# 2.3 GHz Portable Internet (WiBro) Overview

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Introduce the overview of TTA PG302 standard.

# 2.3GHz Portable Internet(WiBro) Overview

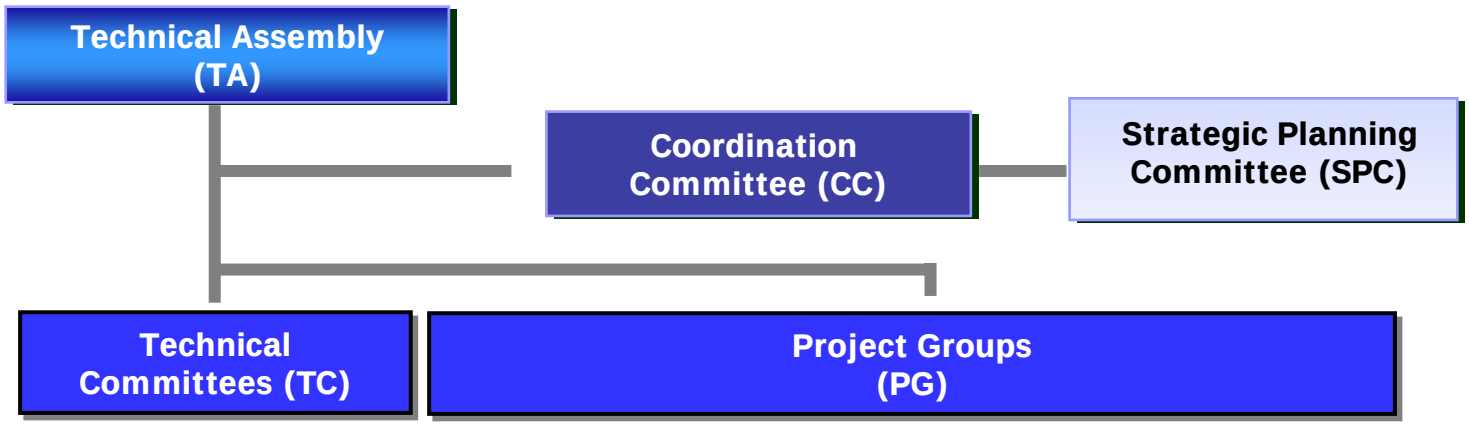
TTA PG302

August 29, 2004


# WiBro overview

# Contents

# Ⅰ. Telecommunications Std Committee of TTA




| | |
|---|---|
| **Common Infrastructure (TC1)** | Information Security, Internet Security, Biometrics, Welfare Communication, IC Card, SoC, Disaster Recovery, Embedded S/W |
| **Transmission (TC2)** | Optical Transmission, Optical Internet, Signaling, Routing Protocol, Quality of Service, VoIP, ENUM, NGN, Active Internet, Charging & Interconnection, Network Management, IPv6, LAN, DSL, Digital Home |
| **Radio Communication (TC3)** | Digital TV, DMB, Digital Cable, WPAN, Wireless LAN, Propagation Measurement, NGMC, LBS, Telematics, **Portable Internet** |
| **IT Application (TC4)** | WEB, Multimedia Application, Workflow, E-commerce, Public information, MetaData, S/W Process, S/W Components. NGIS, ITS, Grid |

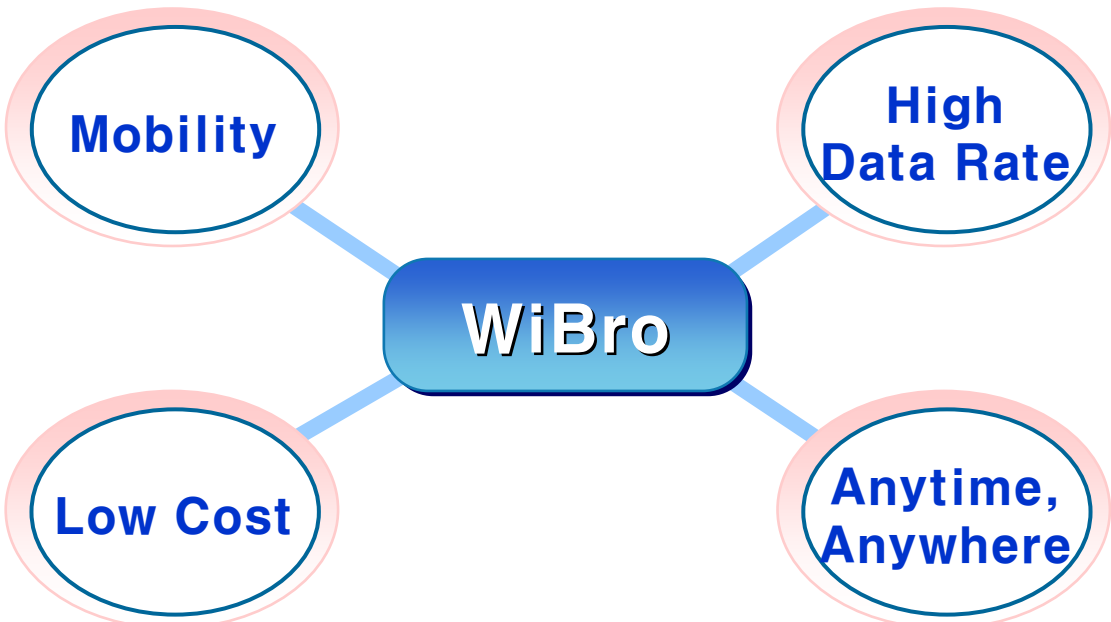
# II. WiBro - Definition

**Definition**

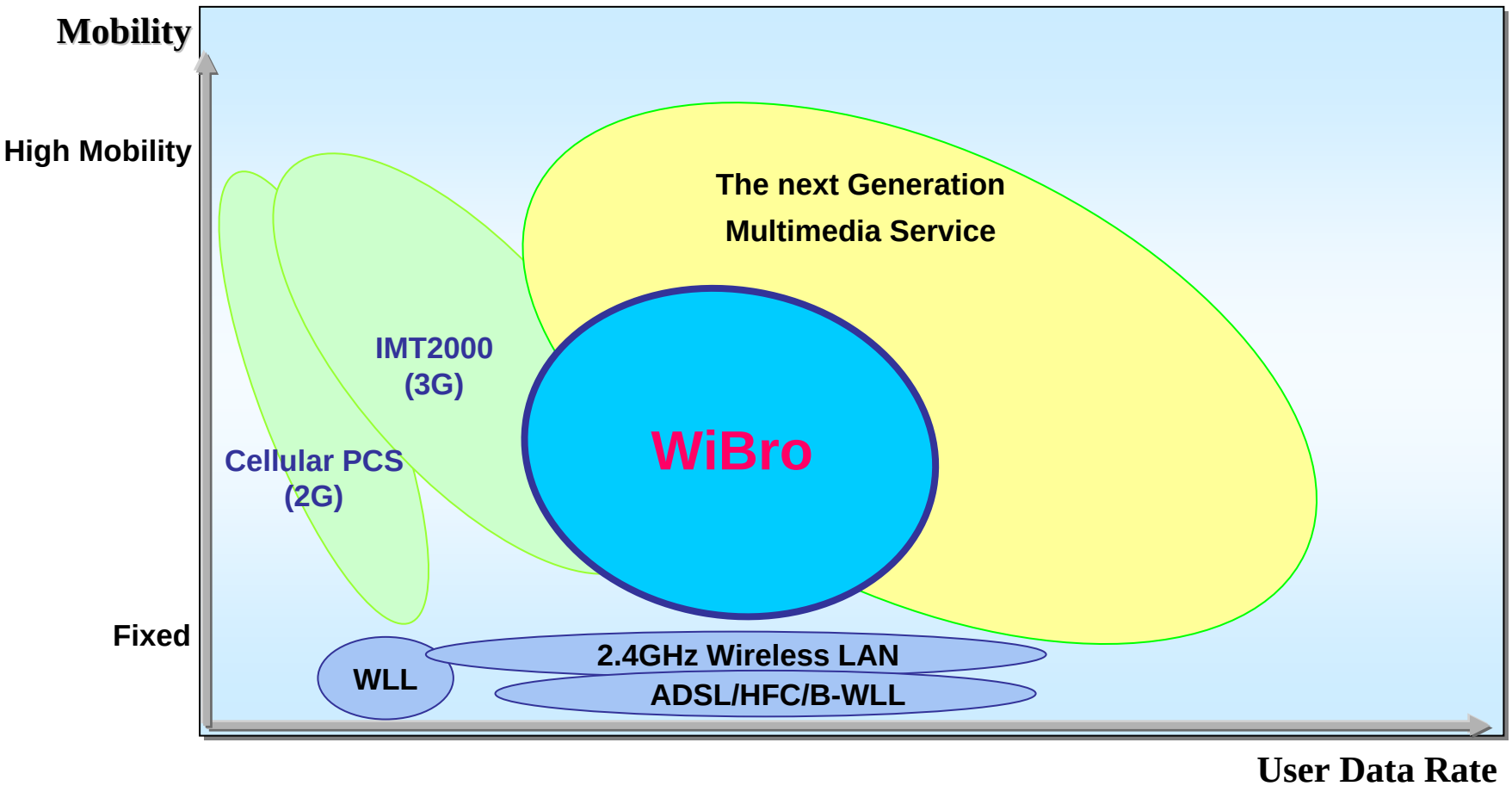
- Portable Internet Service(WiBro) is to providea high data rate wireless internet access with PSS(Personal Subscriber Station) under the stationary or mobile environment, anytime and anywhere.

