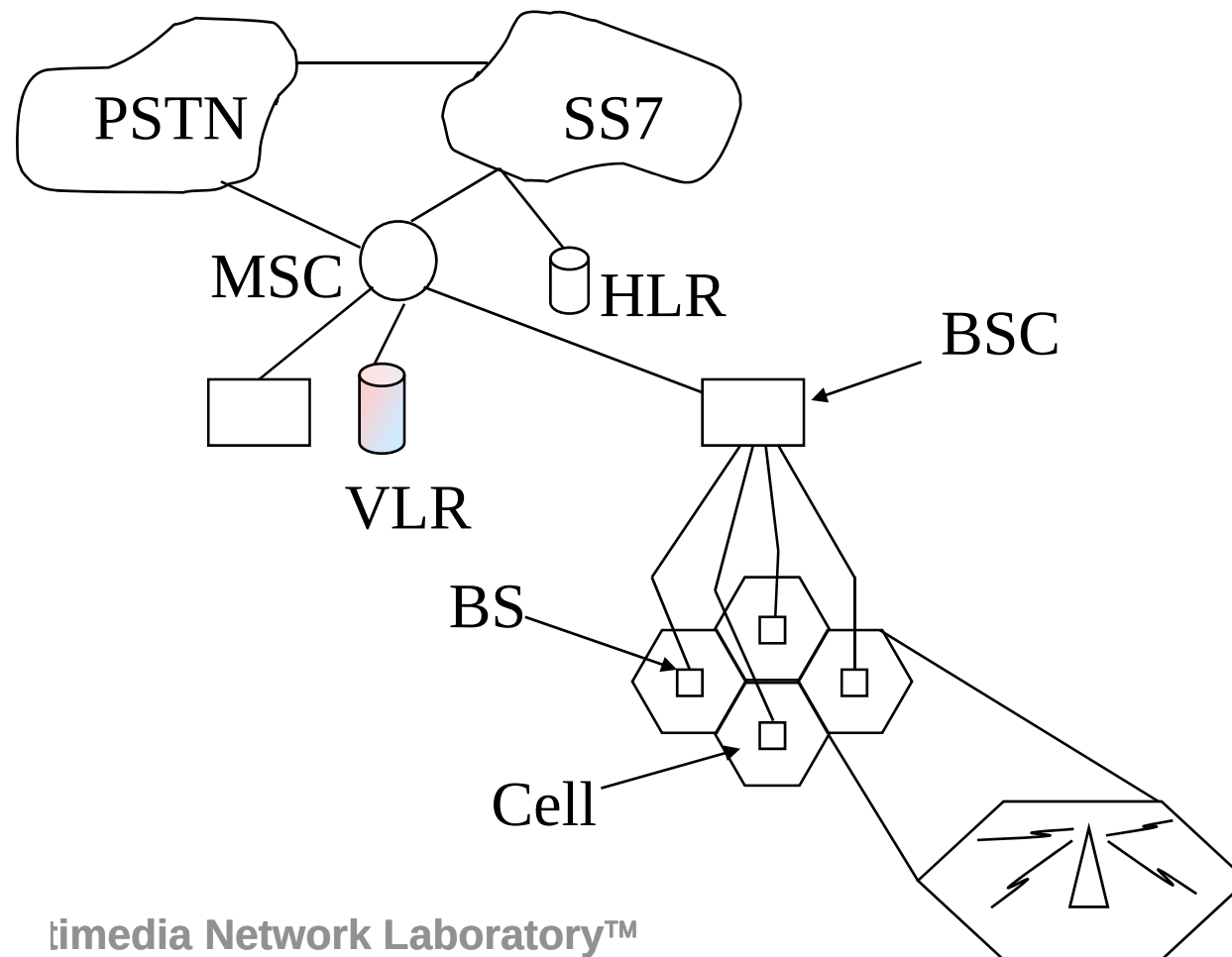


Evolutions of PCS

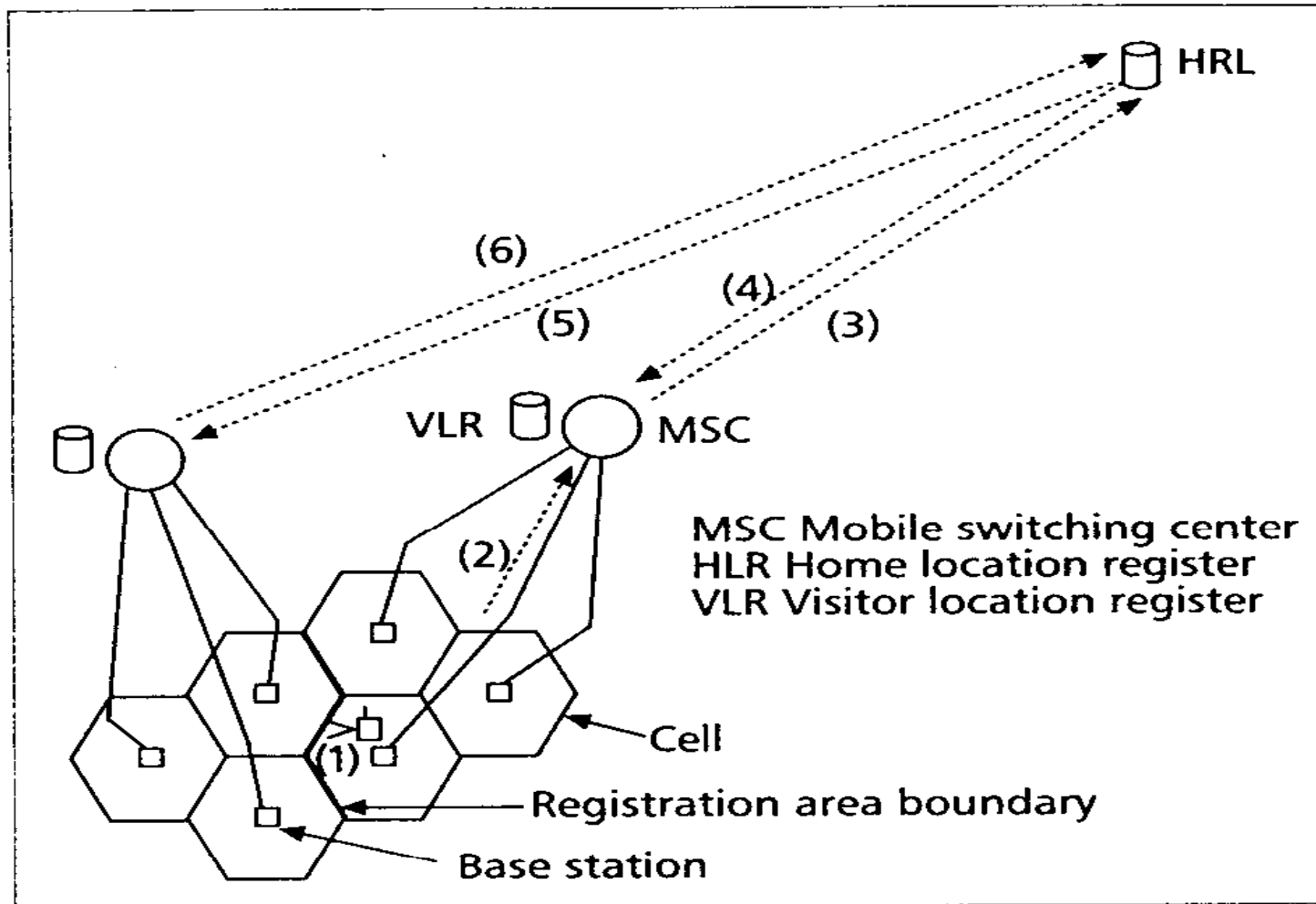


PCS Requirements

PCS network architecture



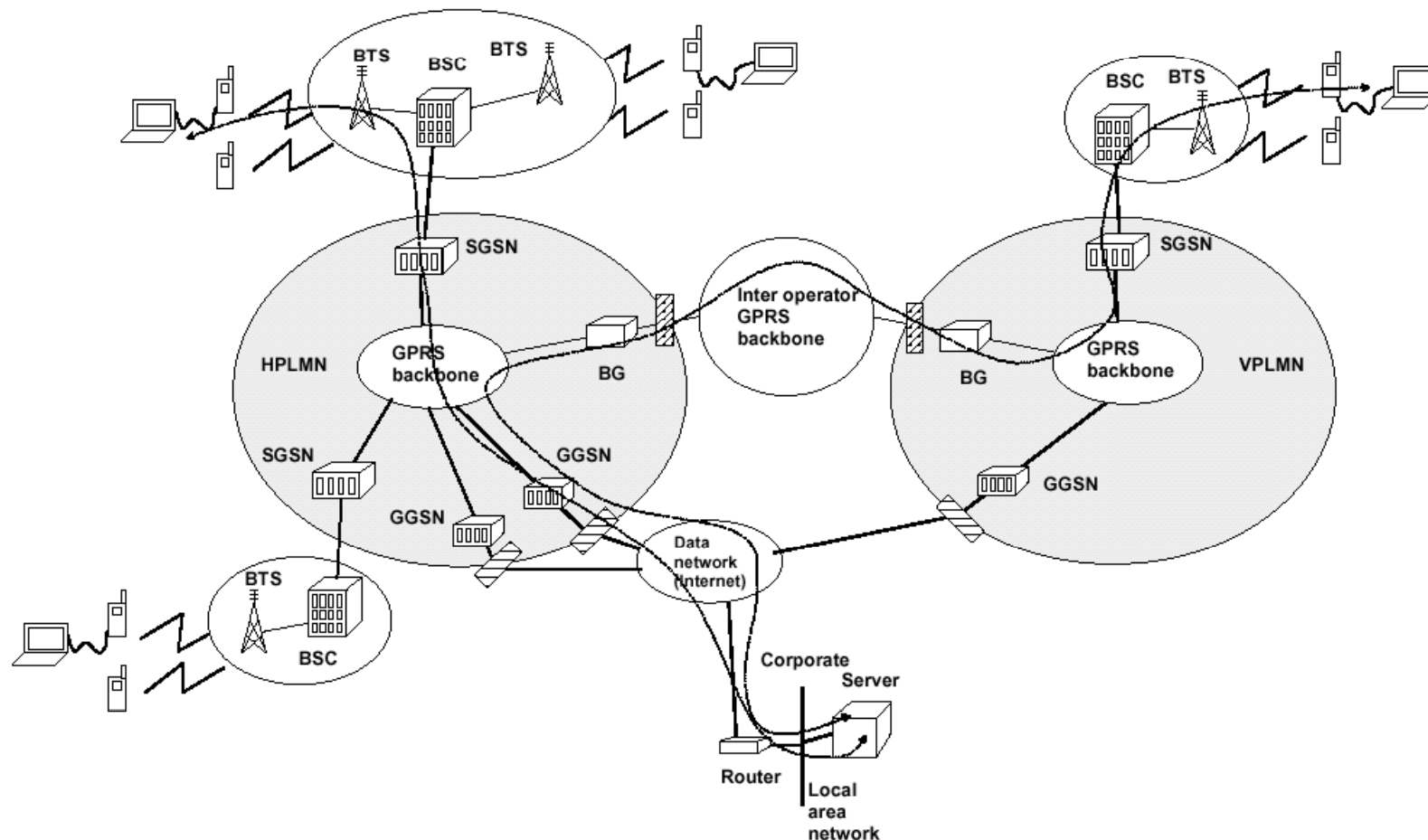
Location Update Procedure



