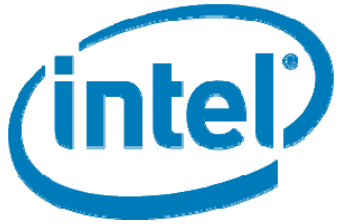

Mobile WiMAX Update and IEEE 802.16m

March 25, 2009
Hassan Yaghoobi
Principal Wireless System Architect, Intel Corporation
IEEE Senior Member

Mobile Wireless Group

Introduction

- Introduction
- WiMAX Forum Update
  - Release 1.0 Certification
  - Release 1.5 and FDD enablement
- IEEE 802.16m Overview
- Update on IMT-Advance
  - Submission of 802.16m and WiMAX Forum Release 2.0

Mobile WiMAX™ Roadmap

* Note: Actual mobility & throughput experienced depends on environmental parameters and Network Operator provisioning

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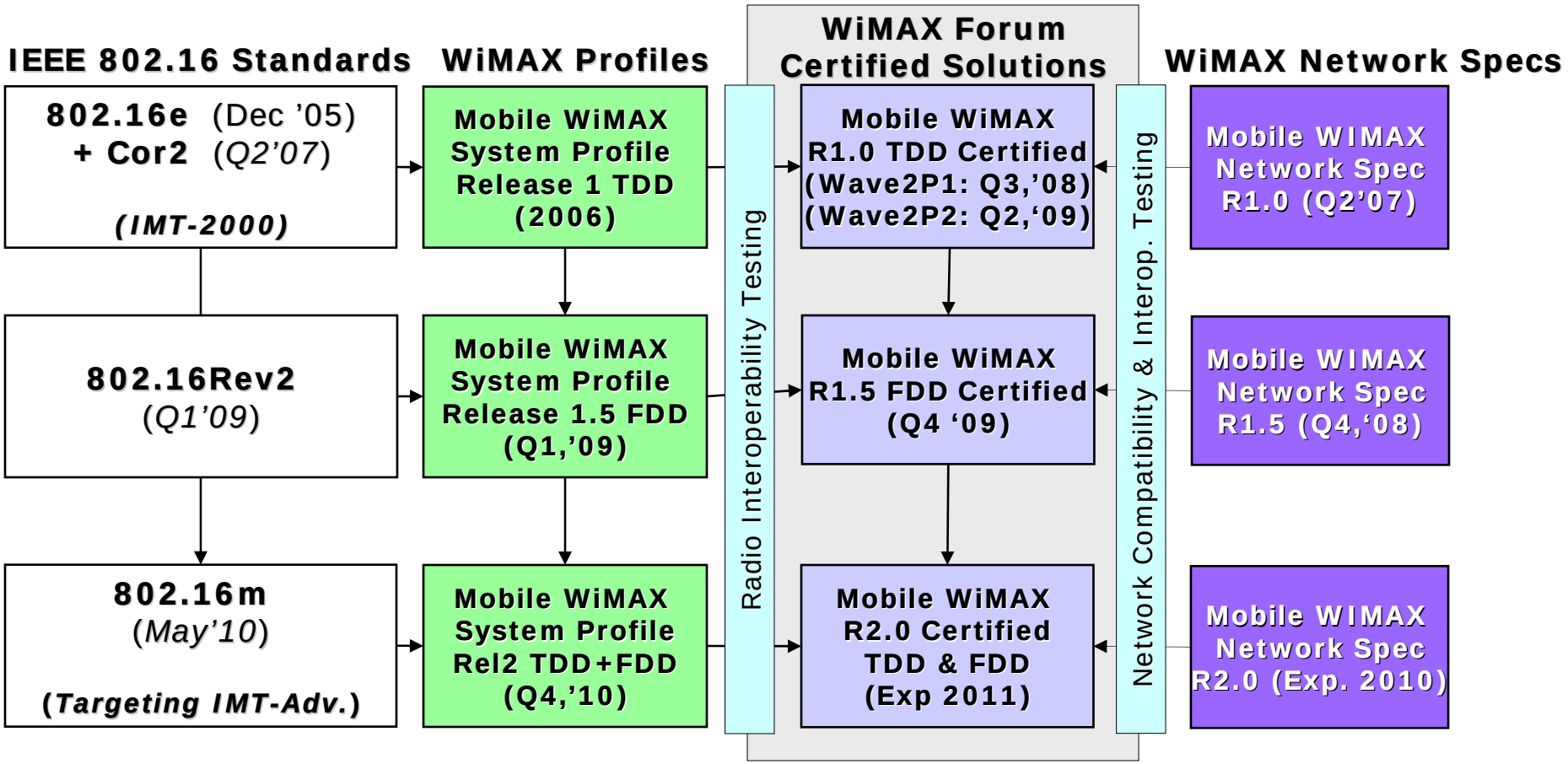
Mobile WiMAX Standards & Specifications Timeline



