#### Rural Telecommunications (6) Access Technology II – Cellular Systems

Jun-ichi TAKADA

Department of International Development Engineering Tokyo Institute of Technology

# Evolution of Cellular Systems

2.5G 3G 1G 2G 3.5G 4G (packet) (multimedia) (HS DL) (broadband) (analog) (digital) 2001 2011? 2006 1979 1993 1997 GSM Europe **GPRS** Local and rest analog systems UMTS/ HSDPA IMT-Advanced WCDMA => LTEPDC PDC Japan Local 3GPP LTE-WIMAX packet system Advanced VS IEEE USA AMPS **IS-95** EV-DO cdma2000 802.16m (WIMAX (cdmaOne) TACS IS-136 advanced) (TDMA)

IMT-2000

3.9G

### Battle between 3GPP vs 3GPP2 for IMT-2000

- 3GPP (third generation partnership project) led by EU to standardize UMTS/WCDMA; new air interface with evolution of GSM network
- 3GPP2 (third generation partnership project II) led by Qualcomm to standardize cdma2000 and EV-DO
- WiMAX forum and IEEE 802.16 TGe contributed to standardize mobile WiMAX

- GSM = Global System for Mobile
  - European cellular standard penetrated in all over the world except Japan and Korea
  - 3 bands are used in ordinary service
    - 900 MHz
    - 1,800 MHz
    - 1,900 MHz (mainly in USA)
  - Voice and messaging (SMS)

## **Free Space Propagation**

• Friis' Transmission Formula



- According to Friis' fomula, lower frequency can expect larger reach with same power.
- Replacement of NMT 450
  - NMT Nomadic Mobile Telephone
  - 1G analog cellular to 2G digital cellular

#### Advantage of GSM 400 over other GSMs



Wider coverage area
 2 W terminal for 40 km radius

## – GSM 400 bites the dust – What happened to GSM 400?

- Support of both Nokia and Ericsson at the beginning
- Expectation of nationwide services though a joint GSM 400/WCDMA (2GHz) network
- Nokia and Ericsson pulled out later.
- Operators were uninterested in it.
- Manufacturers are unwilling, or in some cases unable, to supply handsets in commercial volumes until there is a perceived demand.

#### <u>Specific system for rural application may not be</u> <u>feasible commercially.</u>

http://www.allbusiness.com/information/telecommunications-wireless/1001913-1.html

# **GSM** Evolution

- High Speed Circuit Switched Data (HSCSD)
  - Circuit switch
- Wireless Application Protocol (WAP)
   1.0 (original) vs 2.0 (i-mode compatible)
- General Packet Radio Service (GPRS)
  - 115 kbit/s
- Enhanced Data for GSM Evolution (EDGE)
  - 384 kbit/s

# IMT-2000 (1)

- A single global standard was aimed.
- Under standardization in ITU

- Unified Systems
  - Land Mobile
  - Cordless
  - Fixed (WLL)
  - Satellite

- Unified Services
  - Voice
  - Fax
  - Data
  - Paging

# IMT-2000 (2)

- Unified
  Environments
  - Mobile
  - Pedestrian
  - Indoor
  - Satellite

- Transmission Rate
  - Indoor: 2 Mbit/s
  - Mobile: 384 kbit/s

# IMT-2000 (3)

- Expected to be a global standard in ITU
  - But given up
  - Single standard could not be achieved
    - Patent battles
  - W-CDMA, cdma2000, TD-CDMA, DECT, WiMAX etc.
  - To optimize the system for different environments and services, the system is with over specification.

# IMT-2000 (4)

- Why was service deployment delayed?
  - GSM/GPRS was sufficient.
  - Over-specification.
  - Frequency auction
    - Operators expected too much revenue for 3G services.
    - They paid too much for license fee, and could not afford for infrastructure.

### cdma450

- Same idea as GSM 400
- cdmaOne-based (2.5G)
- 180km max by parameter adjustment

Comparative CDMA Range (Not to Scale)





## cdma450

- 2<sup>nd</sup> generation ⇒ 3<sup>rd</sup> generation (GSM, cdmaOne) (WCDMA, cdma2000)
- CDMA 450: 450MHz version of cdma2000
  - High quality voice
  - Data up to 153kbit/s (1x) / 2.4 Mbit/s (EV-DO)
  - Partly used as fixed
  - Candidate for replacement of NMT
    - 4-5 MHz NMT bandwidth can be used for 1.25 MHz x 3-4 frequency channels

# Example

- Win Phone of LaoTel
- Fixed phone + USB adaptor





http://www.laotel.com/laotel2006/index\_winphone.php

# **Evolution of Cellular Systems**

	1G (analog)	2G (digital)	2.5G (packet)	<b>3G</b> (multimedia)	3.5G (HS DL)	4G (broadband)
	1979	1993	1997	2001	2006	2011?
Europe and rest	Local analog systems	GSM	GPRS	UMTS/	HSDPA	IMT-
Japan	Local system	PDC	PDC packet	WCDMA	=> LTE (3.9G)	3GPP LTE vs
USA	AMPS		IS-95	cdma2000	EV-DO	IEEE
	TACS	IS-136 (TDMA)	(cdmaOne)			002.1011

## Why is 2G system still alive?

- Big demand in developing world
- Global roaming
- Voice and SMS still sufficient
  - Video call (typical application of 3G) is not needed.
  - Operators are doing good business with voice and SMS.
- High speed data fee still very high
- Cost: SMS is cheaper than voice (sometimes free)
- Investment for 3G network (replacement) is large.
- Terminal is cheaper; terminals with minimum feature, secondhand market, large number of products
- Data terminal in 3G needs large size; it is in contradiction to small, lightweight and cheap terminal.

## Why is 2G system still alive? Class opinion

- 3G is specifically used for data and voice is not encouraged to transmit; 2G is sufficient for voice. (Indonesia)
- Voice and message are sufficient for communications
- For rural applications, 3G terminals are still expensive.

# Repeater (1)

 Repeater system is installed within BTS cell. It amplifies the weak RF signal from the BTS to the designed area and vice versa.



http://www.wtw.jp/tu/TU-TI-RF-2-J.htm

# Repeater (2)

- The population density in their licensed coverage areas is low enough so that most base stations will be underused.
- High-powered CDMA repeaters have provided the carriers with the means to cost-effectively deploy CDMA networks in their rural BTAs.
- They used the approach to design their networks with a combination of base stations and repeaters, which is known as a hybrid network.
- CDMA networks operate using a 1:1 frequency-reuse scheme. Consequently, there is no requirement for frequency-reuse planning. Repeaters can be used anywhere in the network.