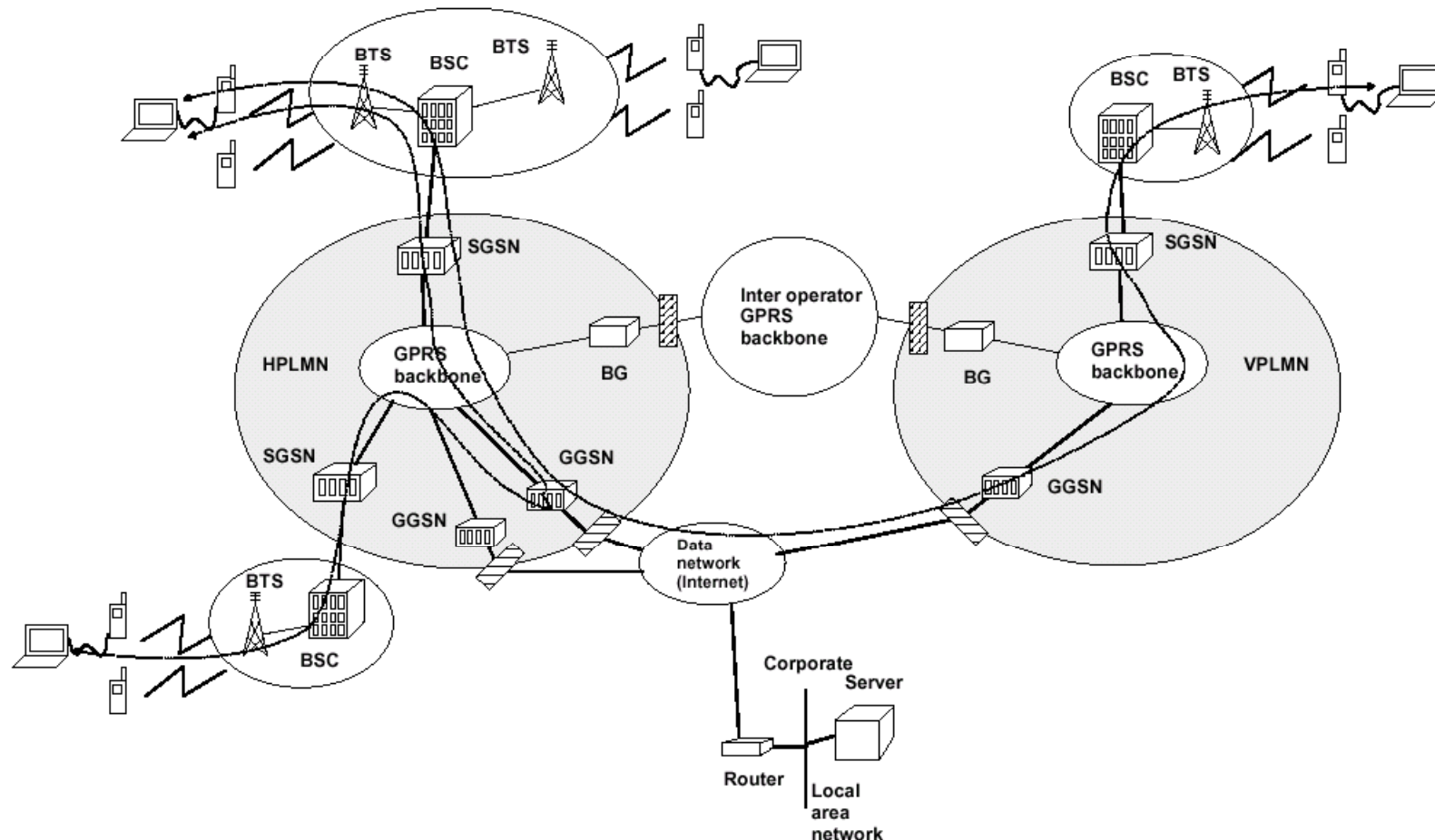
■ Figure 3. Location registration procedures.



Data transfer MS-fixed



Data transfer MS-MS



Coming Challenges for IP



Location Managements~ handoff, roaming