- Mobile WiMAX R2 is fully backward compatible with R1 and min. 2-3X increased performance
- Mobile WiMAX R1 and R1.5 already competitive with 3GPP LTE
- Mobile WiMAX R2 expected to deliver superior performance to 3GPP LTE
- 802.16m expected to meet/exceed IMT-Advanced Requirements
- Stable 802.16m Draft Standard expected by Q2, 2009

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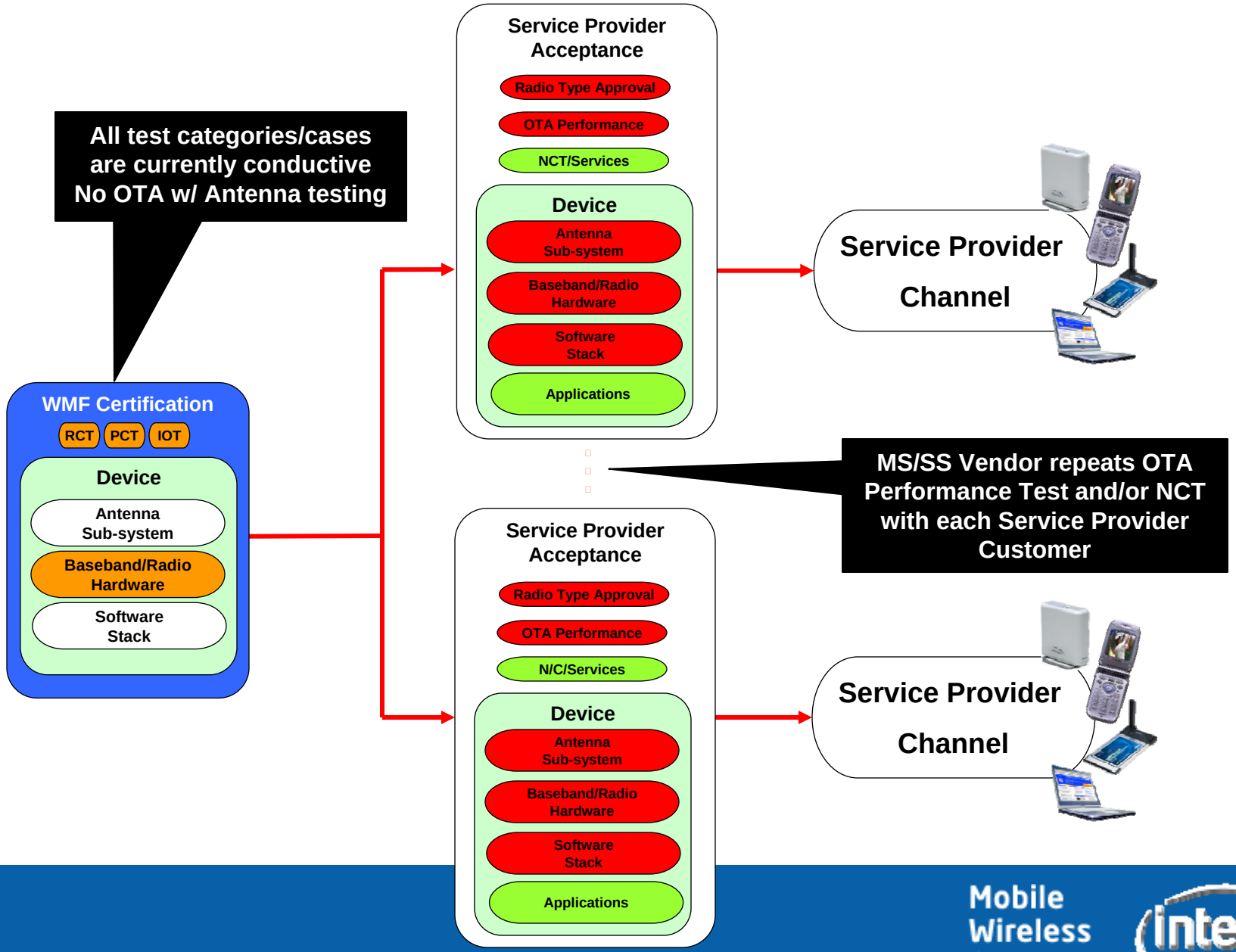
WiMAX Forum Short Update

