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

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)

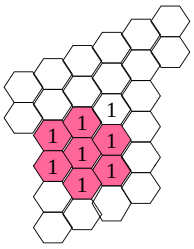
Reading

- [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

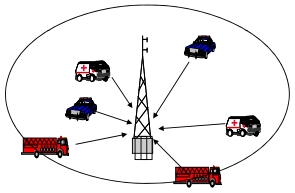


Idealized grid of Hexagonal cells

- 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)

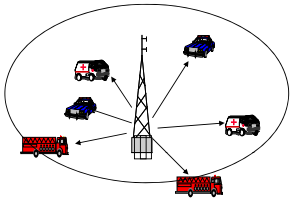
- Reverse Link: asynchronous, asynchronous CDMA system is vulnerable to the "near-far" problem
- Power Control: minimize consumption of the transmitted power, fast enough to compensate for Rayleigh fading
- Capacity is bounded by number of users (MAI Multiple Access interferences)



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)

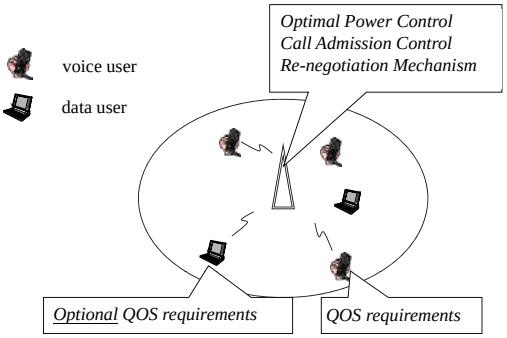
$$\left(\frac{E_b}{\eta_0}\right)_{eff} = \frac{1}{\frac{\eta_0}{E_b} + \frac{2}{3G}(M-1)(1+K)\alpha}$$

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

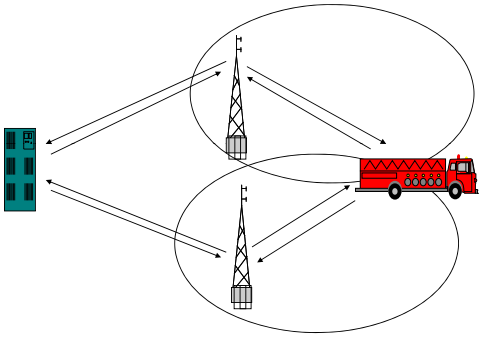
Radio Resource Management

- 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

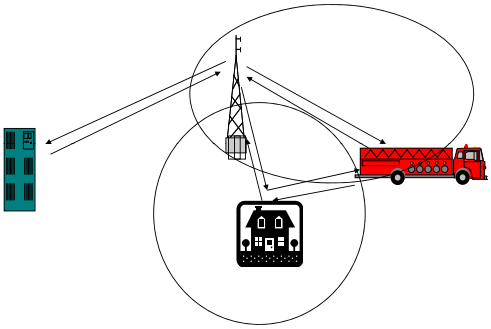
Call Admission Control



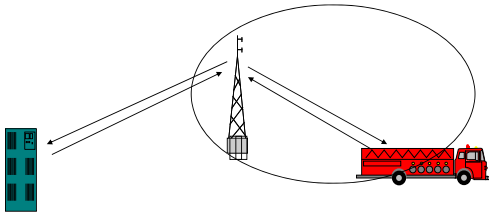
Soft Handovers (Macro Diversity)



Softer Handovers (Space Diversity)

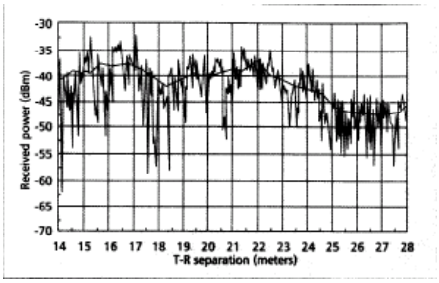


Power Control (Open & Close Loop)



Close-Loop Power Control

- Compensates a fading channe(1500 times per second)