QoS Transport~ Backbone delivery

Mobility

◆ User mobility

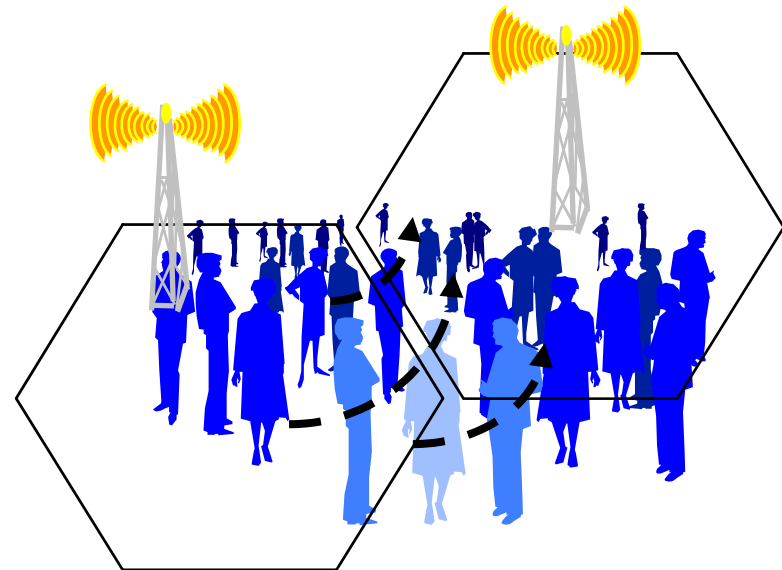
- Micro
- Macro



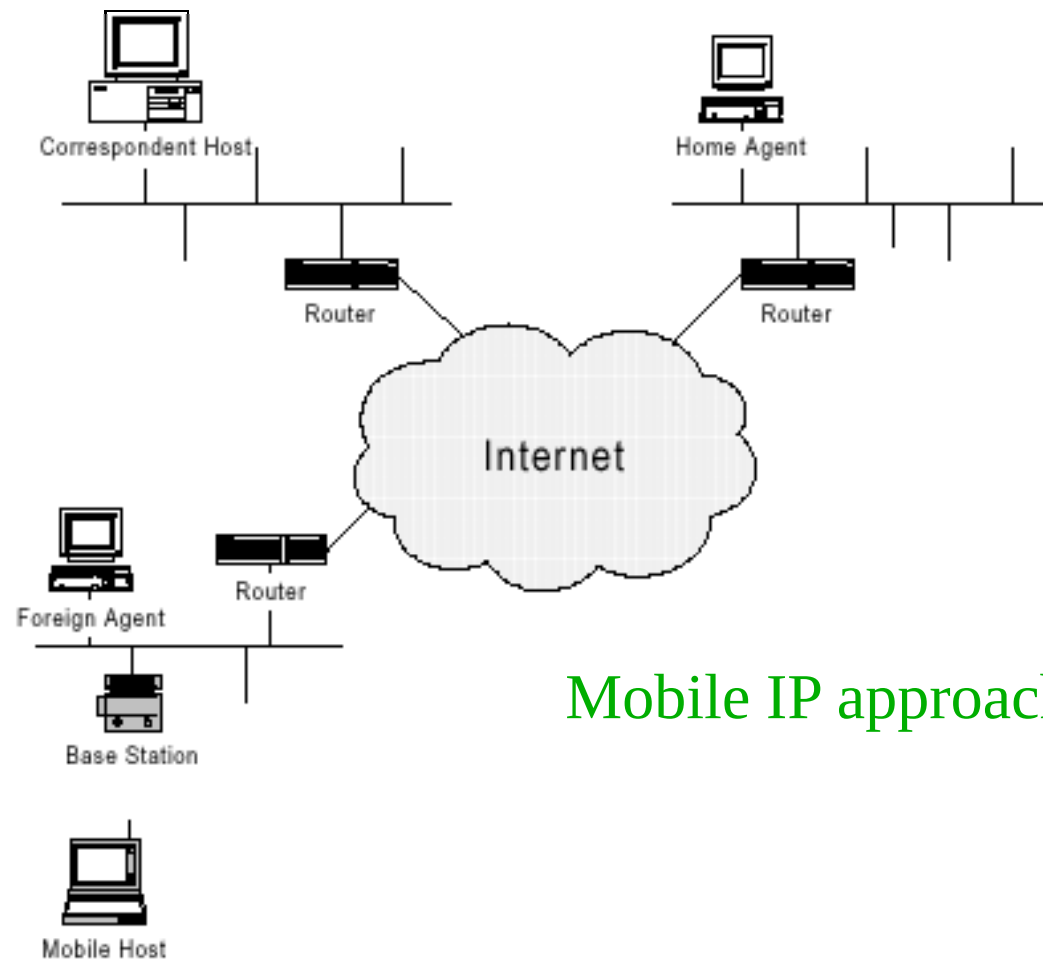
- Handoff issue
- Location management
- Paging