**Reference**

- 『Portable Internet』 was named as 『WiBro』. (End of April, 2004)
- WiBro : Wireless Broadband



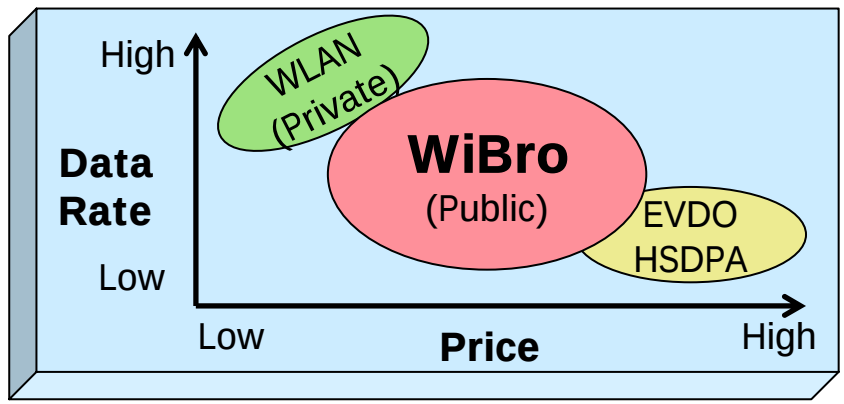
# III. WiBro - Positioning



# IV. Establishment of Standardization Committee(PG302)

## Background

- Demand on (wire/Wireless) Internet services in Korea has risen dramatically.
- An efficient frequency band was sought by Industries; the government reallocated 2.3GHz, once allocated for FWA, for Portable Internet service (Dec. 2002)
- Korean market wants Portable Internet service




| | Wired Line | Wireless |
|---|---|---|
| Data | ✓Cable Modem, ADSL, VDSL<br>✓Telephone Line Modem, PDSN, Router/ATM | |
| Voice | ✓PSTN, ISDN<br>✓Key Phone, PABX | ✓CDMA, WCDMA<br>✓TRS |

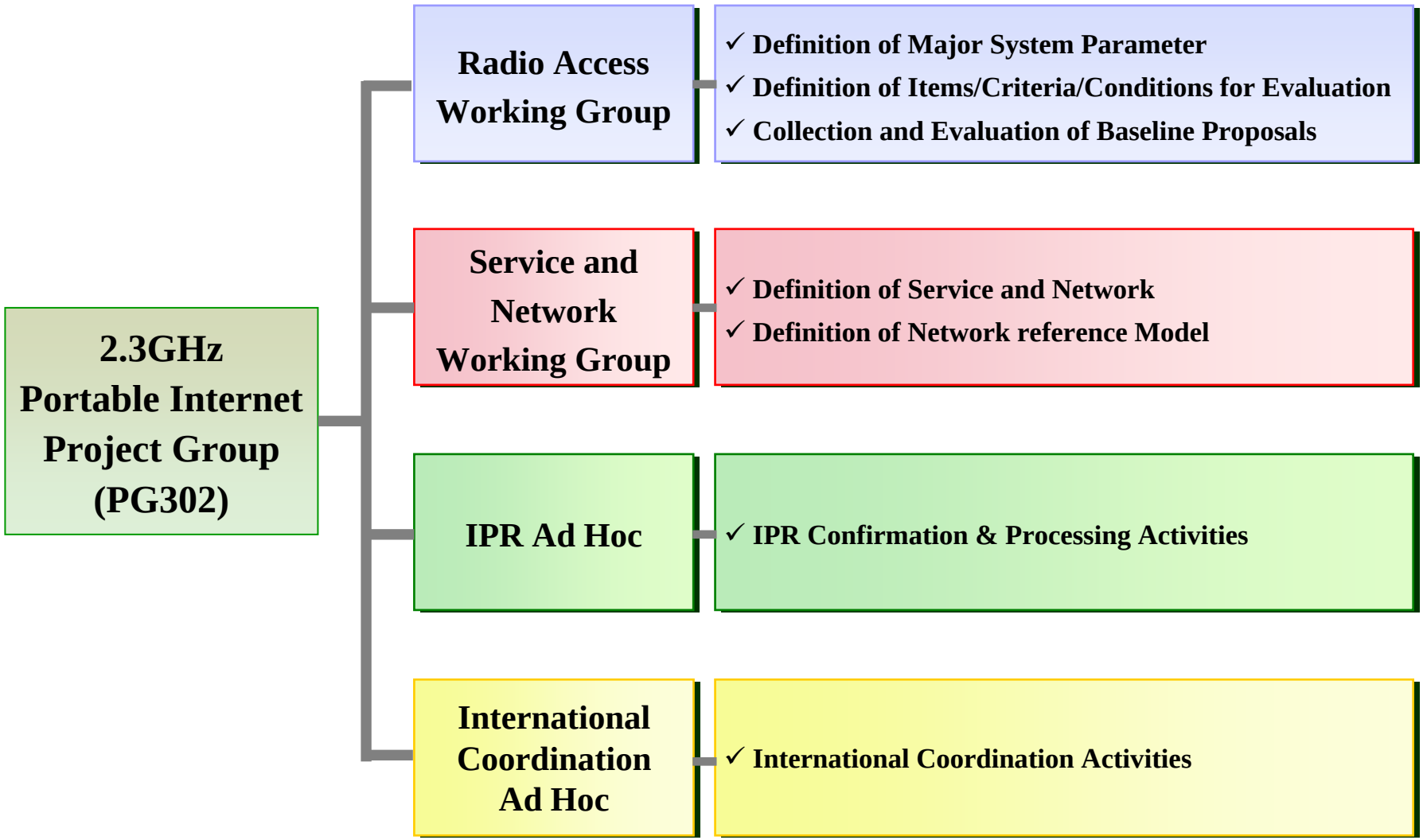
# IV. Establishment of PG302 (cont'd)

## Establishment of PG302 for WiBro standardization

- Technical Assembly(TA) of TTA standardization committee approved the establishment of 2.3GHz Portable Internet Project Group(PG302, renamed from PG05) in June, 2003
- The first meeting was held on 30 July, 2003 and The Chairman was elected.
- The second meeting was held on 5 September, 2003 and approved the followings
  - The establishment of 2 Working Groups and 2 Ad Hoc
  - The Goal of PG302 Activities & Timeline is as follows.

| Time | Goal (Phase 1 Standardization) |
|---|---|
| 3Q 2003 | **Definition of Target Requirements**<br>- Minimum Service Requirements<br>- Minimum System Requirements |
| 4Q 2003 | **Preparation of the Draft Standard**<br>- Definition of major system parameters<br>- Definition of items/criteria/conditions for Evaluation<br>- Collection and Evaluation of Baseline Proposals<br>- Selection of Baseline Proposal(s)<br>**IPR Confirmation and Processing Activities**<br>**International Cooperation Activities** |
| 1Q 2004 | **Completion of Draft Standard** |
| 2Q 2004 | **Approval and Notification of Standard** |

# V. Committee Structure and ToR of PG302




* ToR : Terms of Reference

# VI. Decision of PG302

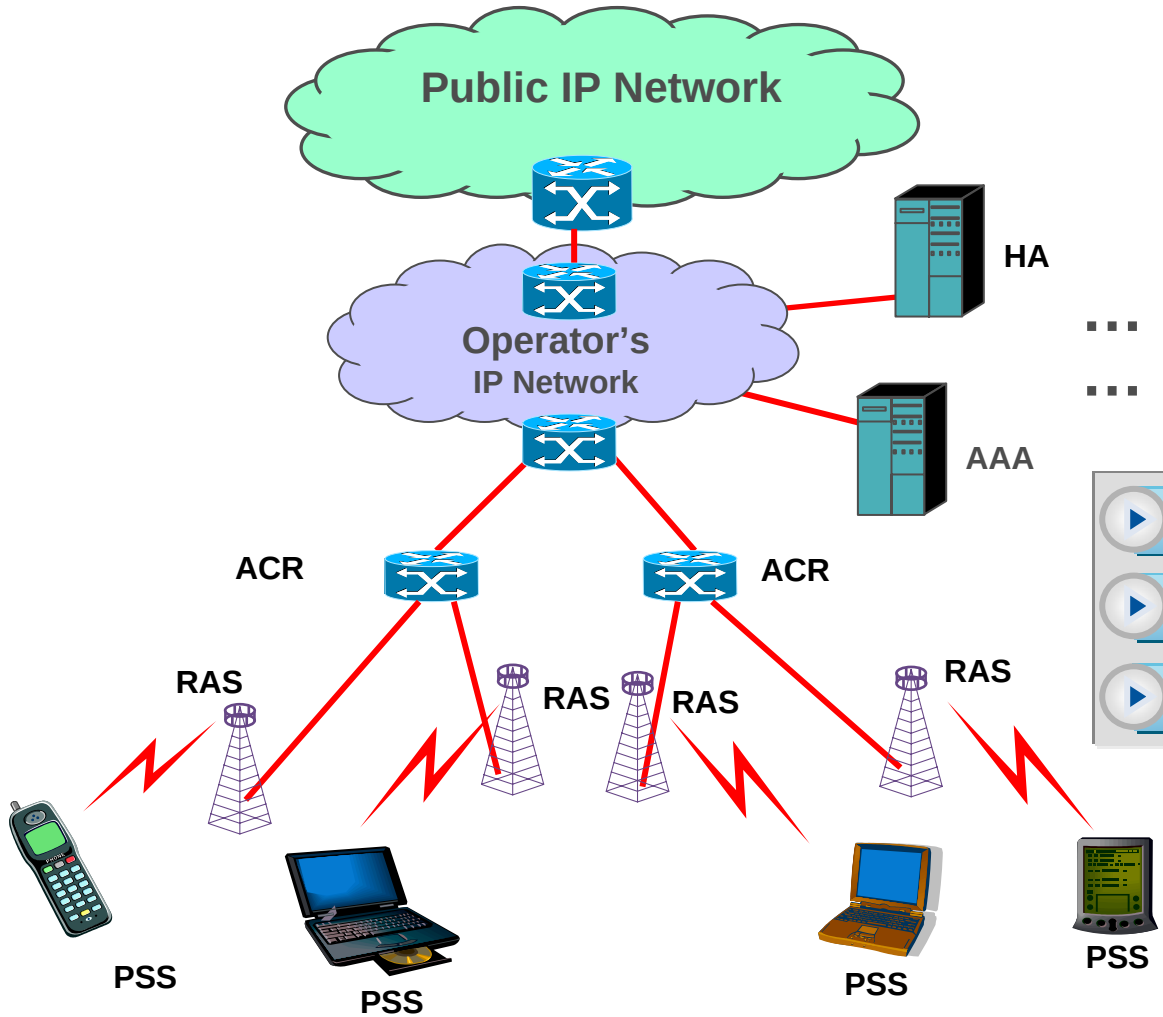
## Maior Decision (Phase I Standardization)

- The PG302 Meeting of Jan 31, 2004 approved the Major System Parameters & Radio Access Requirements as follows

| Major System Parameters | | Radio Access Requirement | |
|---|---|---|---|
| Duplexing | TDD | Frequency Reuse Factor | 1 |
| Multiple Access | OFDMA | Mobility | ≤ 60 [Km/h] |
| Channel BW | 10 [MHz] | Service Coverage | ≤ 1 [Km] |
| | | Spectral Efficiency [bps/Hz/cell(sector)] | Max. DL / UL = 6 / 2<br>Aver. DL / UL = 2 / 1 |
| | | Handoff | ≤ 150 [ms] |
| | | Throughput (per user) | Max. DL / UL = 3 / 1 [Mbps]<br>Min. DL / UL = 512 / 128 [Kbps] |

# VI. Decision of PG302 (cont'd)

## Network Architecture of WiBro (Phase I Standardization)




- ACR : Access Control Router
- RAS : Radio Access Station
- PSS : Personal Subscriber Station