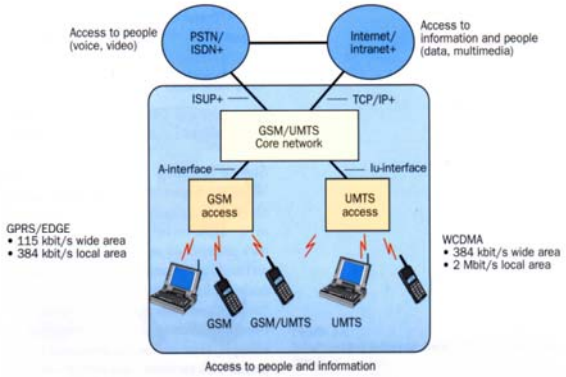


UMTS/IMT-2000 Based on Wideband CDMA

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



RS Spectrum Allocation

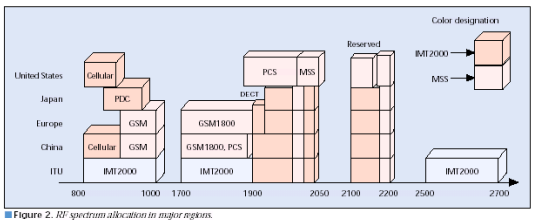
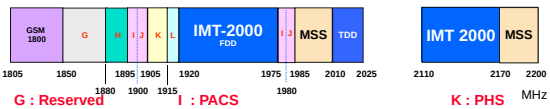


Figure 2. *RF spectrum allocation in major regions.*



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

Wireless Mobile Interface

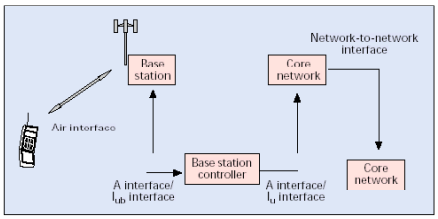
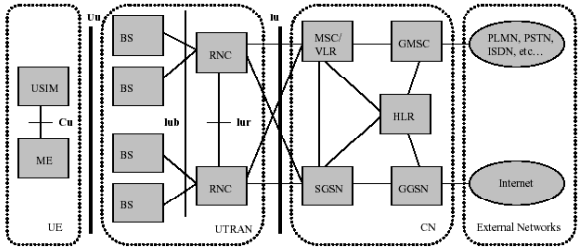
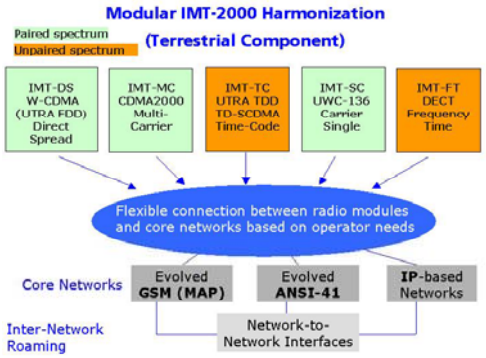