◆ IP mobility support

- Mobile IP
- Cellular IP
- HAWAII

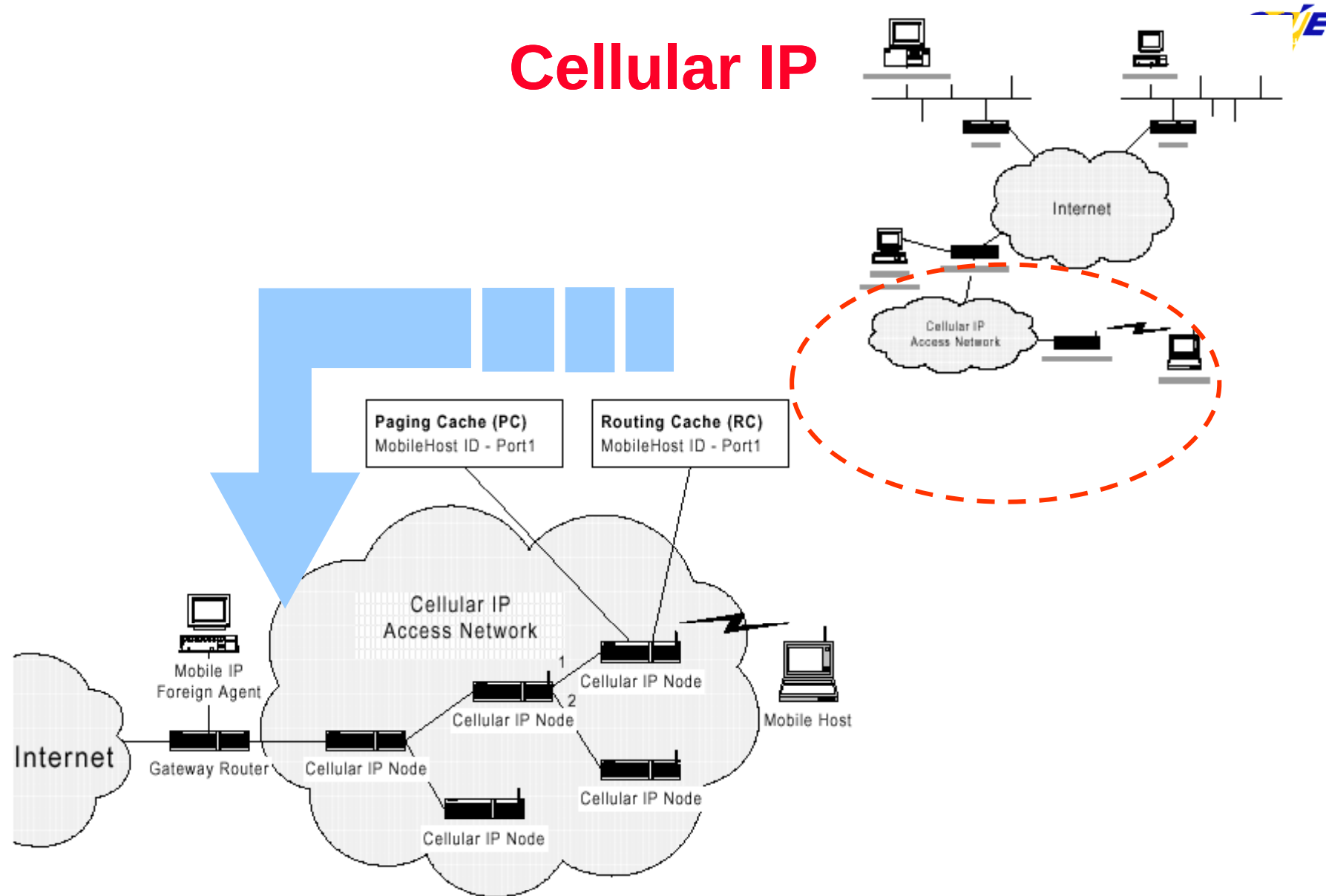


Nomadic wireless access

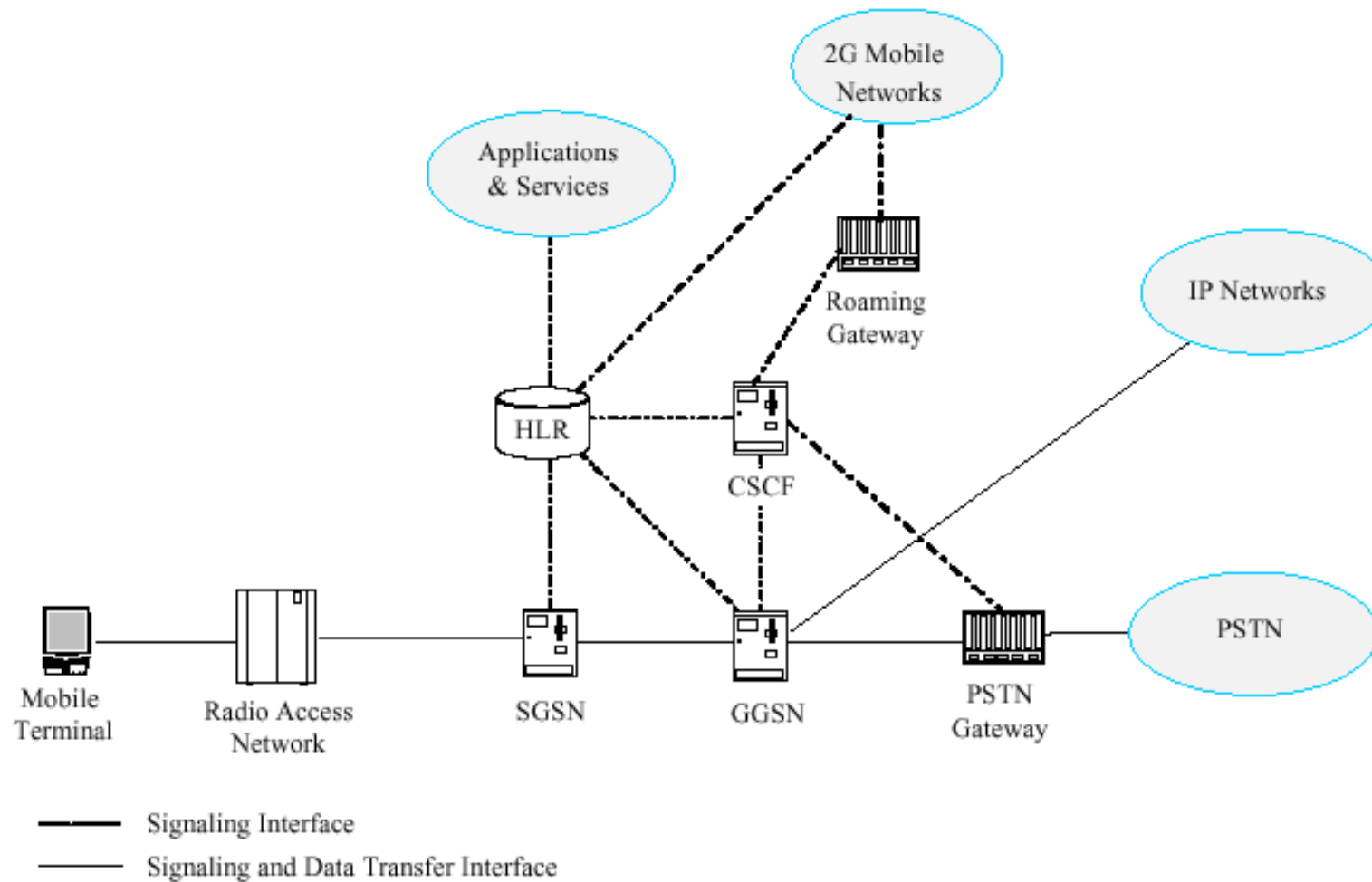


Mobile IP approach

