

Introduction to WiBro Technology

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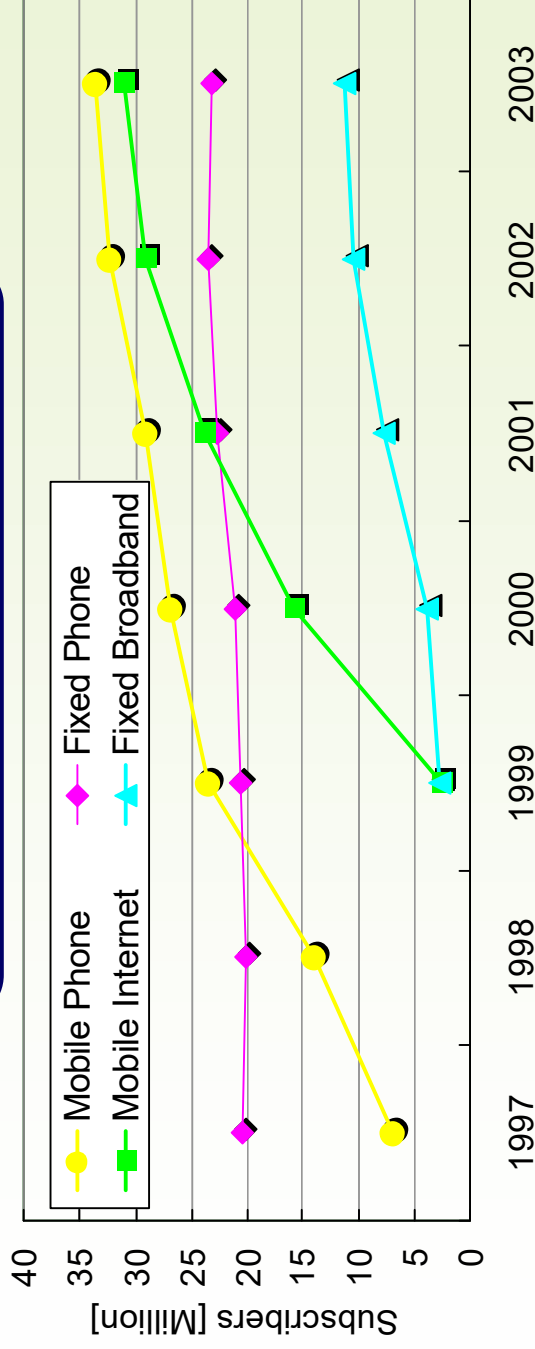
Background of WiBro Service

Market Trend in Korea (1)

□ Korea Telecommunication Market Trend

- ◆ 2001-2003 subscriber growth rate
 - Fixed BB(44%) > Mobile internet(30%) > Mobile phone(16%) > Fixed phone(2%)
- ◆ Voice market is saturated (fixed phone) or slowly growing (mobile phone)
- ◆ Data market (mobile internet & fixed BB) is growing faster than voice

Subscribers Trend



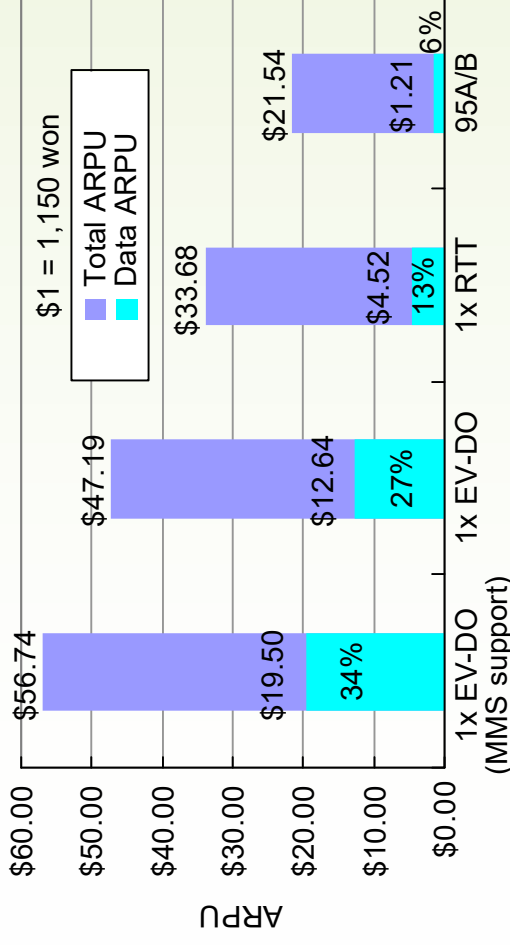
? Number of mobile phone users includes mobile internet users