# VI. Decision of PG302 (cont'd)

**Progress**

- **PG302**
  - selected two baselines for WiBro (March, 2004)
  - and then, approved one baseline as Draft between two baseline (April, 2004)
- **The Draft for WiBro in circulation to members of TTA.**
  - May 3 ~ May 30, 2004 (during 4 weeks)
- **PG302 selected the Draft as a Draft Standard for WiBro**
  - June 7, 2004
- **And, Radio & Broadcasting Technical Committee(TC3) of TTA selected the Draft Standard.**
  - June 9, 2004
- **Finally, The Draft Standard was approved as a Standard (phase I) for WiBro in Technical Assembly (TA) of TTA.**
  - June 25, 2004

# VII. Future Plan of PG302 (Phase II Std)

Phase II Standardization for advanced WiBro will be started from 3Q 2004.

| Time | Goal (Phase II Standardization) |
|---|---|
| 3Q 2004 | • Definition of Service and System Requirements<br>• Determination of scope of technologies for improvements of system capacity<br>• Harmonization and collaboration with IEEE 802.16<br>• Preparation of detailed guideline for IPR Processing |
| 4Q 2004 | • Design of Evaluation Criteria of technologies for improvement of System Capacity<br>• Proposal and Evaluation of technologies for improvement of System Capacity<br>• Preparation of Evaluation Methodology for functional improvement for System<br>• Harmonization and Collaboration with IEEE 802.16<br>• IPR activities (Patent issue of factor technology, Patent Forum etc.) |
| 1Q 2005 | • Proposal and Evaluation of technologies for improvement of System Capacity<br>• Proposal and Evaluation of technologies for improvement of System Function<br>• Preparation of the Draft Standard<br>• Harmonization and Collaboration with IEEE 802.16<br>• IPR activities (Patent issue of factor technology, Patent Forum etc.) |
| 2Q 2005 | • Completion of Draft Standard<br>• Harmonization and Collaboration with IEEE 802.16<br>• IPR activities (Patent issue of factor technology, Patent Forum etc.) |

PART II

# WiBro Standard overview

# Contents

# I. Introduction of the PHY Spec. – feature (1/3)

- **Supporting High spectrum efficiency**
  - TDD: Minimize guard-band ➔ Maximize available frequency resource
    - Synchronous RAS is required
  - 10 MHz broadband / OFDMA
    - Minimized MPI ➔ Enhanced transmission efficiency
  - Using CTC with QPSk/16/64 QAM modulation CTC(Convolutional Turbo Code) ➔ Enhanced transmission rate with respect to SINR perspective
- **Supporting wide Coverage**
  - With supporting of Frequency reuse factor '1'
    - Higher spectrum efficiency and Easy deployment of RASs
    - Using Reed Solomon sequence based Diversity subchannel → minimize other RASs interferences
    - In the Cell edge with bad SINR area, The operation guaranteed with Low rate FEC
  - Supporting Safety Channel in order to reduce interference of the Cell edge area

# I. Introduction of the PHY Spec. – feature (2/3)

- **Performance enhancement features consider mobility**
  - H-ARQ
    - Enhanced link performance guaranteed
  - For low mobility user, supporting of “the Band selection AMC subchannel” ➔ increase transmission rate and coverage
    - Allocate good channel status band for each appropriate user increase the transmission rate
    - Terminal measure the channel status, request either the “Band selection AMC” or “Diversity” Subchannel
    - Diversity Subchannel is suitable to the mobile user: Maximum separated tone are allocated for frequency diversity
  - Guarantee the 60 km/h mobility
    - Short OFDM symbol length minimize the degradation due to the mobility
    - The pilot structure supporting channel estimation under mobility

# I. Introduction of the PHY Spec. – feature (3/3)

- **Flexible resource allocation for multiple subscriber**
  - TDD DL/UL duty rate
    - 1:1, 2:1, 5:1 DL/UL duty ratios are available
  - In order to support multiple subscriber scheduling algorithm
    - Management the status of individual terminals and packet scheduling algorithms are considered
- **Supporting various QoS**
  - Best Effort
  - Real-time polling
  - Non-real-time polling
- **Handheld support**
  - Supporting sleep mode ➔ reduced terminal power consumption
- **TDD Smart Antenna (optional feature)**
  - For slow mobility user, Apply the Smart Antenna increase the Coverage and TX rate

# II. Parameters of WiBro specification (1/2)

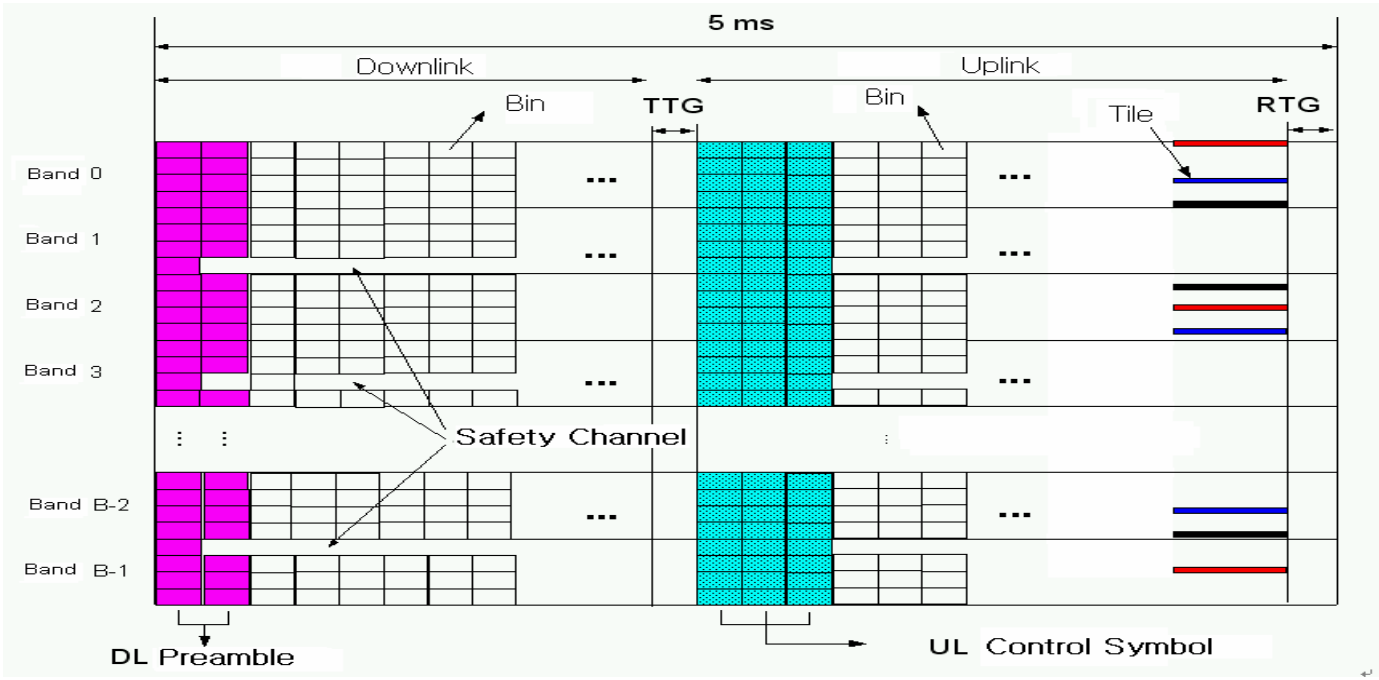
| Parameter | Value |
|---|---|
| Duplex | TDD |
| Multiple Access | OFDMA |
| System Bandwidth | 10 MHz |
| Sampling frequency | 10 MHz |
| Number of used tones | 864 out of 1,024 |
| Number of data tones | 768 |
| Number of pilot tones | 96 |
| Tone spacing | 9.765625 kHz |
| Signal bandwidth | 8.447 MHz |
| Ratio of cyclic prefix time to the basic OFDM symbol time | 1/8 |
| Basic OFDMA symbol time | 102.4 μs |
| Cyclic prefix time | 12.8 μs |
| OFDMA symbol time | 115.2 μs |
| TDD frame length | 5 ms |
| Number of symbols in a frame | 42 |

# II. Parameters of WiBro specification (2/2)

| Downlink symbol parameter | Value |
|---|---|
| Number of bands | 24 |
| Number of bins per band | 4 |
| Number of tones per bin | 9 (8 data + 1 pilot tones) |
| Number of tones per AMC subchannel | 54 (48 data + 6 pilot tones) |
| Number of tones per diversity subchannel | 54 (48 data + 6 pilot tones) |
| Number of bins per AMC subchannel | 6 |

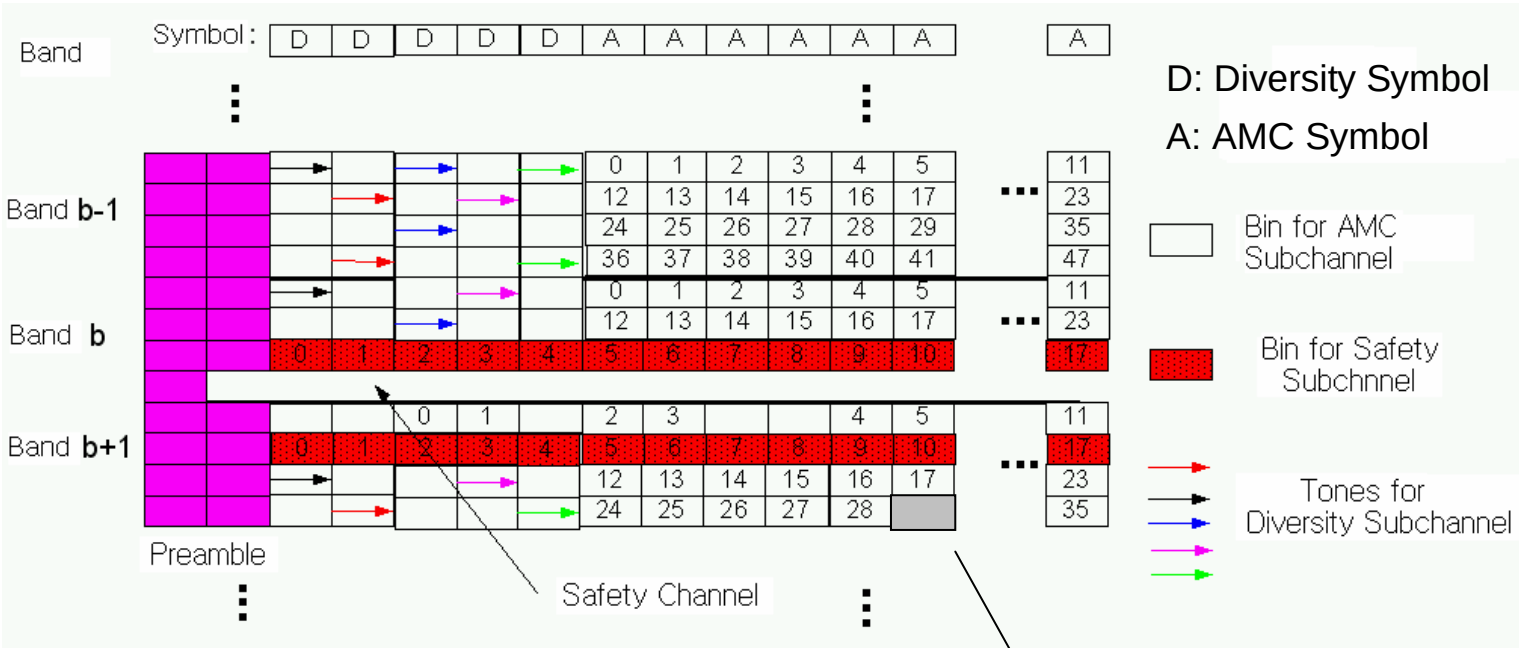
| Uplink symbol / tile parameter | Value |
|---|---|
| Number of bands | 24 |
| Number of bins per band | 4 |
| Number of tones per bin | 9 (8 data + 1 pilot tones) |
| Number of tones per tile | 9 (8 data + 1 pilot tones) |
| Number of bins per AMC subchannel | 6 |
| Number of tiles per diversity subchannel | 6 |