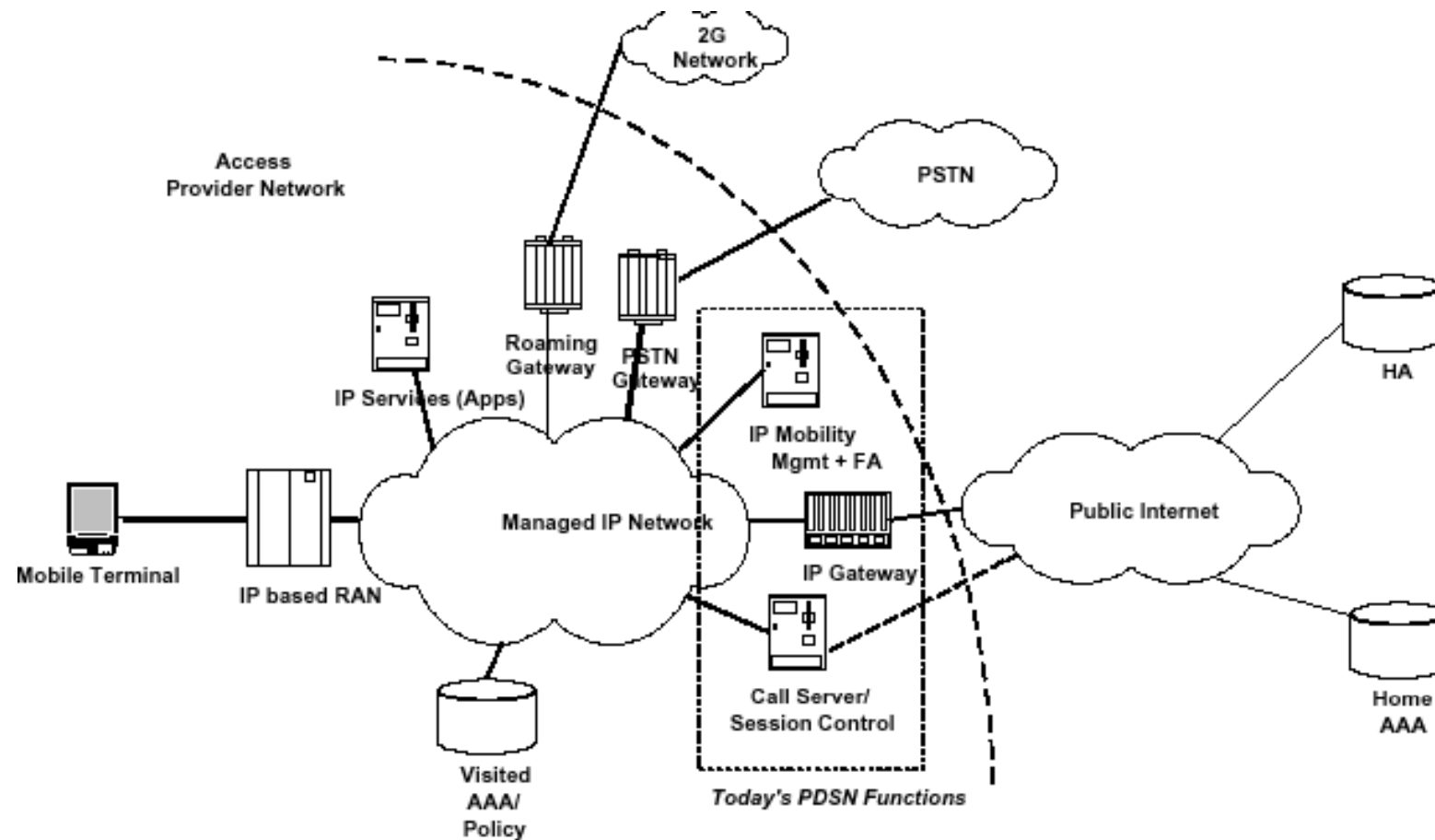
Cellular IP



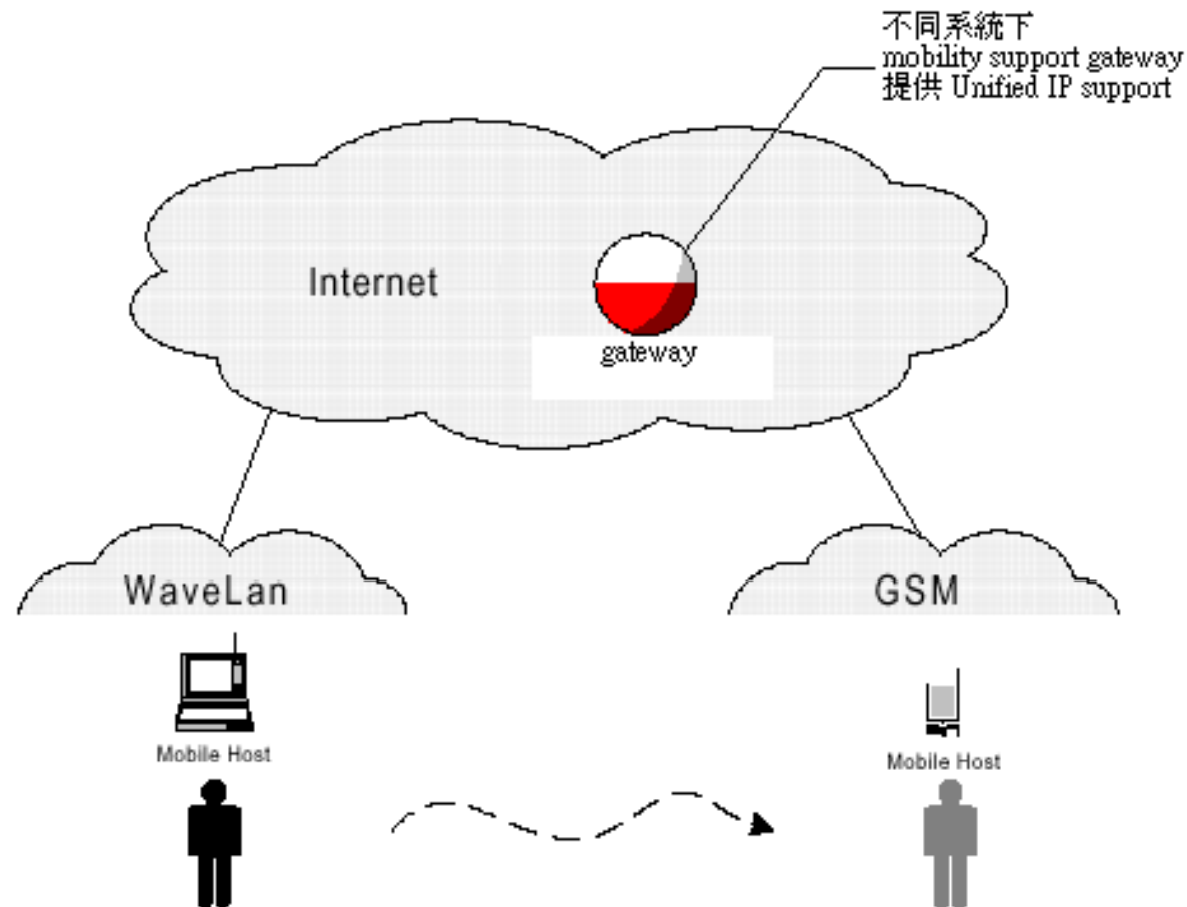
3GPP IP reference architecture



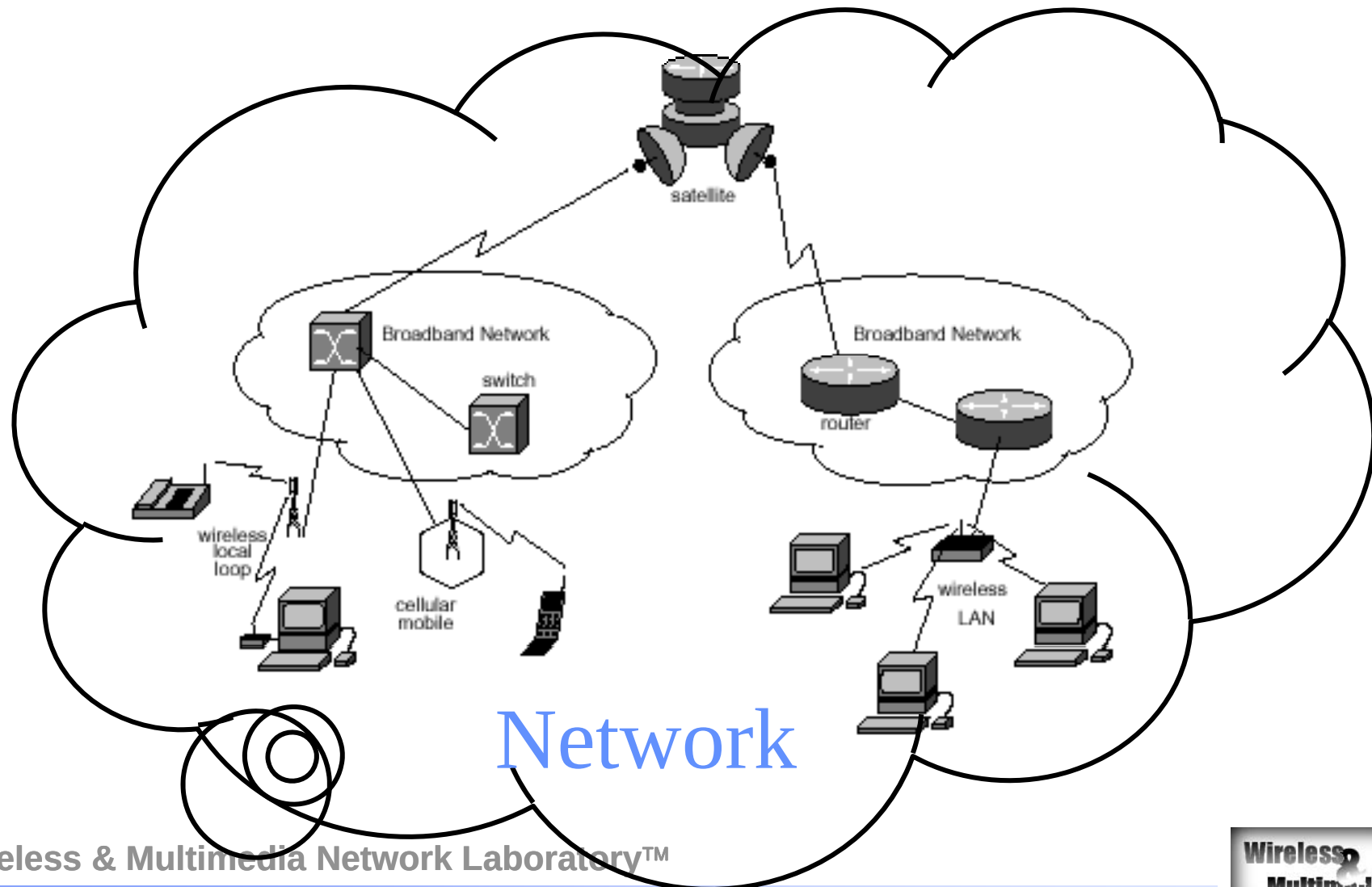
3GPP2 IP reference architecture