Source : KISDI (Korea Information Strategy Development Institute)

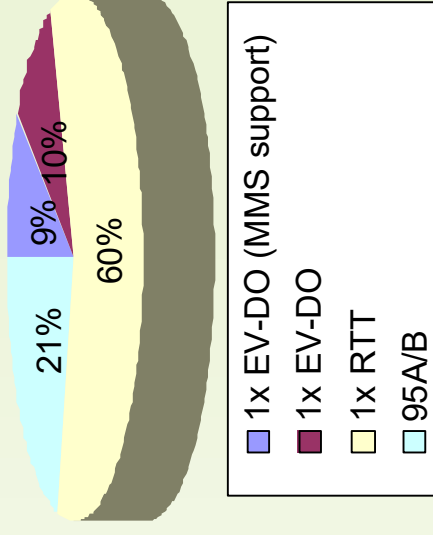
Market Trend in Korea (2)

- Mobile Data ARPU (2003 Dec. SKT user basis)
 - ◆ As network evolves, data ARPU portion increases
 - ◆ Data rate is one of the key factor to increase data ARPU
 - ◆ Data ARPU is expected to keep increasing as the market churns

ARPU by Handset Type



User Potion



*Total ARPU is net of interconnection fees and signup fees

*Data ARPU = Wireless Internet revenues including phone mail revenue / internet user