# III. Frame Structure

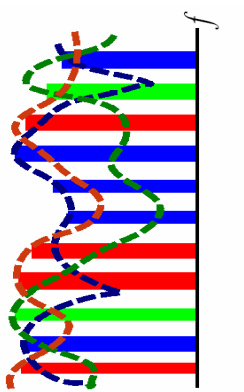


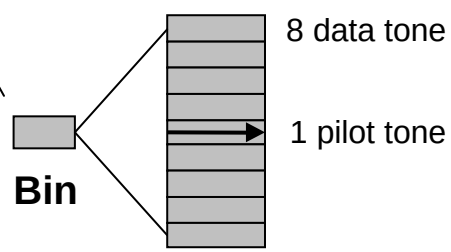

| Frame structure (ref: duty ratio 2:1) | | DL | UL |
|---|---|---|---|
| Number of symbol | | 27 | 15 |
| Number Preamble | | 2 | 0 |
| Number of Control symbol | | 1 | 3 |
| Number of Date symbol | | 24 | 12 |
| Time duration | Tx duration ($T_{Trans}$) | 3.1104 ms | 1.728 ms |
| | TDD Gap time ($T_{guard}$) | 121.2 μs (TTG) + 40.4 μs (RTG) | |
| Effective BW=BW*($T_{Trans}$+$T_{guard}$/2)/$T_{Frame}$ | | 6.3824 MHz | 3.6176 MHz |

# III. Frame Structure (Downlink PHY)

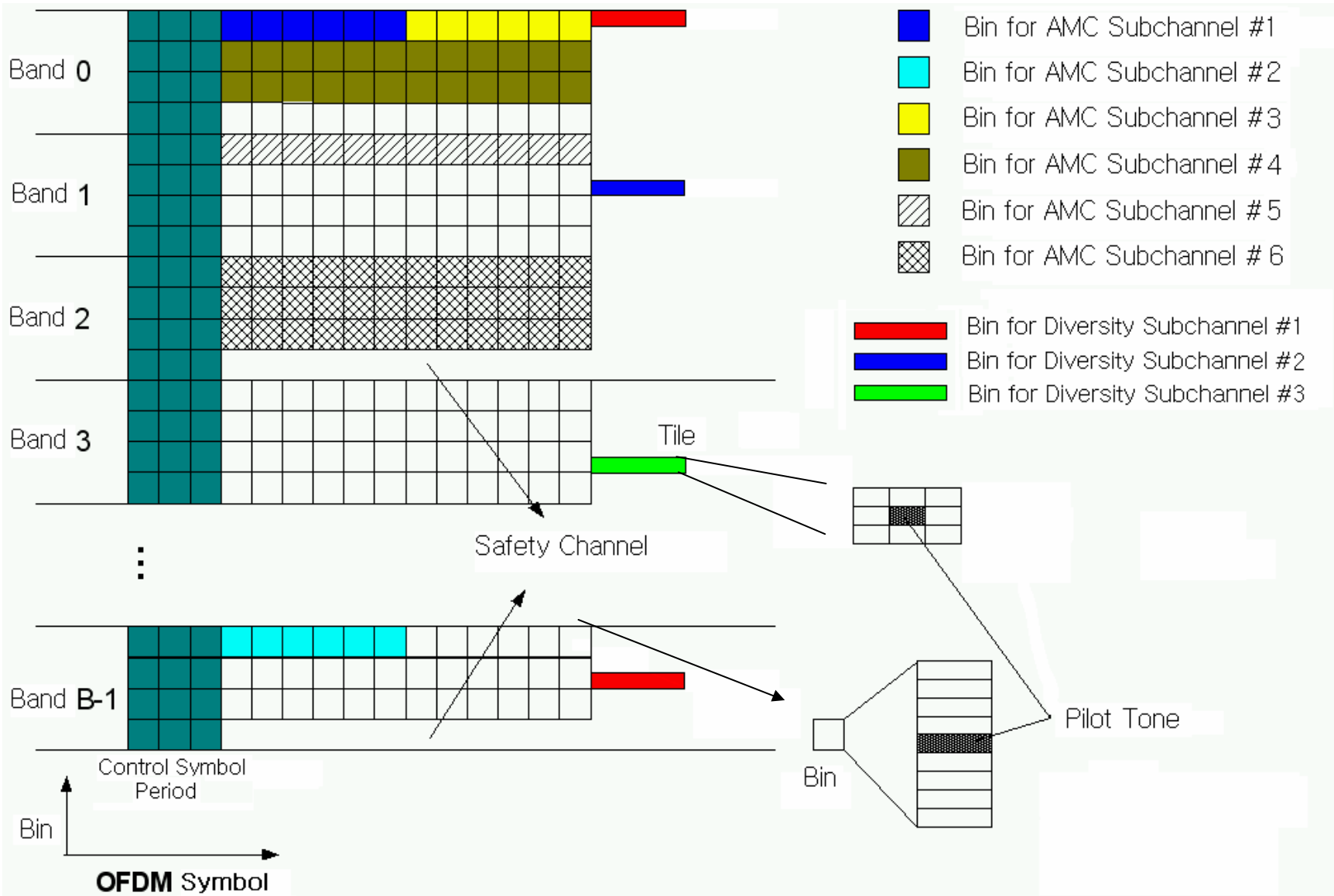



Band Selection AMC





# III. Frame Structure (Uplink PHY)

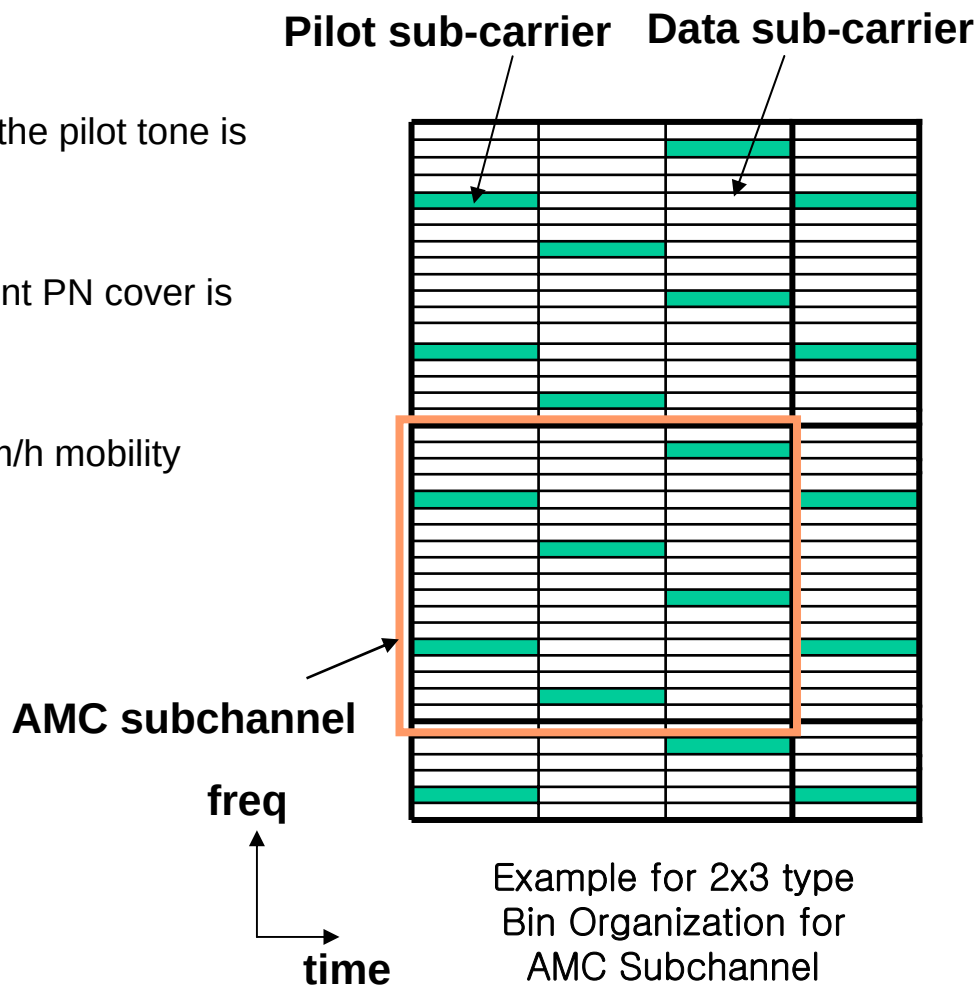


# IV. Pilot Tone (Downlink)

- Rotated pilot tones
  - In all the RAS/Sectors position of the pilot tone is colocated
  - In each RAS/Sectors apply different PN cover is used to differentiate each other
- Supporting channel estimation for 60km/h mobility
  - 2.35 GHz, 60 km/h
    - Doppler freq (fd)

      =130.56 Hz
    - Coherence time(1/fd)