Heterogeneous access network

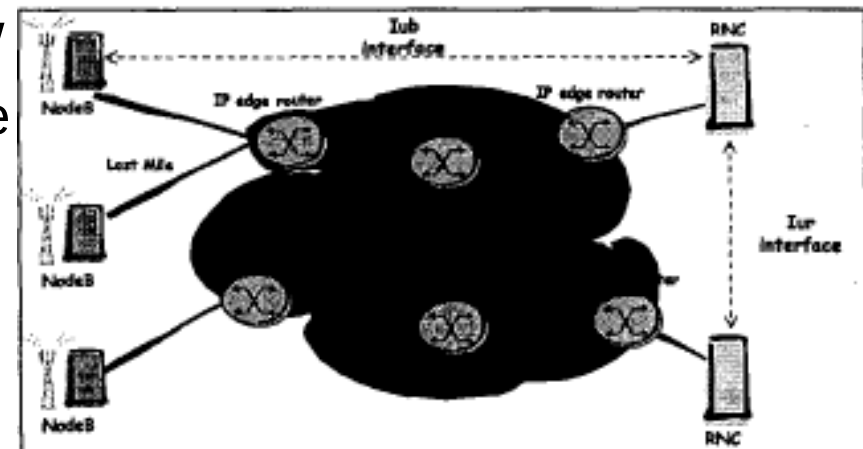


Heterogeneous End System



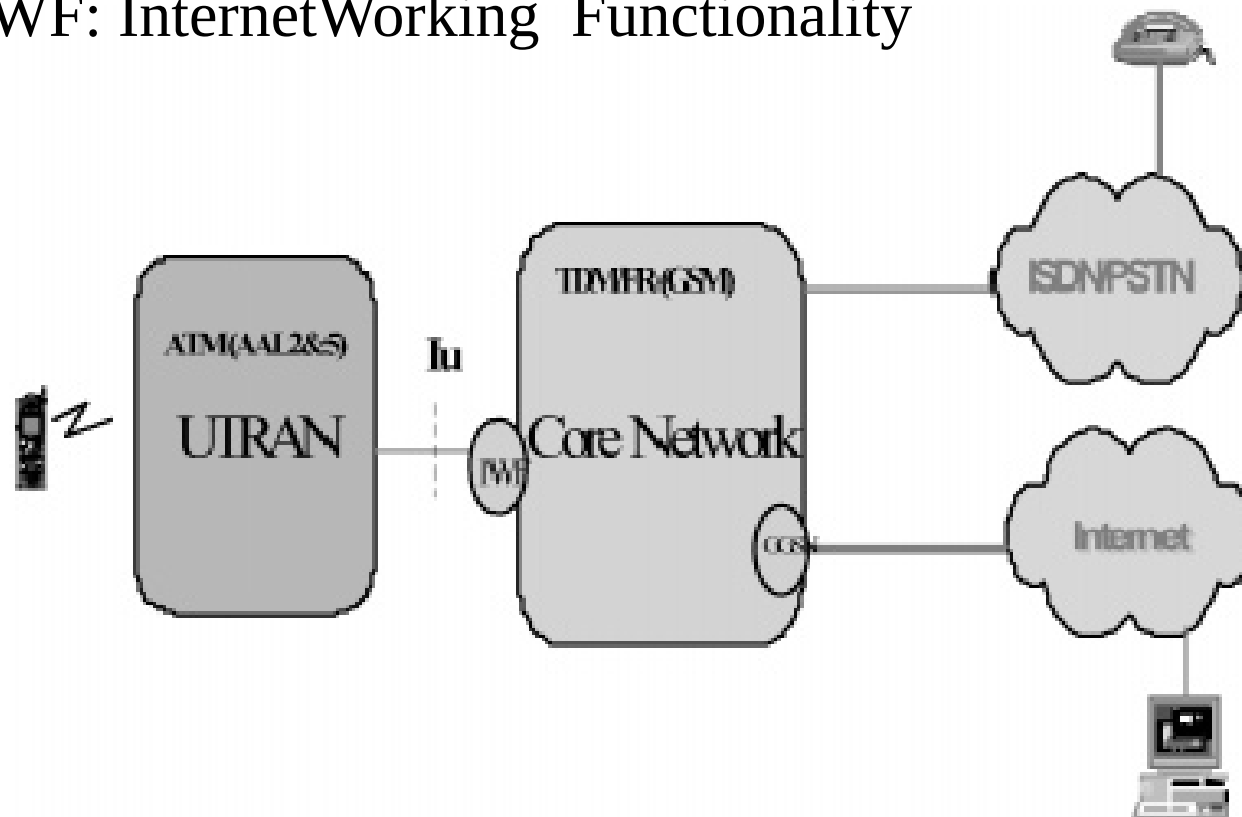
Last Mile QoS Issues

- ◆ Last mile connect NodeB and RAN. It is usually low bandwidth links.
- ◆ limit the transmission time for a packet.
- ◆ Three choices
 - Fragmentation on a layer below
 - Fragmentation on a layer above
 - Fragmentation in IP Layer