ARPU : Average Revenue Per User

MMS : Multi Media Service

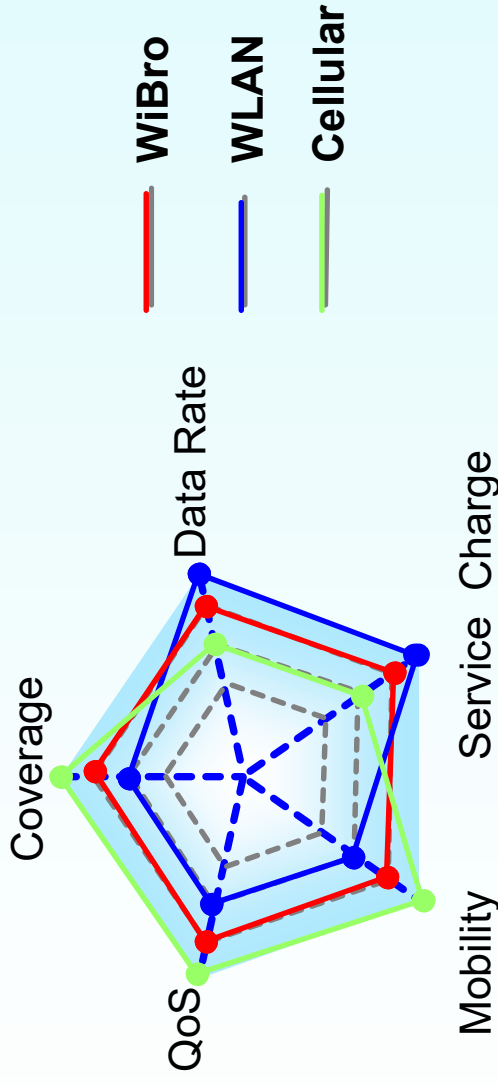
Source : SKT IR Data, 2004

Needs for WiBro Service

Limit of Existing Technologies

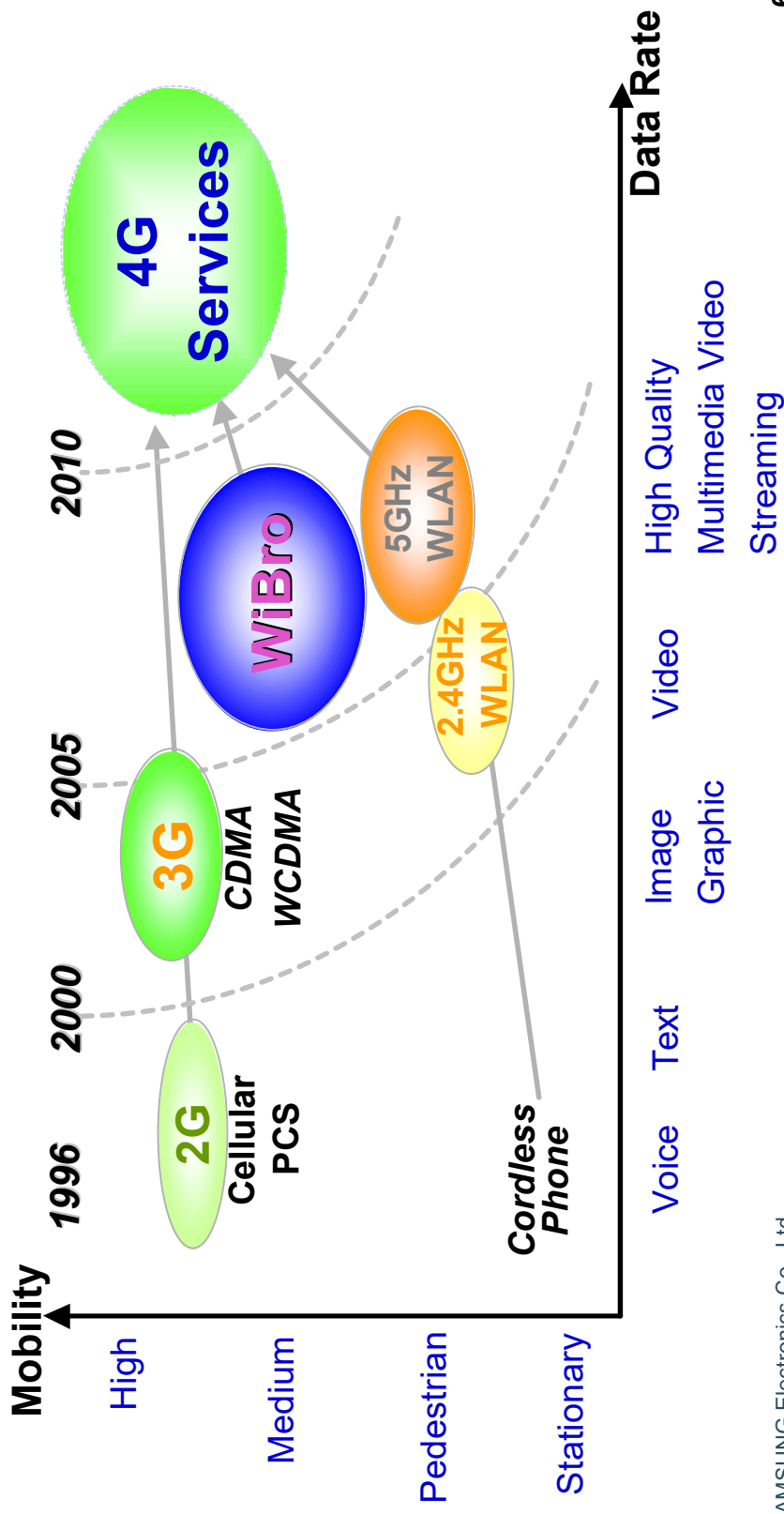
- ❑ **WLAN (IEEE 802.11 series)**
 - ◆ Support very high data rate but limited coverage and mobility not supported
- ❑ **Cellular (cdma2000 1X, 1xEV-DO, WCDMA)**
 - ◆ Support large coverage and fast mobility but data rate is low and too expensive

Technology Comparison



Service Position in Network Evolution

- ❑ WiBro is now located between WLAN and Cellular service.
- ❑ In the future, WiBro service will evolve to 4G Network which provide higher data rate and mobility



HPI(High Speed Portable Internet) Project

- ETRI/Samsung HPI Project Objective
 - ◆ Development of HPI system at 2.3GHz
 - ◆ HPI RTT specification & system development
- Period: 2003.1. ~ 2005.12.
- Sponsors : HTI, KT, KTF, SKT, Samsung
- Results
 - ◆ ETRI/Samsung
 - WiBro spec proposed to TTA and accepted as baseline
 - ◆ ETRI
 - Prototype system development
 - ◆ Wired and wireless operators
 - Requirements definition