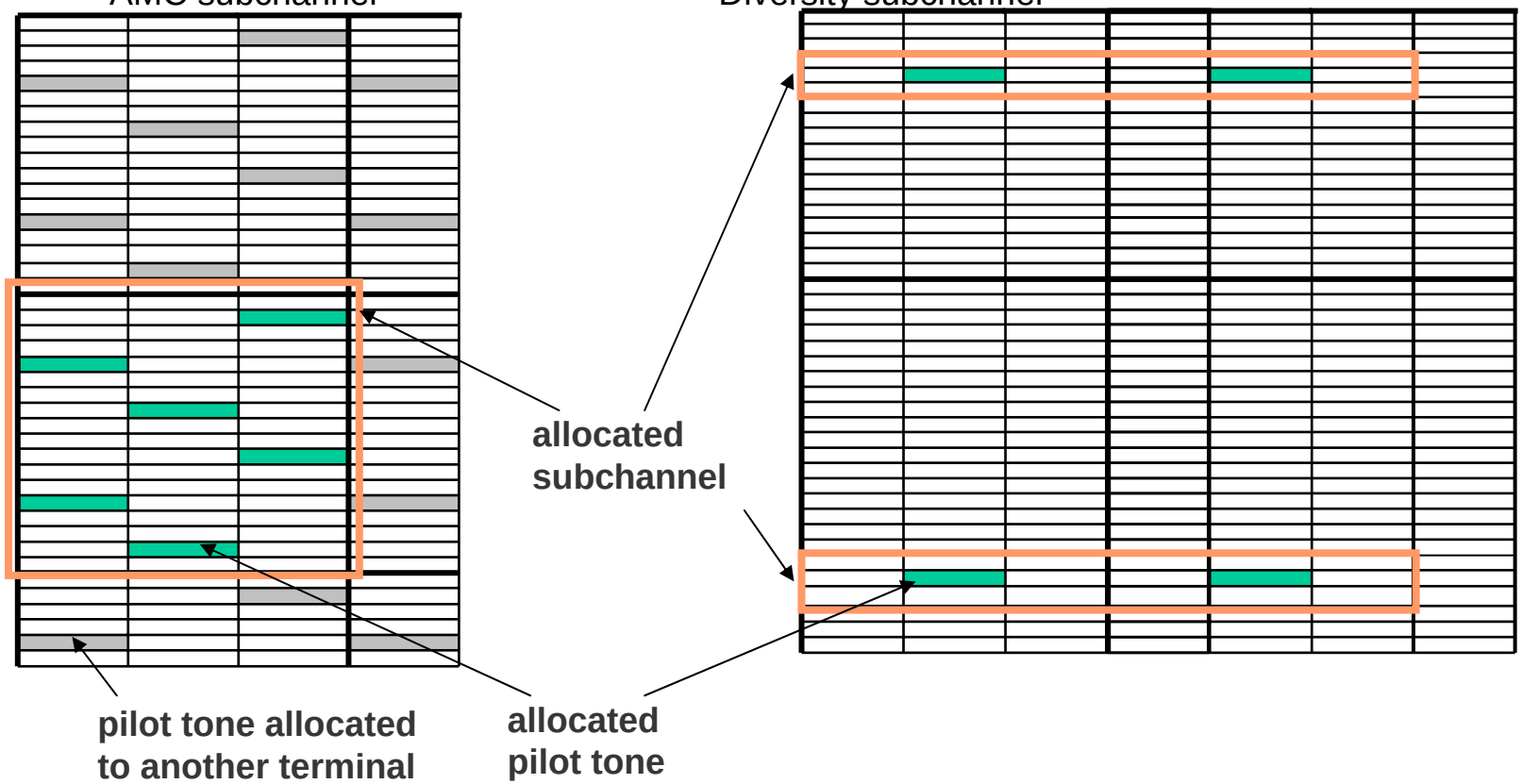
      =7.66 ms
  - DL pilot subcarrier rotation period
    - 345.6 us <0.1* Coherence time




Example for 2x3 type Bin Organization for AMC Subchannel

# IV. Pilot Tone (Uplink)

- Different pilot position for different subchannelization structure
  - AMC subchannel: rotated pilot tones
  - Diversity subchannel: locate in the center frequency of each tile
- AMC subchannel



# V. CQI Channel

The CQI is represented by 5-bit symbol according to the channel SNR measured in the PSS.
The CQI information is either the full CQI value or the differential CQI value.
These 5 bits are encoded into a length 6 codeword over 8-ary alphabet for the error protection

| Channel SNR [dB] | CQI 5-bit symbol | Vector Indices per Tile Tile(0), Tile(1), … , Tile(5) |
|---|---|---|
| Below -3.0 | 00000 | 0, 0, 0, 0, 0, 0 |
| -3.0 to –2.0 | 00001 | 1, 1, 1, 1, 1, 1 |
| -2.0 to –1.0 | 00010 | 2, 2, 2, 2, 2, 2 |
| -1.0 to 0.0 | 00011 | 3, 3, 3, 3, 3, 3 |
| 0.0 to 1.0 | 00100 | 4, 4, 4, 4, 4, 4 |
| ~ | ~ | ~ |
| 21.0 to 22.0 | 11001 | 5, 7, 1, 3, 6, 0 |
| 22.0 to 23.0 | 11010 | 6, 0, 2, 4, 7, 1 |
| 23.0 to 24.0 | 11011 | 7, 1, 3, 5, 0, 2 |
| 24.0 to 25.0 | 11100 | 0, 2, 4, 6, 1, 3 |
| 25.0 to 26.0 | 11101 | 1, 3, 5, 7, 2, 4 |
| 26.0 to 27.0 | 11110 | 2, 4, 6, 0, 3, 5 |
| Above 27.0 | 11111 | 3, 5, 7, 1, 4, 6 |

# VI. ACK Channel

The ACK channel is 1-bit symbol
according to whether a packet is received successfully or not in the PSS.
The acknowledgement bit of the n-th ACK channel shall be ‘0’ (ACK)
if the corresponding downlink packet has been successfully received;
otherwise, it shall be ‘1’ (NAK).
This 1 bit is encoded into a length 3 codeword over 8-ary alphabet for the error protection as shown in Table

ACK Symbol and Codeword Assignments

| ACK 1-bit symbol | Vector Indices per Tile Tile(0), Tile(1), … , Tile(5) |
|---|---|
| 0 | 0, 0, 0 |
| 1 | 4, 7, 2 |

# VII. Orthogonal modulation of ACK/CQI channel

**Orthogonal Modulation Index in CQI/ACK Channel**

| Vector index | |
|---|---|
| 0 | P0, P1, P2, P3, P0, P1, P2, P3 |
| 1 | P0, P3, P2, P1, P0, P3, P2, P1 |
| 2 | P0, P0, P1, P1, P2, P2, P3, P3 |
| 3 | P0, P0, P3, P3, P2, P2, P1, P1 |
| 4 | P0, P0, P0, P0, P0, P0, P0, P0 |
| 5 | P0, P2, P0, P2, P0, P2, P0, P2 |
| 6 | P0, P2, P0, P2, P2, P0, P2, P0 |
| 7 | P0, P2, P2, P0, P2, P0, P0, P2 |

$$P0 = \exp(j \cdot \frac{\pi}{4}),$$

$$P1 = \exp(j \cdot \frac{3\pi}{4}),$$

$$P2 = \exp(-j \cdot \frac{3\pi}{4}),$$

$$P3 = \exp(-j \cdot \frac{\pi}{4})$$

CQI/ACK Symbol Mapping in m th Tile

| | | |
|---|---|---|
| $M_{n,8m}$ | $M_{n,8m+3}$ | $M_{n,8m+5}$ |
| $M_{n,8m+1}$ | Pilot Tone | $M_{n,8m+6}$ |
| $M_{n,8m+2}$ | $M_{n,8m+4}$ | $M_{n,8m+7}$ |

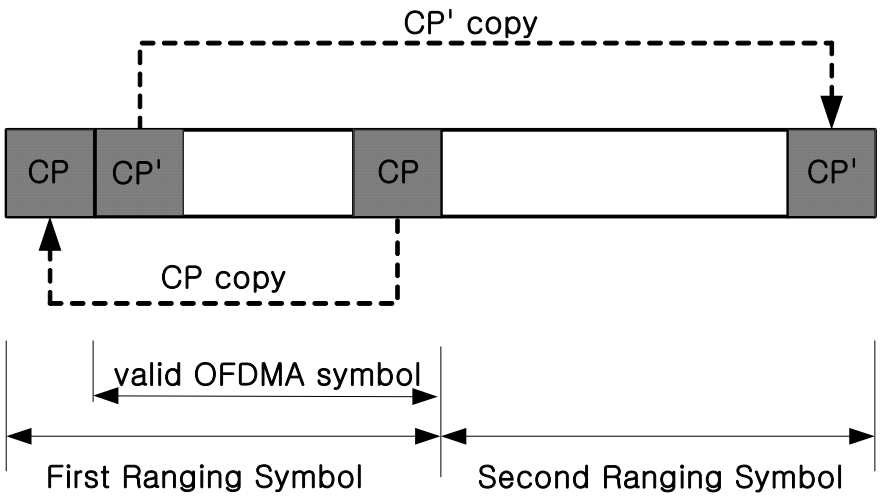
Where
P0, P1, P2, P3 denote QPSK modulation symbols mapped to the subcarriers.

$M_{n,8m+k}$ = modulation symbol index of the k-th modulation symbol in the m-th tile of the n-th CQI/ACK channel

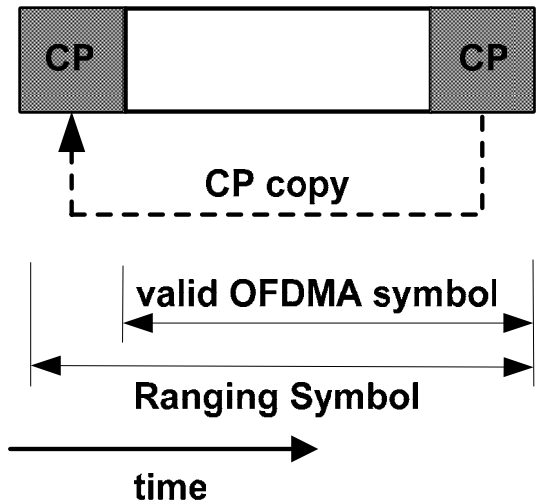
n = CQI channel index from the set [0~ $N_{CQI}$ -1] or ACK channel index from the set [0~ $N_{ACK}$ -1]

m = CQI channel tile index from the set [0~5] or ACK channel tile index from the set [0~2]
k = CQI/ACK subcarrier index of a CQI/ACK channel from the set [0~7].