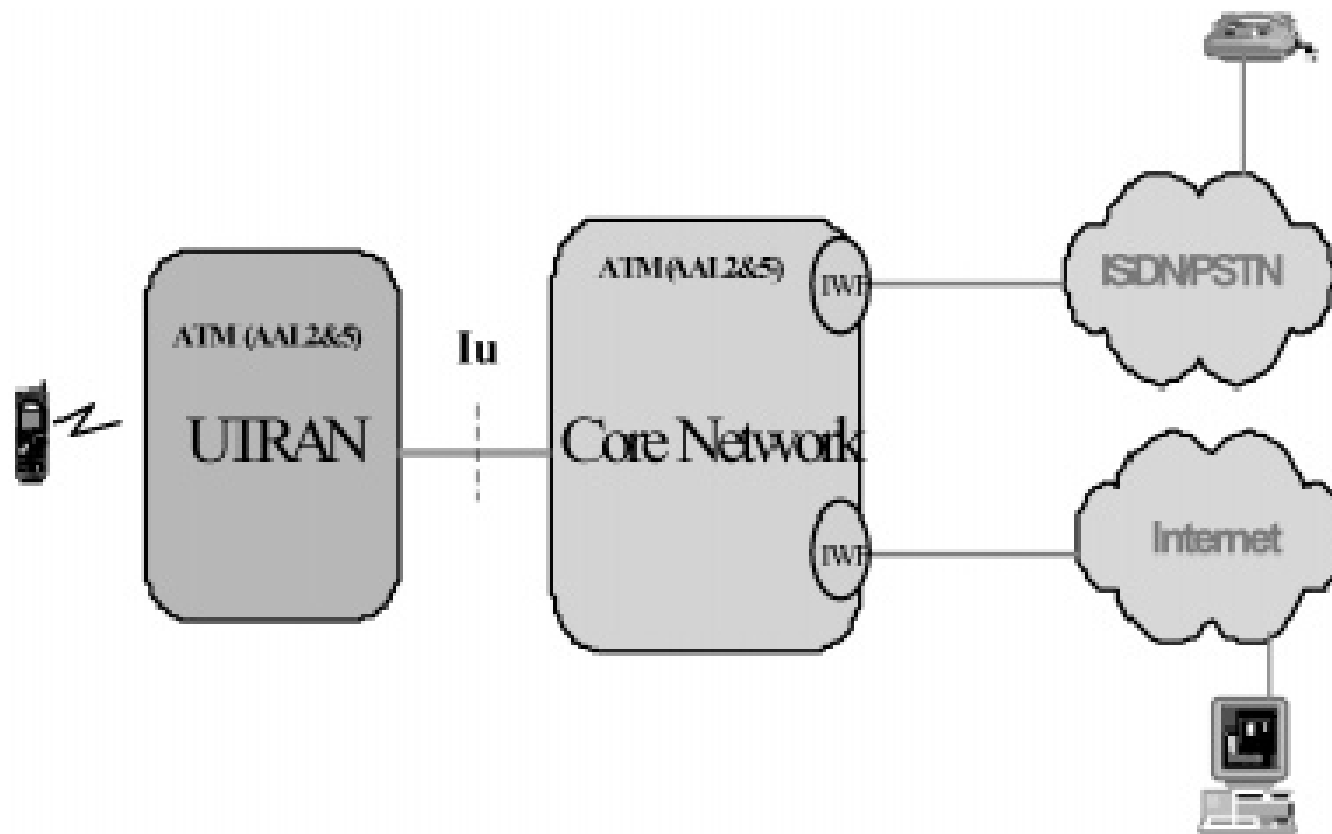


Option1

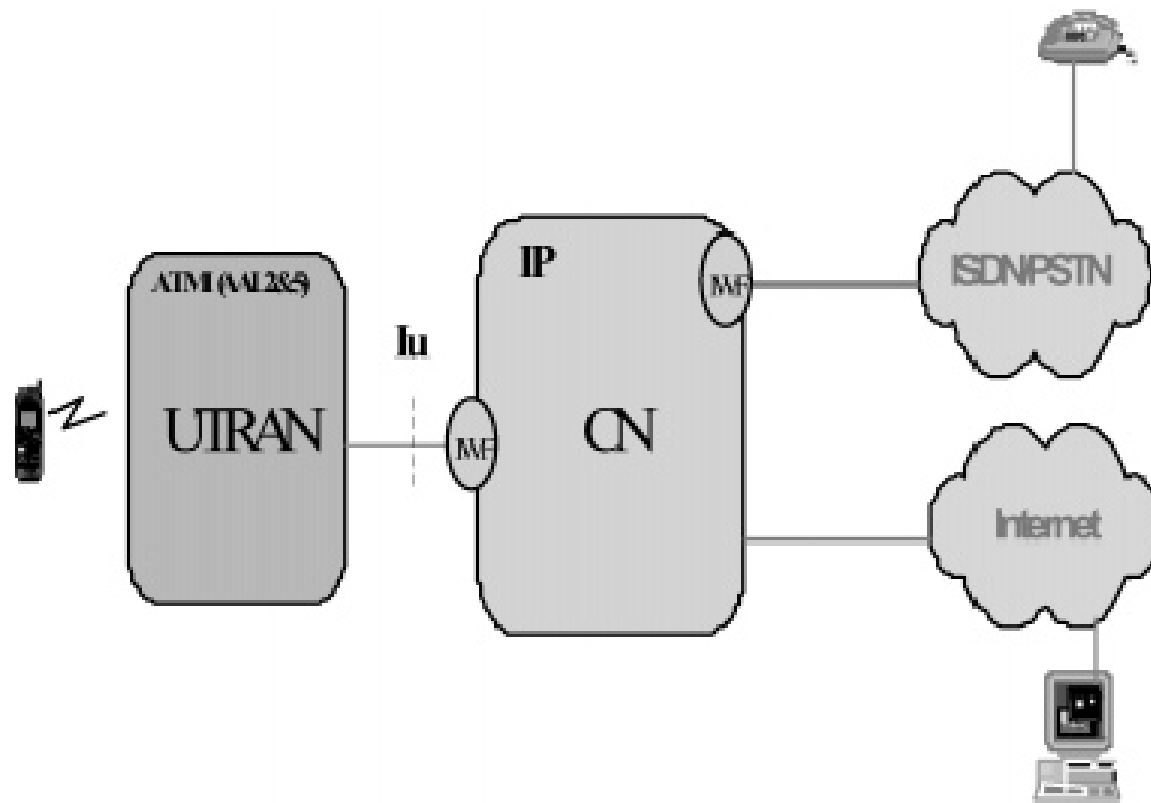
IWF: InternetWorking Functionality



Option 2



Option 3



Option 4