Figure 4. *Wireless mobile system interface definition.*

Elements of UMTS Architecture



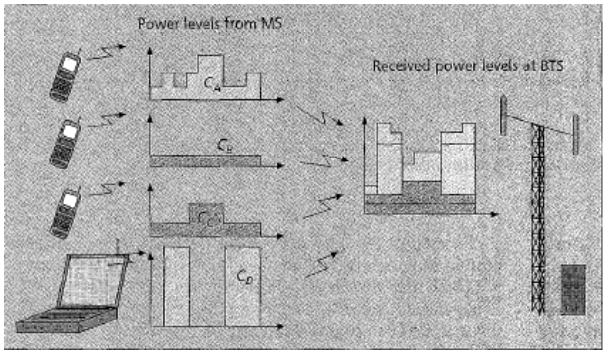
第三代行動電話之技術標準



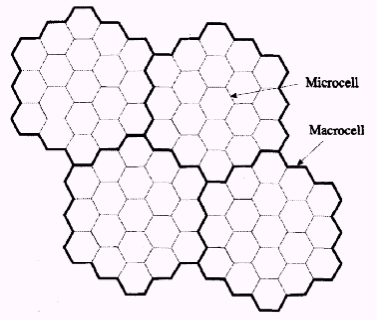
Key W_CDMA Features

- 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

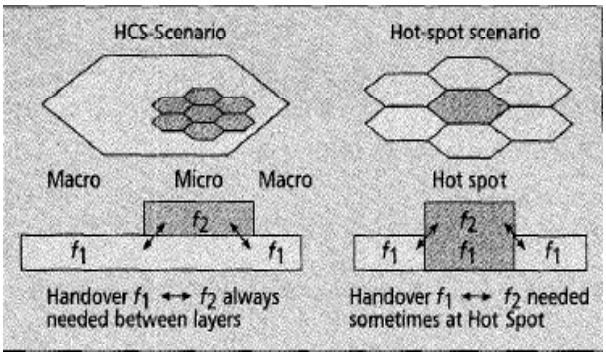
Multiplexing variable bit rate users



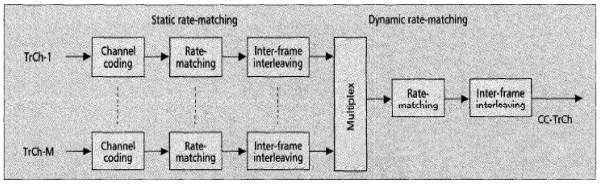
An example of two-tier cellular system



Handoff

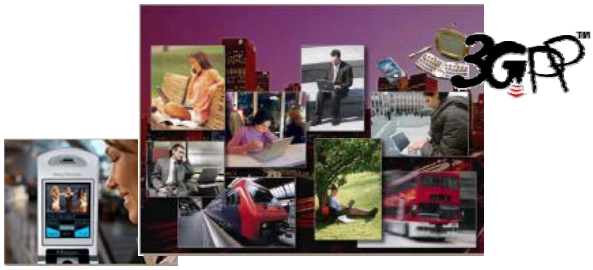


Transport of the channel



Enhanced WCDMA - 3.5G HSDPA

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

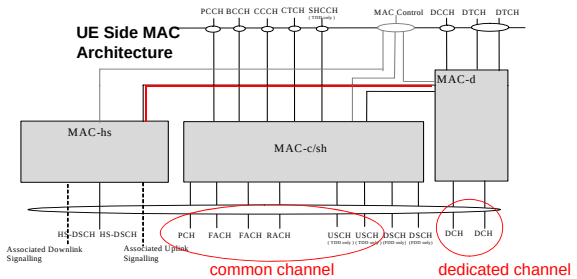


HSDPA Characteristic

- 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

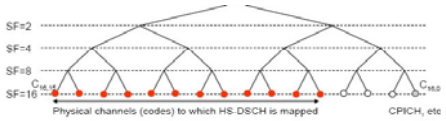
- UTRAN Side MAC entity is similar to the UE side except that there will be one MAC-d for each UE.



SF and Modulation

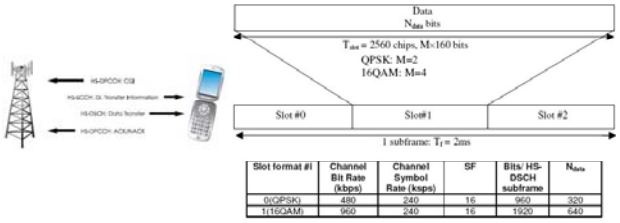
- QPSK can show 2 bits per symbol, and 16QAM can show 4 bits per symbol

- Channelization code at a fixed SF = 16.



HS-PDSCH

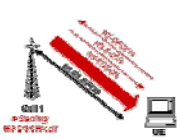
- HS-PDSCH carries the data traffic in terms of MAC-hs PDU.
- Fixed SF=16; up to 15 parallel channels
- 14Mbps = 960 x 15 ~= 14400 kbps

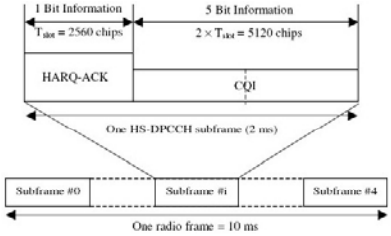


Slot format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ HS-DSCH subframe	N_{data}
0(QPSK)	480	240	16	960	320
1(16QAM)	960	240	16	1920	640

HS-DPCCH

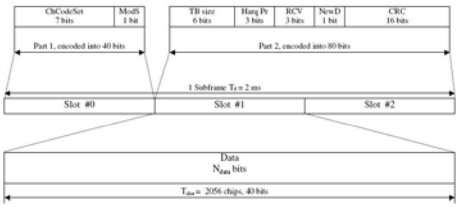
- HS-DPCCH feedbacks ACK/NACK and channel quality information (CQI).
- Fixed SF=256.





HS-SCCH

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

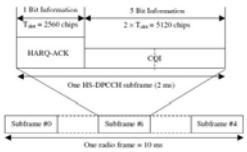


DCH, DSCH and HS-DSCH

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



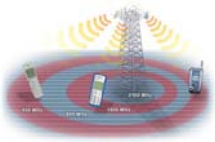
UE Category

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

Category	Codes	Inter-TTI	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

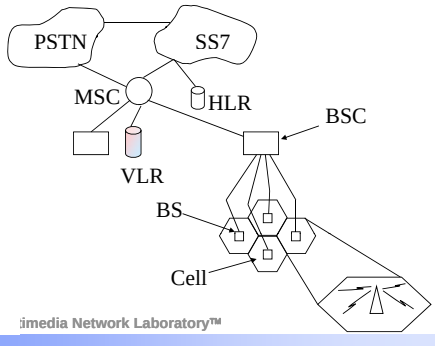
CQI value	Transport Block Size	Number of HS-PDSCH	Modulation	Reference power adjustment Δ	Nir	Xri
0	N/A	Out of range				
1	137	1	QPSK	0	9600	0
2	173	1	QPSK	0		
3	233	1	QPSK	0		
4	317	1	QPSK	0		
5	377	1	QPSK	0		
6	461	1	QPSK	0		
7	650	2	QPSK	0		
8	792	2	QPSK	0		
9	931	2	QPSK	0		
10	1262	3	QPSK	0		
11	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		