RTT: Radio Transmission Technology

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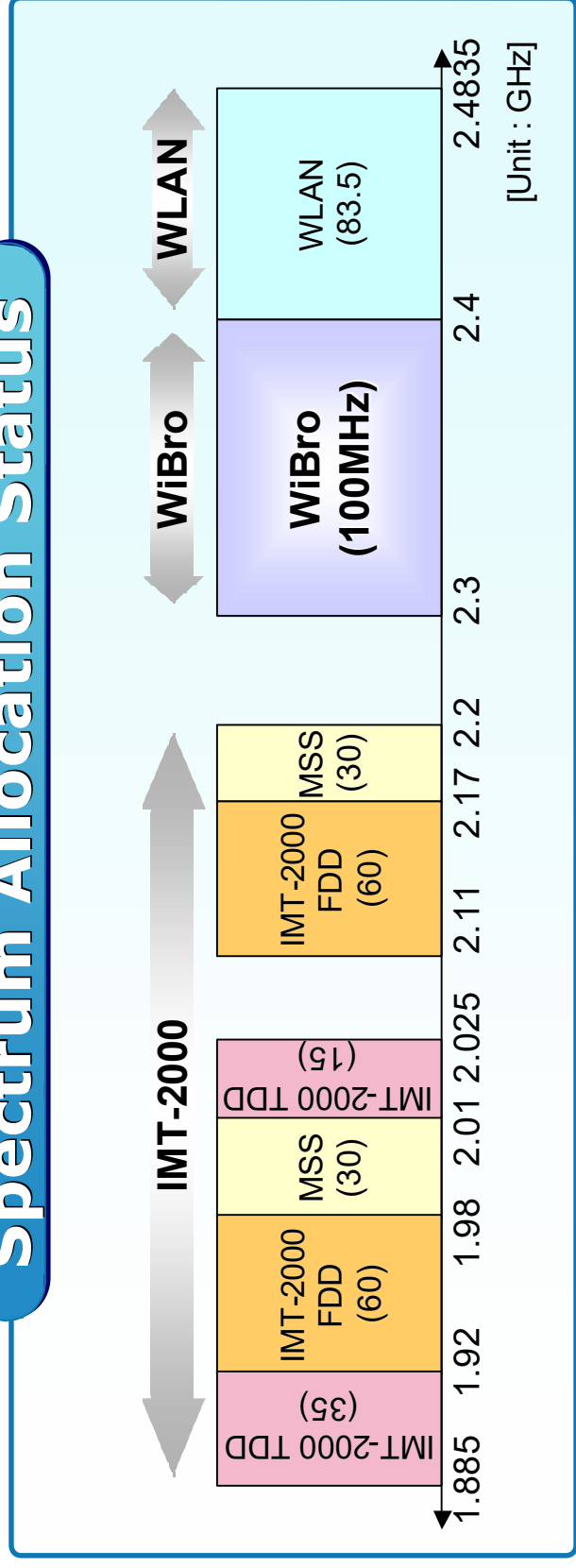
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WiBro Spectrum Allocation of Korea

- MIC allocated 2.3GHz spectrum for WiBro services
(Official MIC notice, Dec. 2002)

- ◆ Frequency BW : 2.3~2.4GHz
- ◆ Purpose : WiBro (Portable Internet)
- ◆ Usage : Fixed / Mobile

Spectrum Allocation Status



MIC : Ministry of Information and Communication

MSS : Mobile Satellite Service

Global TDD Spectrum Allocation

□ Global TDD Spectrum Allocation Status

- ◆ FDD band is about 3 times larger than TDD band
- ◆ More TDD band will be required

➤ For high data rate support, new systems requiring broader bandwidth etc.

[GHz]	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	>2.7
WRC					35 IMT-2000 15	IMT-2000						
Europe			GSM	20 IMT-2000 15	IMT-2000	IMT-2000			ISM	IMT extension reserved for TDD		3.4GHz
U.S.A.	700Mhz	Future 3G	PCS						ISM	ITFS, BRS		3.4GHz
Australia/ New Zealand				IMT-2000		IMT-2000	MMDS		ISM	IMT extension reserved for TDD		3.4GHz
Japan			PHS	IMT-2000		IMT-2000			ISM	IMT extension reserved for TDD		
China			GSM	40 IMT-2000 15	IMT-2000	IMT-2000		TDD	ISM	IMT extension reserved for TDD		
Korea			CDMA	35 IMT-2000 15	IMT-2000	IMT-2000		WiBro	ISM	IMT extension reserved for TDD		

■ 3GPP TDD ■ IMT extension reserved for TDD ■ Other TDD Bands

WRC : World Radiocommunication Conference

ITFS : Instructional Television Fixed Service

© BRS : Broadband Radio Service

MMDS : Multichannel Multipoint Distribution System

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WiBro Technology Overview

System Requirements

High Data Rate

- ☐ Maximize sector/user throughput
- ☐ Broad bandwidth
- ☐ MAC & RRC

Mobility

- ☐ Vehicular speed mobility (~60km/h)
- ☐ Seamless service
- ☐ Longer battery usage