# VIII. Ranging Symbol structure

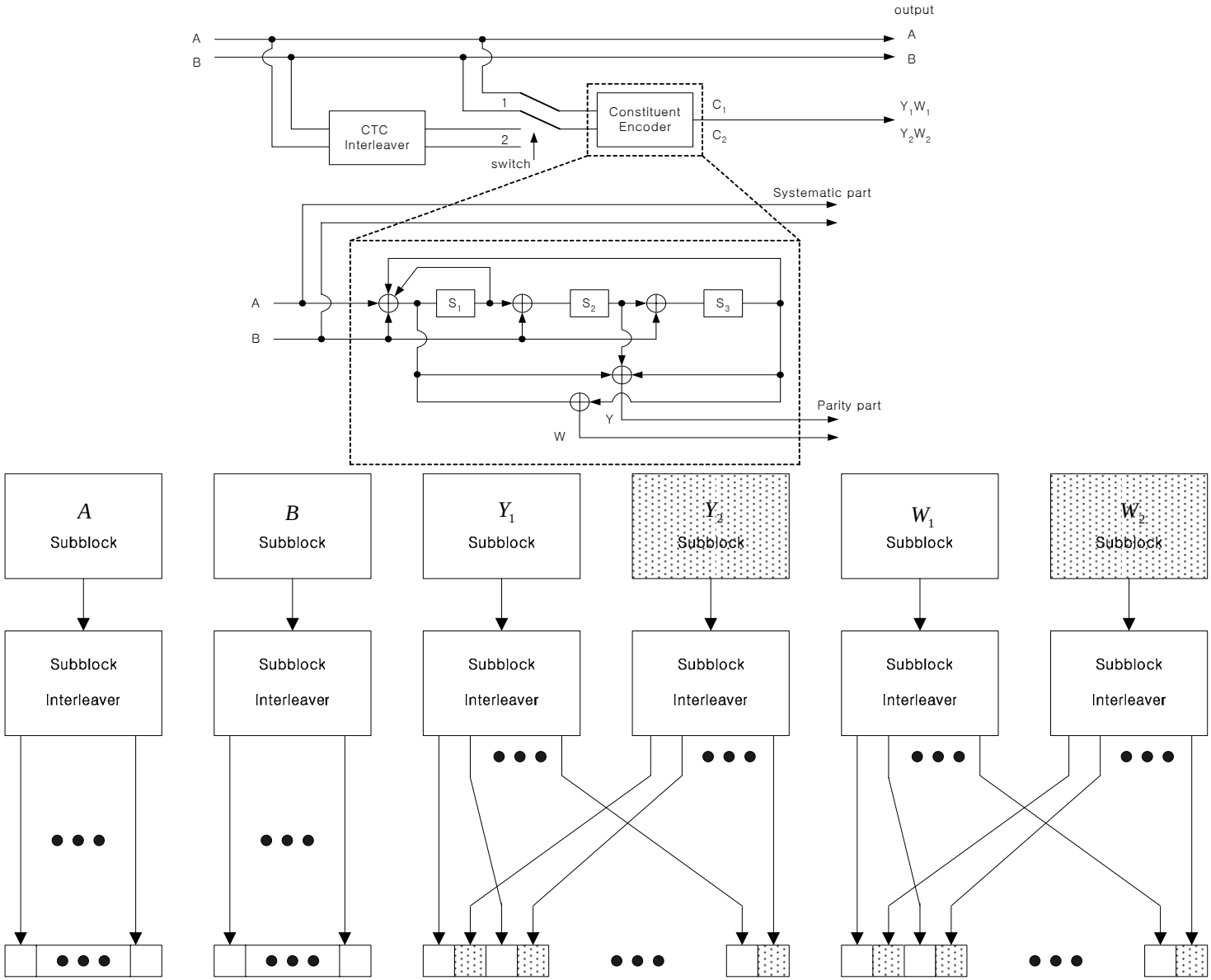



Initial ranging and Handoff ranging transmission for OFDMA




Periodic-ranging or bandwidth-request transmission for OFDMA using one code

# IX. H-ARQ with CTC



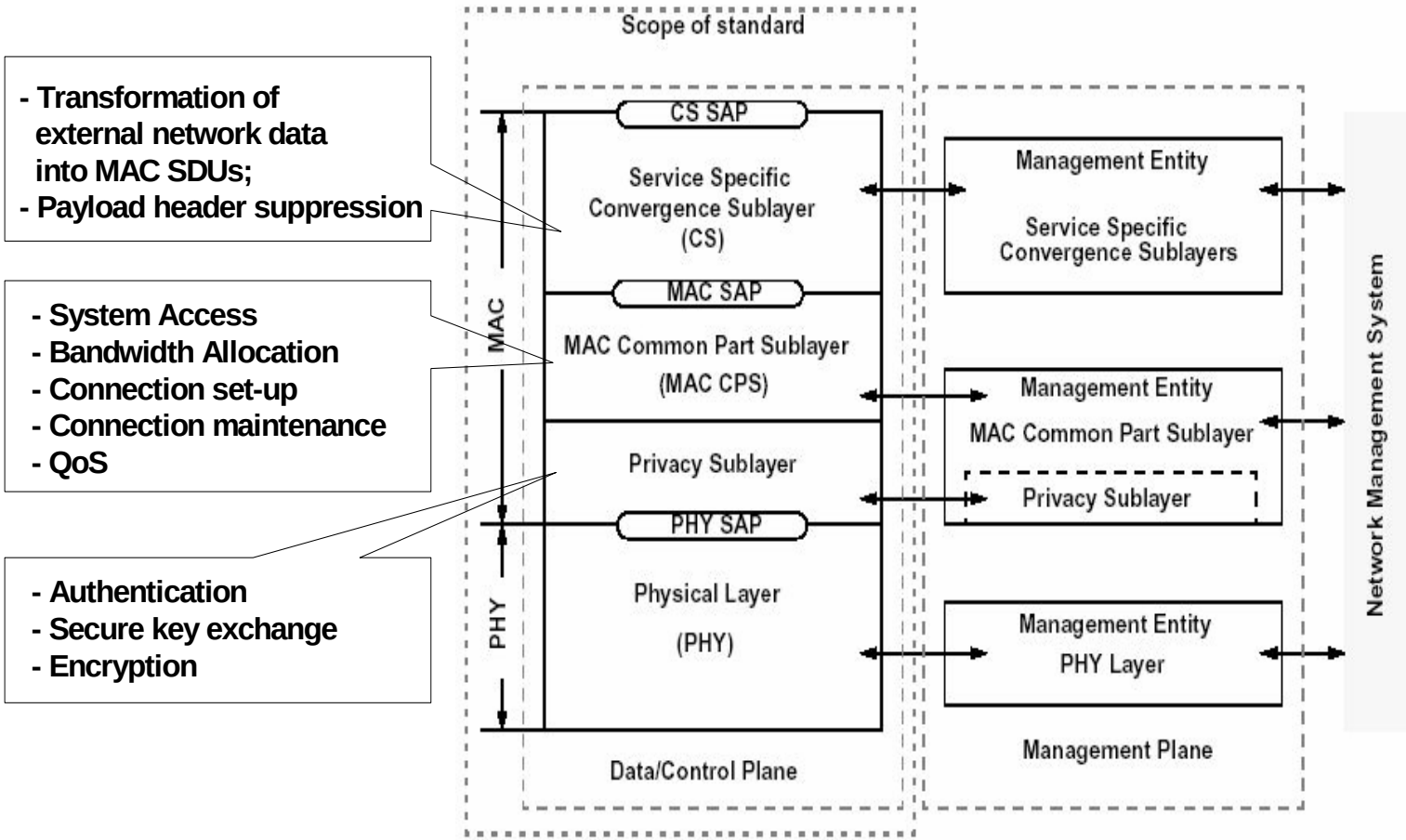
# X. Summary of Key Features (1/2)

- Multiple Access/Duplexing: OFDMA/TDD
- Frame length: 5 msec
- Bandwidth: 10MHz with 1k-FFT
- Flexible subchannelization for band selection and diversity
- Fast AMC (adaptive modulation and coding) subchannel based on uplink CQI (channel quality indicator)
- Full diversity subchannel by multiple symbol grouping
- Preamble for Cell differentiation with different PN sequences

# X. Summary of Key Features (2/2)

- Pilot tone based downlink and uplink
- Separate ranging channel time slot
- Safety channel
- More efficient channel coding: convolutional turbo code and short block codes
- H-ARQ with CTC in the downlink and uplink
- Modulation level: QPSK(DL/UL), 16QAM(DL/UL), 64QAM(DL only)
- Optional AAS (adaptive antenna system) support

# XI. Introduction of MAC : Reference Model

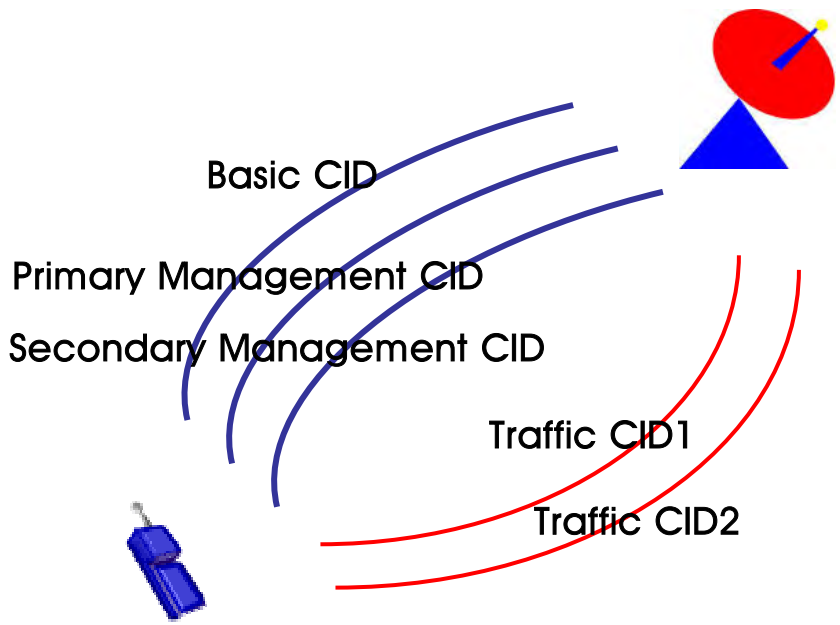


# XI. Introduction of MAC : General Overview

| | OFDMA | |
|---|---|---|
| PDU Construction | | |
| PDU format | Flexible size | |
| | Header + subheader + payload + optional CRC | |
| | MAC subheader<br>- Fragmentation subheader<br>- Packing subheaders<br>- ARQ Feedback | |
| Construction | Fragmentation | |
| | Packing<br>-Packing for non-ARQ connections and ARQ-enabled connections | |
| Protocol control | | |
| ARQ | Optional | |
| | Sequence number comparison | |
| | Four transmit states ( not sent, o outstanding, discarded and waiting-for-retransmission.) | |
| | Receiver states (CRC-32 checksum) | |
| Uplink Scheduling | Scheduling (UGS, rtPS, nrtPS and BE) | |
| BW allocation | Contention based CDMA bandwidth requests | |
| Ranging | | |
| Ranging | Ranging<br>- Initial ranging(Random Access)<br>- Periodic ranging(Invited / Random Access)<br>- BW request ranging(Random Access) | Ranging Subchannel and a set of special pseudo-noise Ranging Codes |