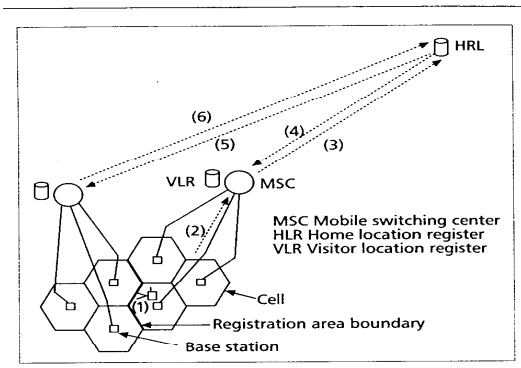
Evolutions of PCS

PCS Requirements

PCS network architecture

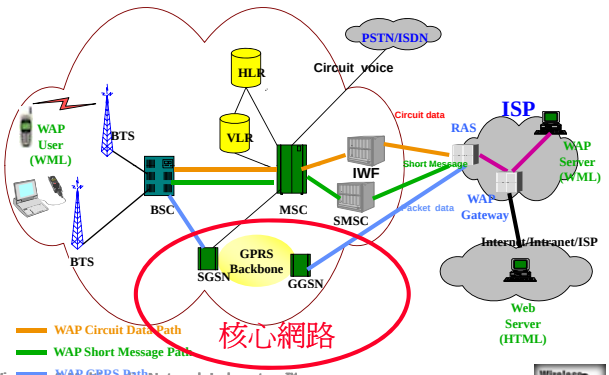


Location Update Procedure

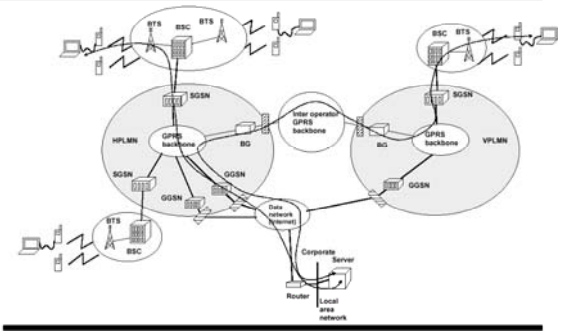


■ **Figure 3.** *Location registration procedures.*

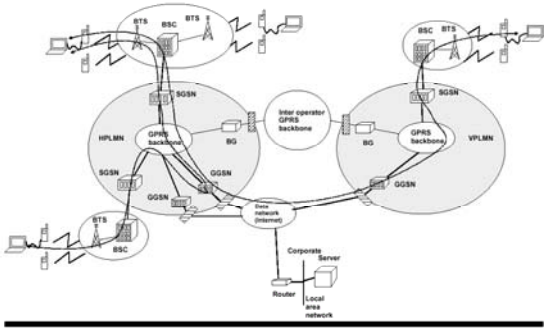
GPRS



Data transfer MS-fixed



Data transfer MS-MS



Coming Challenges for IP

Location Managements~ handoff, roaming

QoS Transport~ Backbone delivery

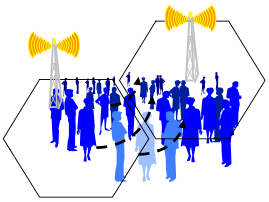
Mobility

- User mobility
  - Micro
  - Macro
- IP mobility support
  - Mobile IP
  - Cellular IP
  - HAWAII