Full Coverage

- ☐ Various types of cell (Macro / Micro / Pico)
- ☐ Easy cell planning
- ☐ Roaming with cellular & WLAN

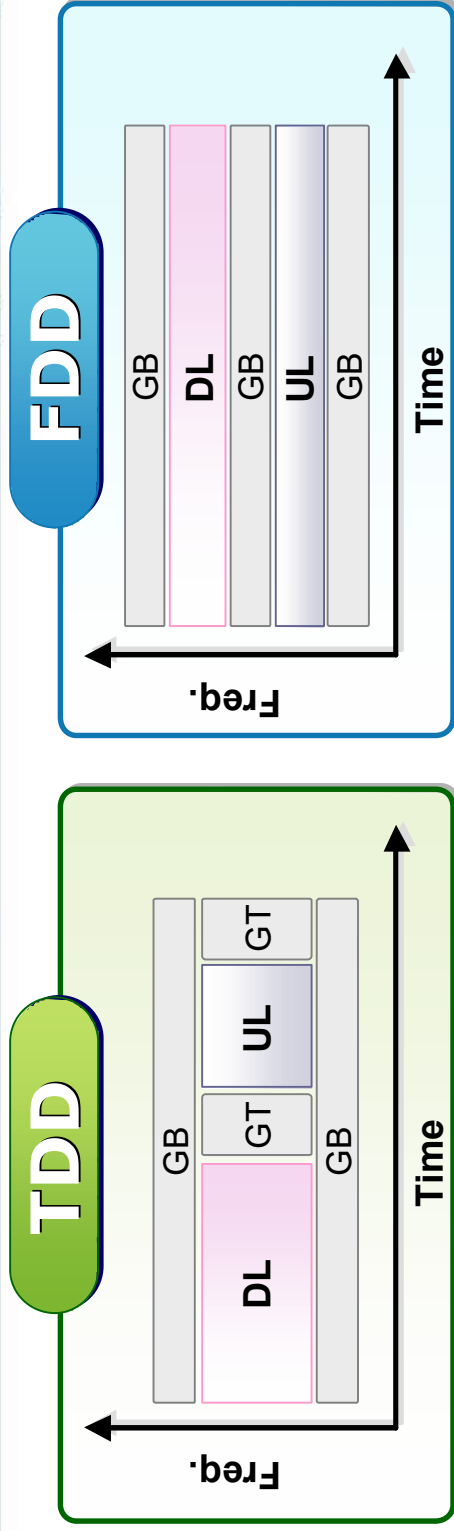
Low Cost

- ☐ Improve spectral efficiency
- ☐ Reduce infra cost
- ☐ Multiplexing gain of packet data.

MAC : Medium Access Control

RRC : Radio Resource Control

TDD vs. FDD



	T D D	F D D
UL/DL Isolation	Guard Time	Guard Band
Spectrum Efficiency	More efficient (Smaller GB)	Less efficient (Larger GB)
UL/DL Channel	Reciprocal (Easy to apply SA, MIMO etc.)	Non-reciprocal
Suitable for	Packet base data traffic	Symmetric traffic like voice
For same coverage	Need more power (duty factor)	Need smaller power
Applied system	WiBro, 802.16, 802.11a/b, TD-SCDMA,	IS-95A/B, CDMA2000, 1xEV-DO, GSM, GPRS, W-CDMA

GB : Guard Band

GT : Guard Time

PHY Spec.

- ❑ Frequency Band : 2.3GHz (Korea)
- ❑ Channel Bandwidth : = 9MHz
- ❑ Duplex : TDD / 5msec frame
- ❑ Multiple Access : OFDMA
- ❑ Modulation : QPSK, 16QAM, 64QAM
- ❑ Channel Coding : CTC
- ❑ Cell Coverage : ~1km
- ❑ Maximum Data Rate
 - ◆ Sector throughput : DL : 18 Mbps, UL : 6 Mbps
 - ◆ User throughput : DL : 3 Mbps, UL : 1 Mbps
- ❑ Optional AAS support

CTC : Convolution Turbo Code

AAS : Adaptive Antenna System

MAC Spec.