# XI. Introduction of MAC : Addressing and Connection

- 3 management connection during initial RNG-REQ/RSP exchange




**Management connection**

❖Basic connection

- ❖short, time-urgent MAC message

❖ Primary management connection

- ❖longer, more delay tolerant MAC message

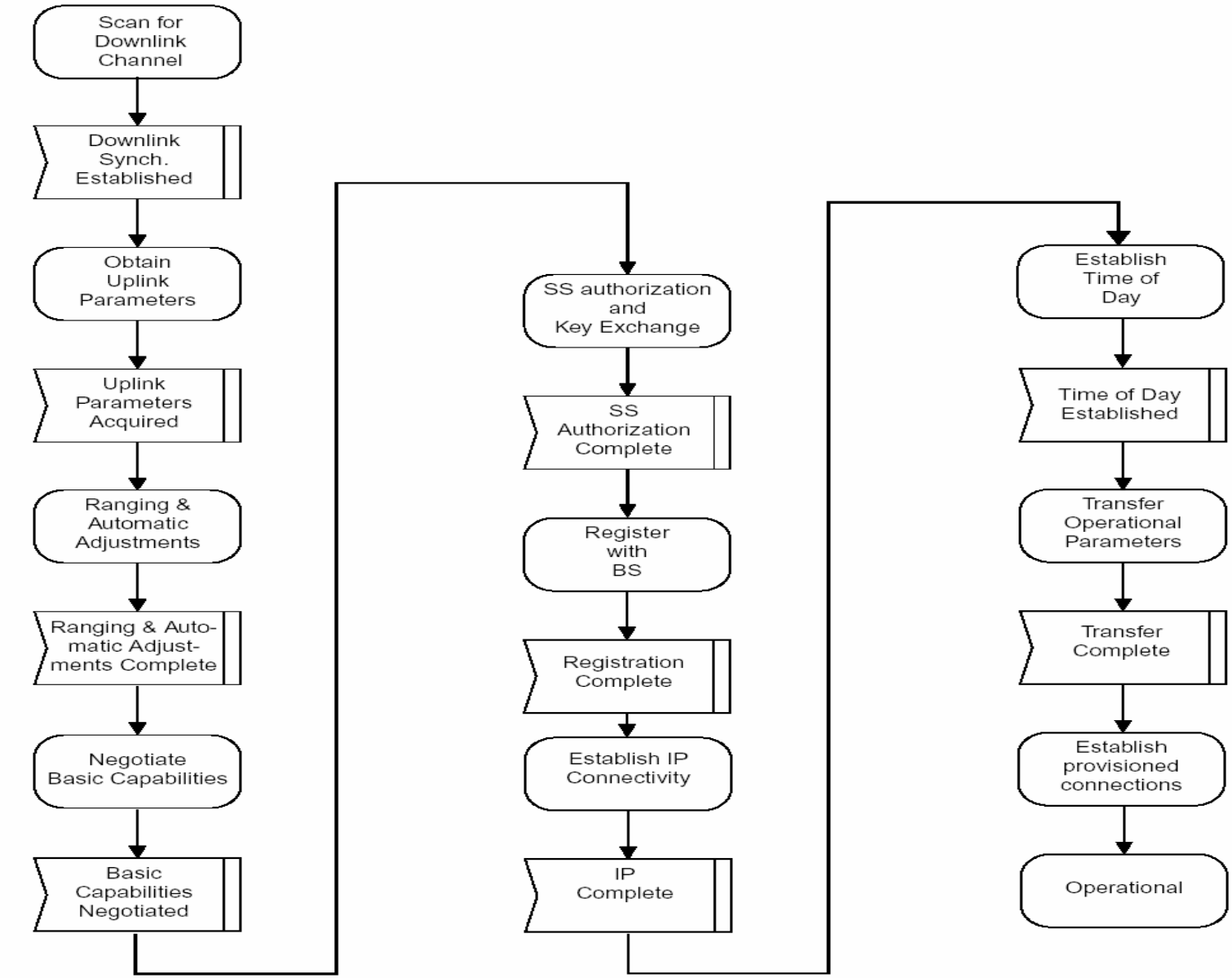
❖Secondary management connection

- ❖delay tolerant, standards based management messages(DHCP, TFTP, SNMP)

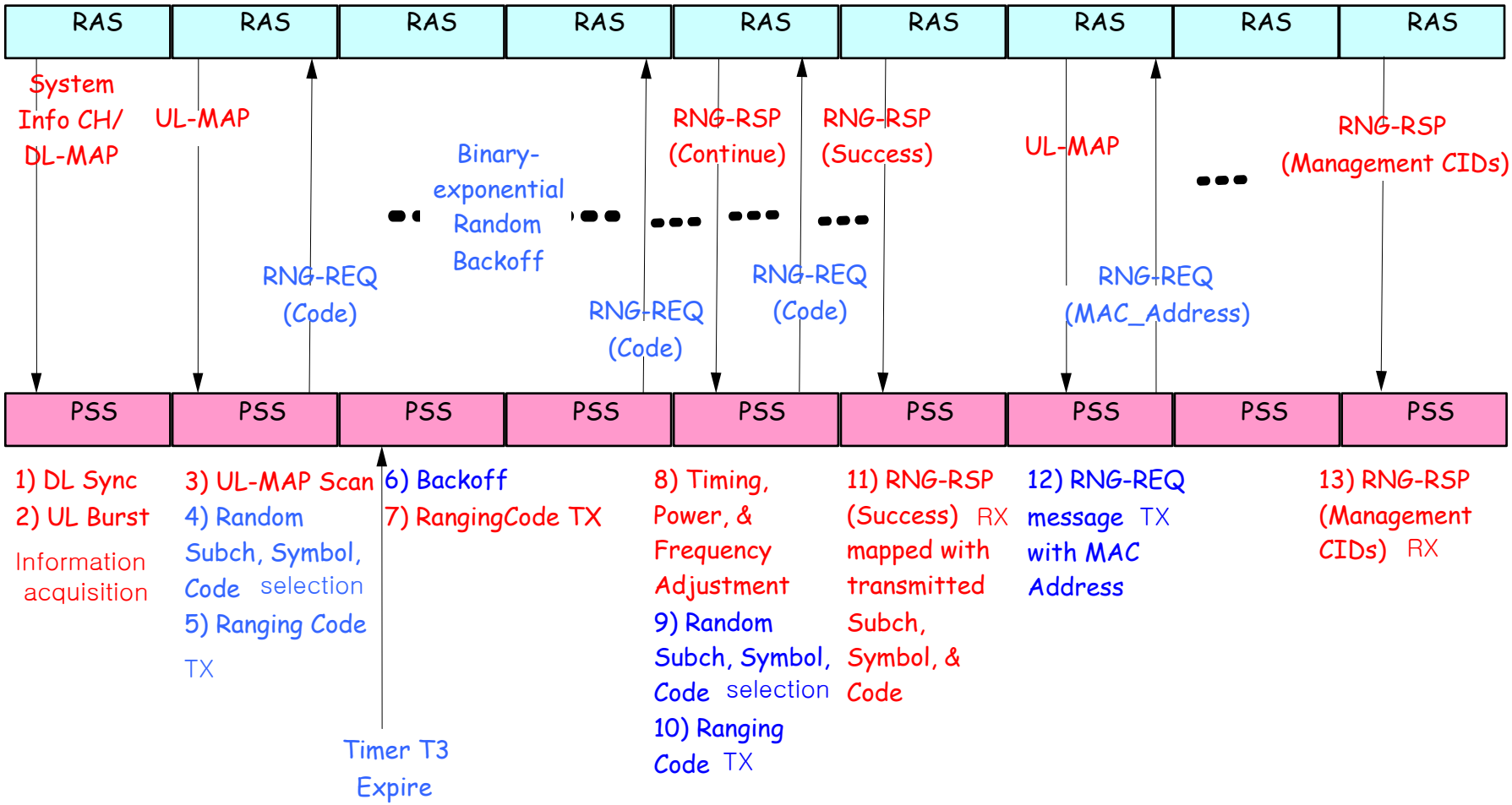
# XI. Introduction of MAC : QoS & Uplink Scheduling

- **Uplink Service Types**
  - Real-time Polling Service (rtPS)
    - MPEG video; To support periodic variable sized data packet.
  - Non-real-time Polling Service (nrtPS)
    - High bandwidth FTP; To support variable sized Data by regular basis
  - Best Effort Service (BE)
    - WWW; To support Best Effort Traffic
- **Uplink Bandwidth Request and Allocation Policy**
  - rtPS (real-time Polling Service)
    - According to polling period set service negotiation, PSS transmit bandwidth request in contention free manner or piggybacking way.
    - QoS Parameter : the Nominal Polling Interval, the Tolerated Poll Jitter, Packet Error Rate and the Request/Transmission Policy
  - nrtPS (non-real-time Polling Service)
    - During periodic or non-periodic poll, PSS transmit Bandwidth request in contention free manner
    - QoS Parameter : the Nominal Polling Interval, the Minimum Reserved Traffic Rate, Maximum Sustained Traffic Rate, Request/Transmission Policy, Packet Error Rate, Traffic Priority
  - BE (Best Effort)
    - Contention Based or Piggybacking manner.
    - QoS Parameter : the Minimum Reserved Traffic Rate, the Maximum Sustained Traffic Rate, Packet Error Rate, the Traffic Priority