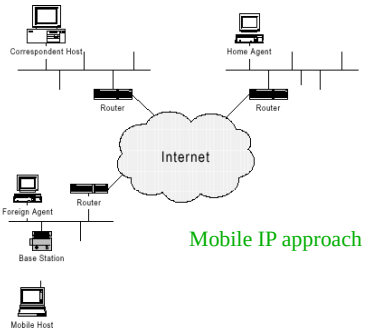
•Handoff issue

•Location management

•Paging

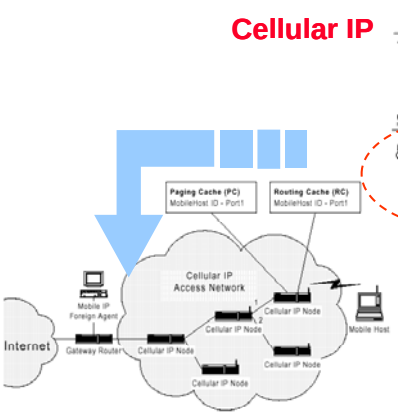


Nomadic wireless access

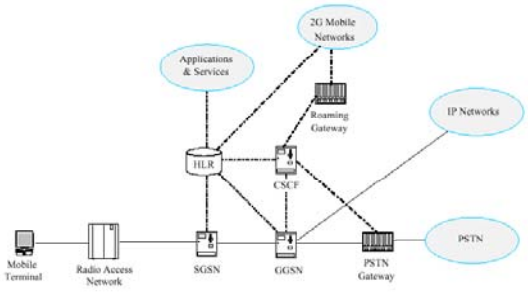


Mobile IP approach

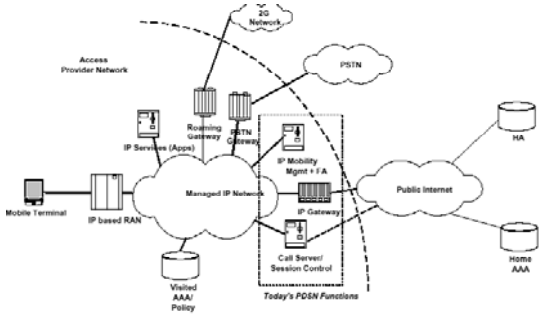
Cellular IP



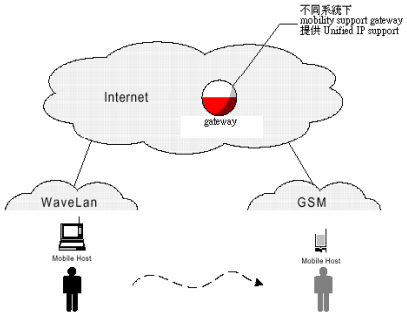
3GPP IP reference architecture



3GPP2 IP reference architecture

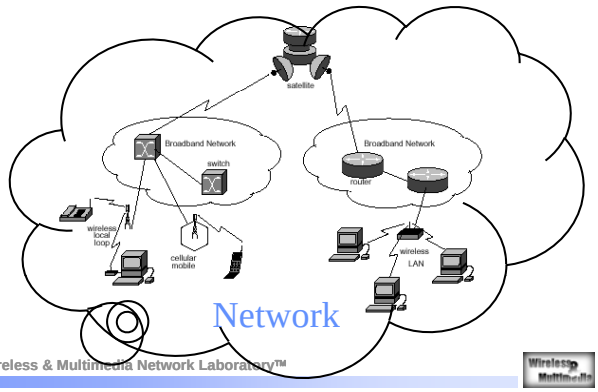


Heterogeneous access network



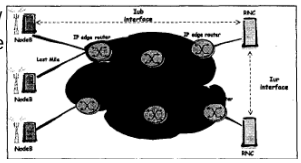
The Mobile People network architecture

Heterogeneous End System



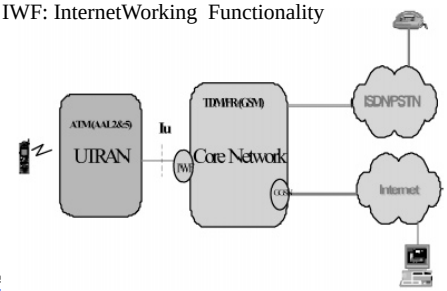
Last Mile QoS Issues

- 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

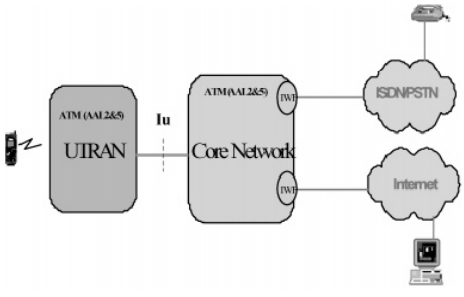


Option1

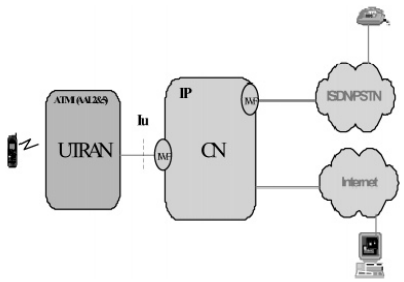
IWF: InternetWorking Functionality



Option 2



Option 3



Option 4