- ❑ Flexible BW Allocation by MAP
 - ◆ Frame by Frame
- ❑ Supports flexible QoS offering
 - ◆ rtPS, nrtPS, BE
 - ◆ Fine granularity
- ❑ Efficient MAC PDU construction
 - ◆ Variable size MAC PDU
 - ◆ MAC-level framing (No PPP)
 - ◆ Fragmentation, packing, concatenation
- ❑ Payload header suppression support
- ❑ Security support
- ❑ Sleep mode support
- ❑ H-ARQ/ARQ support
- ❑ Handoff : BBM
- ❑ AMC support

rtPS : real-time Polling Service

BE : Best Effort

H-ARQ : Hybrid Automatic Response ReQuest

AMC : Adaptive Modulation and Coding

nrtPS : non-real-time Polling Service

PDU : Protocol Data Unit

BBM : Break Before Make

PHY Characteristics (1)

□ High Spectral Efficiency Support

- ◆ TDD
 - Minimize guard band to increase spectral efficiency
- ◆ 10 MHz BW / OFDMA
 - Minimize multi-path interference to increase spectral efficiency
- ◆ Support various modulation schemes (QPSK, 16QAM, 64QAM) and CTC to maximize data rate

□ Full Coverage Support

- ◆ Support cellular operation with frequency reuse factor of 1
 - High spectral efficiency & easy cell planning
 - Minimize interference using diversity subchannel based on Reed Solomon sequence
 - Compensate low SINR at cell edge using low rate coding
- ◆ Fast handover with mobile IP

PHY Characteristics (2)

□ Performance Enhancement considering Mobility(1)

◆ H-ARQ

- Increase the efficiency of re-transmission resulting from fading and interference

◆ Band selection AMC & diversity subchannel

- Mobile stations request to select band selection AMC or diversity subchannel by monitoring channel status
- For slowly moving users : allocate band selection AMC subchannels which have high quality channel response to increase transmission efficiency and coverage
- For fast moving users : allocate diversity subchannels distributed over whole frequency band to maximize frequency diversity

PHY Characteristics (3)

□ Performance Enhancement considering Mobility(2)

- ◆ Support 60km/h mobility
 - Minimize distortion due to mobility using short OFDM symbol
 - Apply pilot structure supporting channel estimation while moving
- ◆ Support fast access during hand-off
 - Apply short frame length (5msec) for fast response
 - Apply additional non-contention based control channel access duration

PHY Characteristics (4)

❑ Flexible Resource Allocation for Multiple Users

- ◆ Asymmetric DL / UL allocation
 - DL/UL : 2:1, 1:1, 5:1
- ◆ Multiple user acceptance
 - Support different packet scheduling algorithm and status management for each type of mobiles

❑ Support Portability

- ◆ Support sleep mode to decrease handset consuming power

❑ TDD Adaptive Antenna System (Optional)

- ◆ Increase coverage and data rate for slowly moving users

PDU : Protocol Data Unit

PPP : Point to Point Protocol

MAC Characteristics

- ❑ Scheduler Design Consideration
 - ◆ Adaptive modulation & coding
 - ◆ QoS guarantee
 - ◆ Throughput maximization
 - ◆ Fairness
 - ◆ Power constraint of mobiles
 - ◆ Scheduling algorithm complexity