# XI. Introduction of MAC : PSS Initialization Overview



# XI. Introduction of MAC : Ranging Procedures



# XI. Introduction of MAC : Overall Handover Procedures

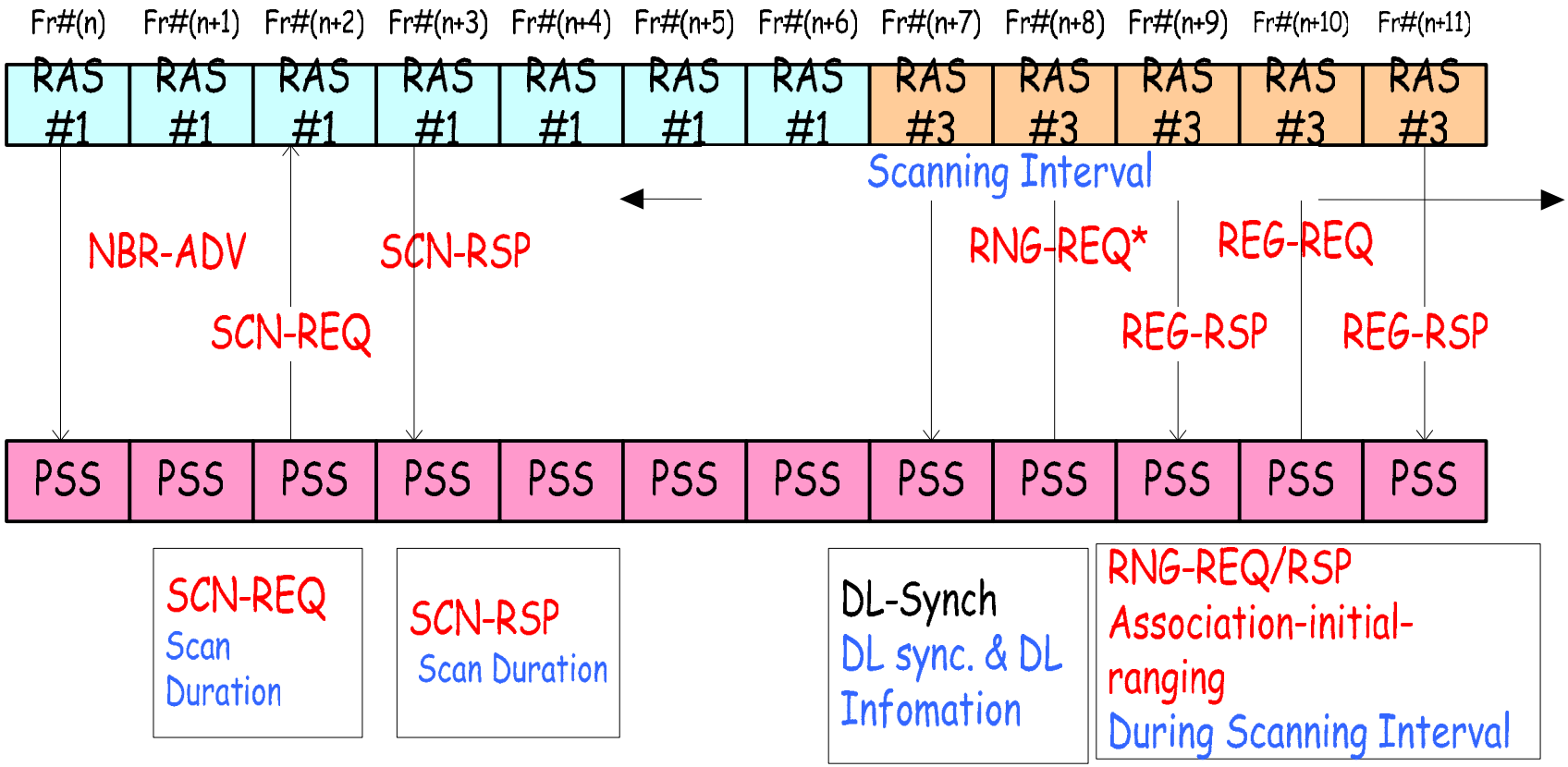
- **Network Topology Acquisition**
  - Network Topology Advertisement
    - Channel information for neighboring RAS normally provided by DCD/UCD message
  - PSS Scanning of neighbor RAS
    - RAS/PSS may allocate/request time intervals to PSS's for the purpose of seeking and monitoring neighbor RAS suitability as targets for HO
  - Association Procedure
    - Pre-Calibration of Ranging Parameter before actual Handover using Ranging
- **HO Process**
  - Cell Selection
    - The process of PSS scanning and/or Ranging one or more RAS in order to determine suitability
  - HO Decision and Initiation
    - RAS initiated Handover Request
    - MS initiated Handover Request
  - HO Cancellation
    - Handover Cancellation by PSS's discretion before actual handover
  - Target RAS scanning and synchronization
  - Termination with the Serving RAS
- **Ping Pong during HO**
  - Report of Ping Pong effect by PSS to target RAS
- **Network entry/re-entry**

# XI. Introduction of MAC : Scanning Operation

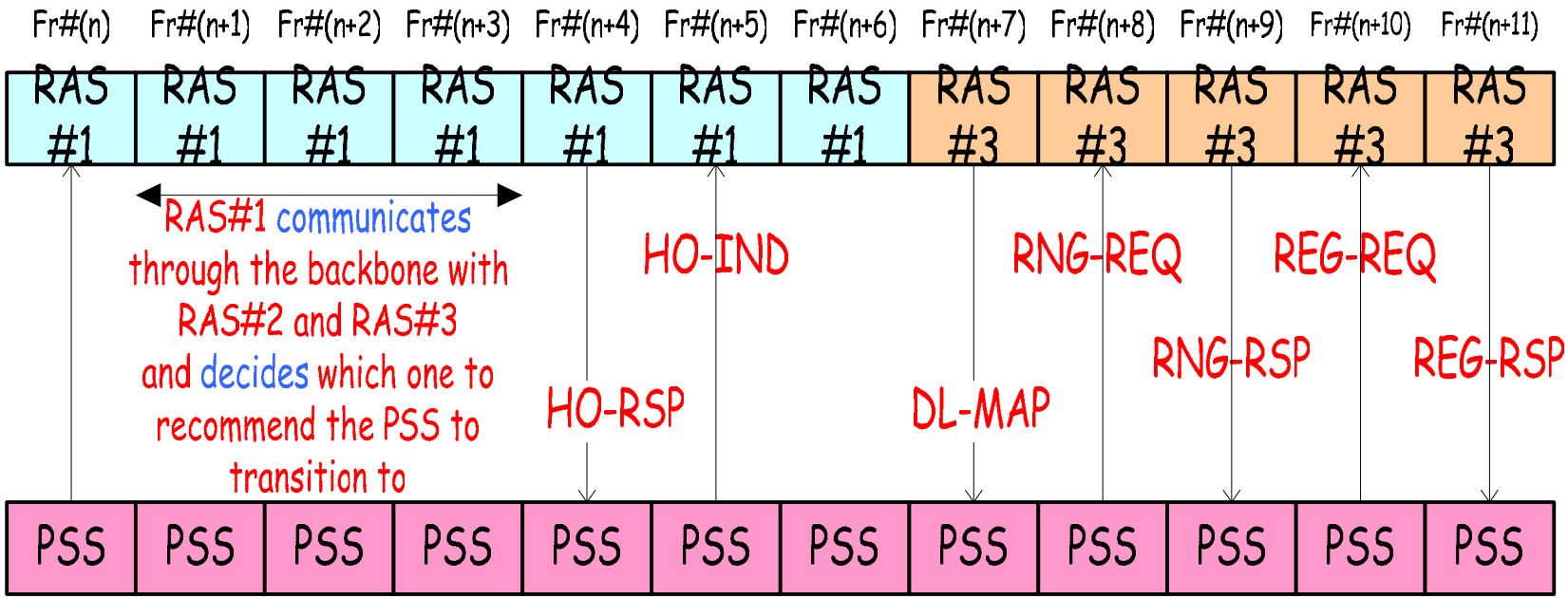
- **Scanning Procedure**
  - When neighbor RAS are identified during scanning, the PSS shall attempt to synchronize with their downlink transmissions, and estimate the quality of the PHY channel.
  - During scanning interval, PSS may try association with scanned neighbor RAS.
  - The RAS may buffer incoming data during the scanning period, and transmit that data after the scanning period.
  - After scanning, the PSS shall report the scanning result periodically or based on event-triggered.

- **Association Procedure**
  - To indicate successful scanning and ranging attempts for the purpose of HO
  - Upon completion of a successful PSS initial-ranging of a RAS
    - When Service Level Prediction parameter = 2 in RNG-RSP
    - the PSS may mark the RAS as Associated
    - recording elements of the RNG-RSP
    - setting an appropriate aging timer
  - While Association is valid (aging timer has not expired), PSS may use recorded Associated Ranging values to set Initial Ranging values in a new initial Ranging event to the same Associated RAS.

# XI. Introduction of MAC : ex. of Scanning Procedure



# XI. Introduction of MAC : ex. of HO Procedure



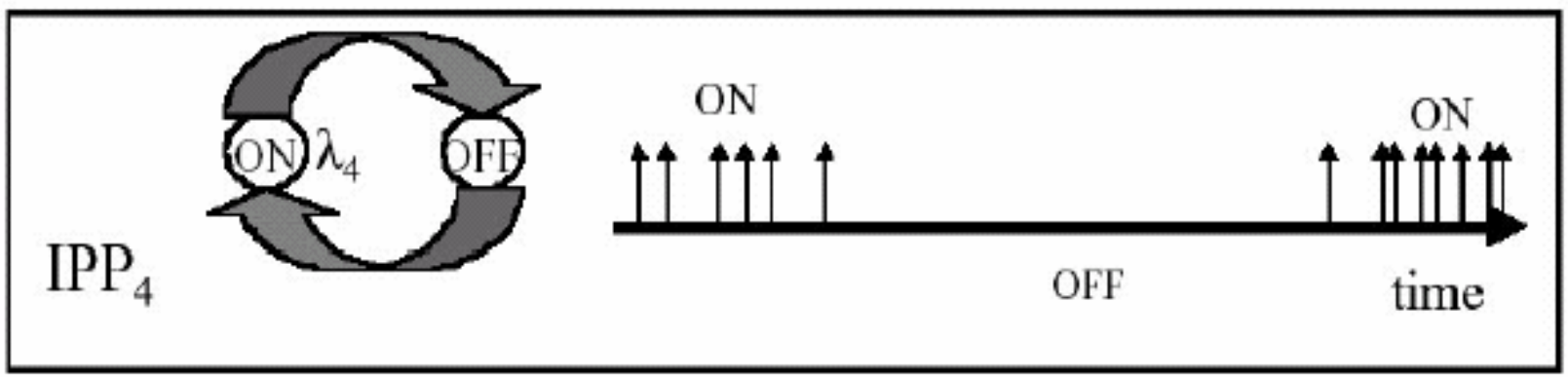

**HO-REQ**
Possible target RAS:
RAS#2: S/N=15dB
RAS#3: S/N=17dB
Time to HO: 7 Frames

**HO-RSP**
Recommended target RAS:
RAS#3: S/N=17dB
Time to HO: 3 Frames

**DL-MAP**
Fast UL Ranging IE = Assign Contentionless ranging opportunity

# XI. Introduction of MAC : Sleep mode(1/2)

- Sleeping mode is to minimize PSS's energy usage as one of mobility supporting while staying connected to the network
- Implementation of power-save mode is optional feature
- Based on 4IPP Traffic model
  - Awake mode : exchanging PDUs in a normal fashion
  - Sleep mode : no exchanging PDUs and the PSS may power down



# XI. Introduction of MAC : Sleep mode(2/2)

- Sleep window = Sleep-interval + Listening-interval
  - Increasing Binary Exponentially until Maximum Sleep window
- Sleep-interval
  - A time duration, measured in whole frames where the PSS is in sleep-mode
  - PSS does not send or receive PDUs, and may power down one or more physical operation components
  - PSS may awaken for periodic ranging
- Listening-interval
  - A time duration, measured in whole frames where the PSS is in Awake-mode
  - PSS shall synchronize with the Serving RAS downlink
  - PSS shall listen for an appropriate MOB-TRF-IND message.
  - The PSS shall decide whether to stay awake or go back to sleep based on the either value of its own 2-bit indicator in the SLPID bitmap or
  - The basic CID of the PSS in a MOB-TRF-IND from the Serving RAS.