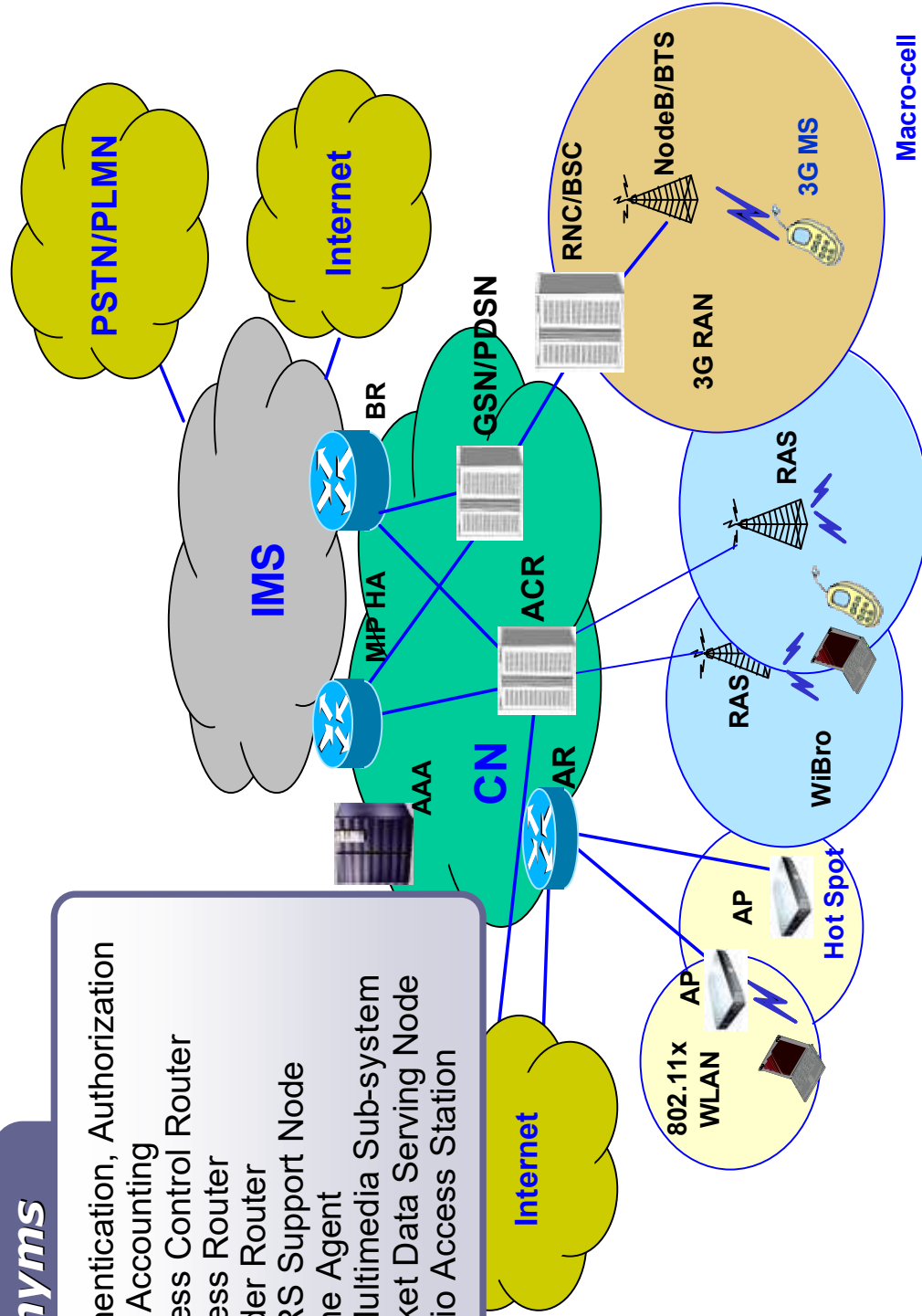
❑ QoS Classes in WiBro

QoS Class	Data type	Application
Real time polling service	• Periodic interval • Variable-sized packet • Real time data stream	MPEG Video, Video telephony
Non real time polling service	• Variable-sized packet • Delay-tolerant data stream • Minimum data rate is required	FTP, WWW
Best effort service	• No minimum service level	FTP, WWW, E-mail

WiBro Network Architecture

Acronyms

- AAA** Authentication, Authorization and Accounting
- ACR** Access Control Router
- AR** Access Router
- BR** Border Router
- GSN** GPRS Support Node
- HA** Home Agent
- IMS** IP Multimedia Sub-system
- PDSN** Packet Data Serving Node
- RAS** Radio Access Station



Network Element Functions

ACR

- ❑ Packet classification & header suppression
- ❑ Service flow management
- ❑ Traffic switching & integration point
- ❑ Handover management
- ❑ Session information maintenance
- ❑ RAS interface
- ❑ Core network interface

RAS

- ❑ PHY processing and air resource scheduling
- ❑ MAC management message processing
- ❑ MAC PDU processing
- ❑ CID management
- ❑ Encryption & Decryption
- ❑ ACR interface

PDU : Protocol Data Unit

CID : Connection ID



Future Plan and Strategy

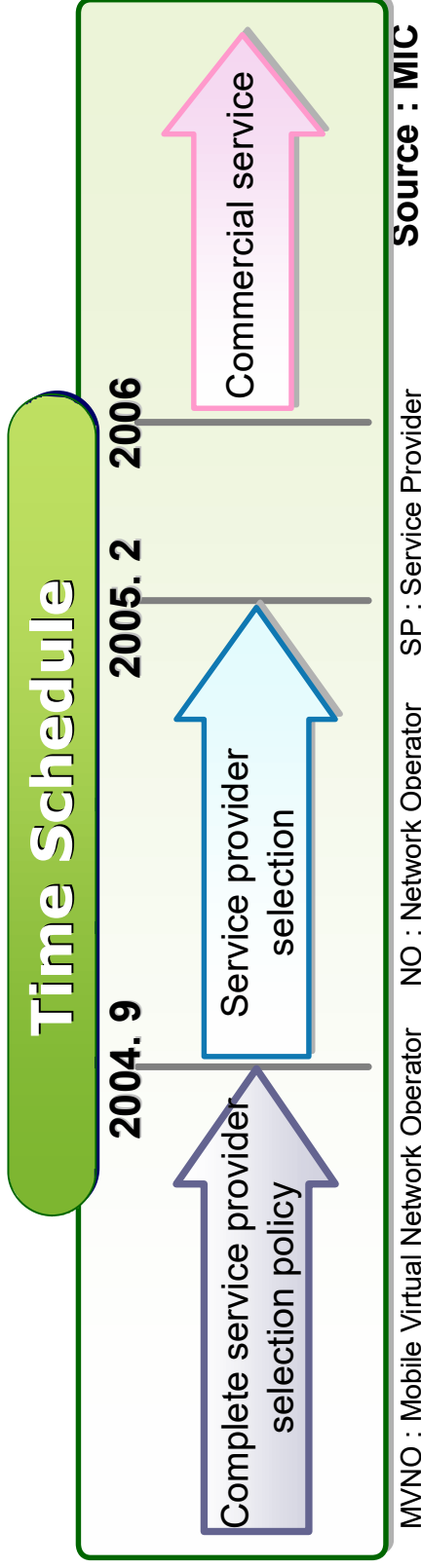
WiBro Policy of Korea

□ Standard

- ◆ Based on IEEE 802.16-2004 & 802.16e Draft3 or later version satisfying:
 - Downlink 512kbps, uplink 128kbps at 60Km/h
 - Channel bandwidth >9MHz
 - Roaming between operator equipment
 - TDD
 - Frequency reuse factor 1

□ Service Provider Selection

- ◆ Number of service provider : 2~3
- ◆ Frequency usage period : 7 years
- ◆ MVNO, NO-SP separation considered



WiBro Mobile Station Development Strategy

❑ Survey Result of WiBro Demand

	Public Users	Enterprise Users
Most important benefit	☐ Cheap service charge and phone	☐ Mobility
Preferred Service charge policy	☐ Fixed amount	
Preferred type of mobile station	☐ Handheld type ? Early adopters prefer notebook type	☐ Notebook type ☐ PDA
Needs for service continuity with existing ones	☐ 78%	☐ 95%

Source : KISDI, 2003

❑ WiBro Mobile Development Strategy

- ◆ Develop low price mobile phones for public users
- ◆ Develop high mobility support mobile phones for enterprise users
- ◆ Support existing services (Develop dual mode type)
- ◆ Develop notebook internal type or card type in early market
- ◆ Move to PDA or handheld type as market matures

WiBro System Development Strategy

- Time-to-market Development of Standardized System
 - ◆ Proof of Concept development through HPI project
- Capacity Enhancement Technology Adoption
 - ◆ MIMO / AAS / Space time coding adoption
 - ◆ Increase the throughput of slowly moving users using UL/DL reciprocal channel characteristics of TDD system
 - ◆ Key technology development and TTA phase 2/IEEE802.16e standardization
- Alternative Low Price Solution Development for Enterprise or Household Users
 - ◆ Standardize the configuration applying low power amplifier or looser RF spec to reduce network deployment cost

Appendix. Technology Comparison

	WiBro	3G Standard			WLAN
		TD-CDMA	HSDPA	EV-DO	
Peak Data Rate	DL : 18.4Mbps UL : 6.1Mbps	DL : 3.1Mbps UL : 900Kbps	DL : 14Mbps UL : 2Mbps	DL : 3.1Mbps UL : 1.2Mbps	802.11b : 11Mbps 802.11a,g : 54Mbps
Bandwidth	= 9MHz	5MHz(10MHz)	5MHz	1.25MHz	20MHz
Multiple Access	OFDMA	TDMA, CDMA	TDMA, CDMA	CDMA	CSMA/CA
Duplex	TDD	TDD	FDD	FDD	TDD
Mobility	Mid	High	High	High	Low
Coverage	Mid	Mid	Large	Large	Small
Standardization	TTA & 802.16e	3GPP	3GPP	3GPP2	IEEE 802.11x
Target Market	Public/ Enterprise	Public	Public	Public	Home/ Enterprise

CSMA : Carrier Sense Multiple Access

CA : Collision Avoidance



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