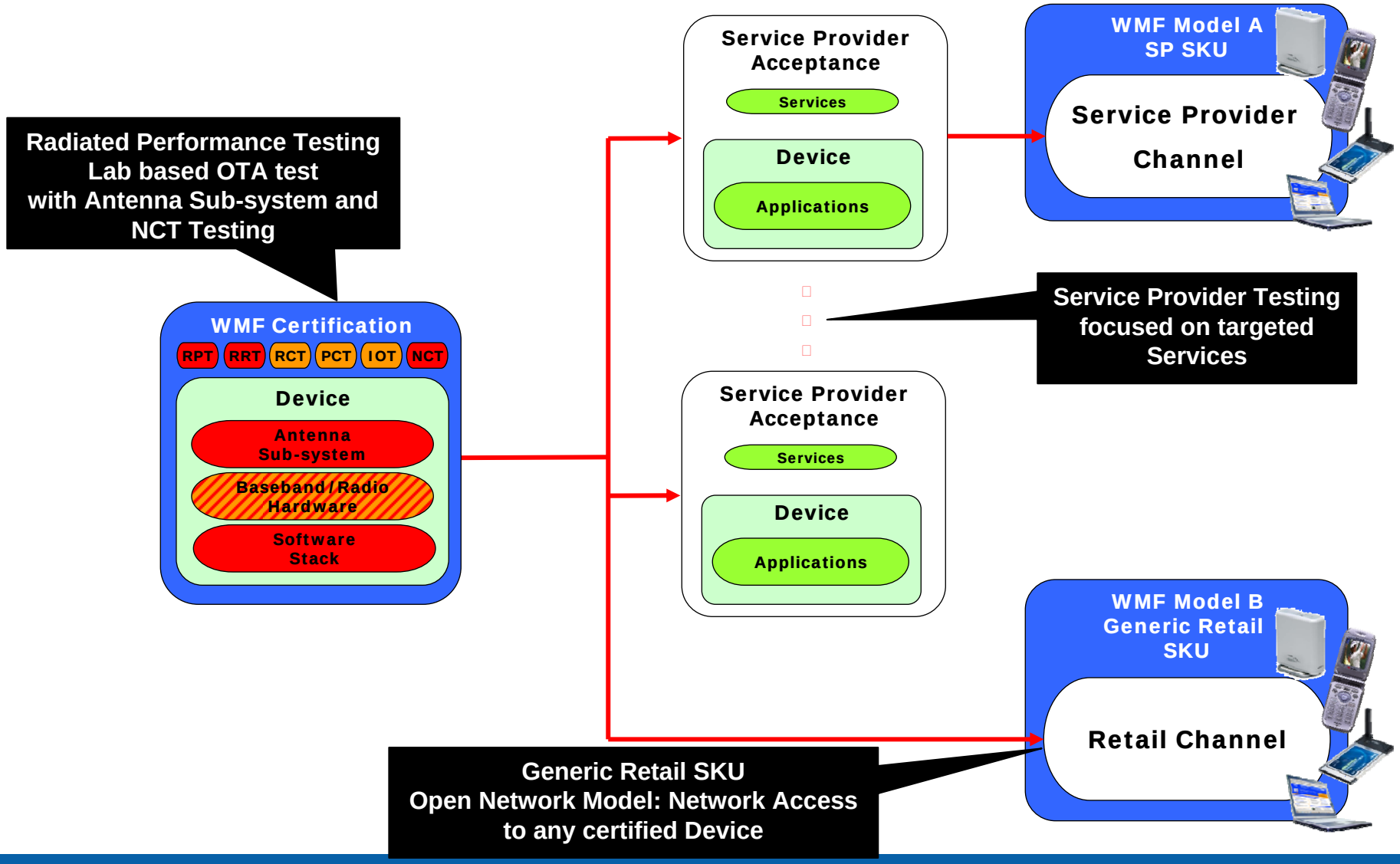
- From Dec 2007 to date, WiMAX Forum has successfully certified many Release 1.0 compliant Mobile Station and Base Station products for BCG 3.A (2.6 GHz TDD, refer to back up)
- In Q1 2009, WiMAX Forum has also certified first batch of R1.0 products for BCG 5.A/B/C (3.5 GHz 5/7/10 MHz BW, TDD)
- Other band classes are in pipeline for certification
- Mobile WiMAX R1.0 is adopted as the IMT-2000 sixth Radio Interface (IMT-2000 OFDMA TDD WMAN)
- WiMAX Forum is currently working on enabling R1.0 elements required by Generic Retail Distribution (Radiated Performance Testing, Radio Requirement Testing, NWIOT)
- WiMAX Forum is also working on enabling Mobile WiMAX FDD through R1.5 Air interface
- Mobile WiMAX R1.5 based on IEEE 802.16/Rev2 has been submitted as an update to IMT-2000 OFDMA TDD WMAN to include FDD
- Preparation work is underway for development of R2.0 conformance and Interoperability specifications based on IEEE 802.16m
- Mobile WiMAX R2.0 is being submitted to ITU as a IMT-Advanced candidate

Conventional Distribution Channel Model*



* Figure extracted from WiMAX Forum TWG contribution

New Distribution Channel Model*



* Figure extracted from WiMAX Forum TWG contribution

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Mobile WiMAX R1.5 Goals

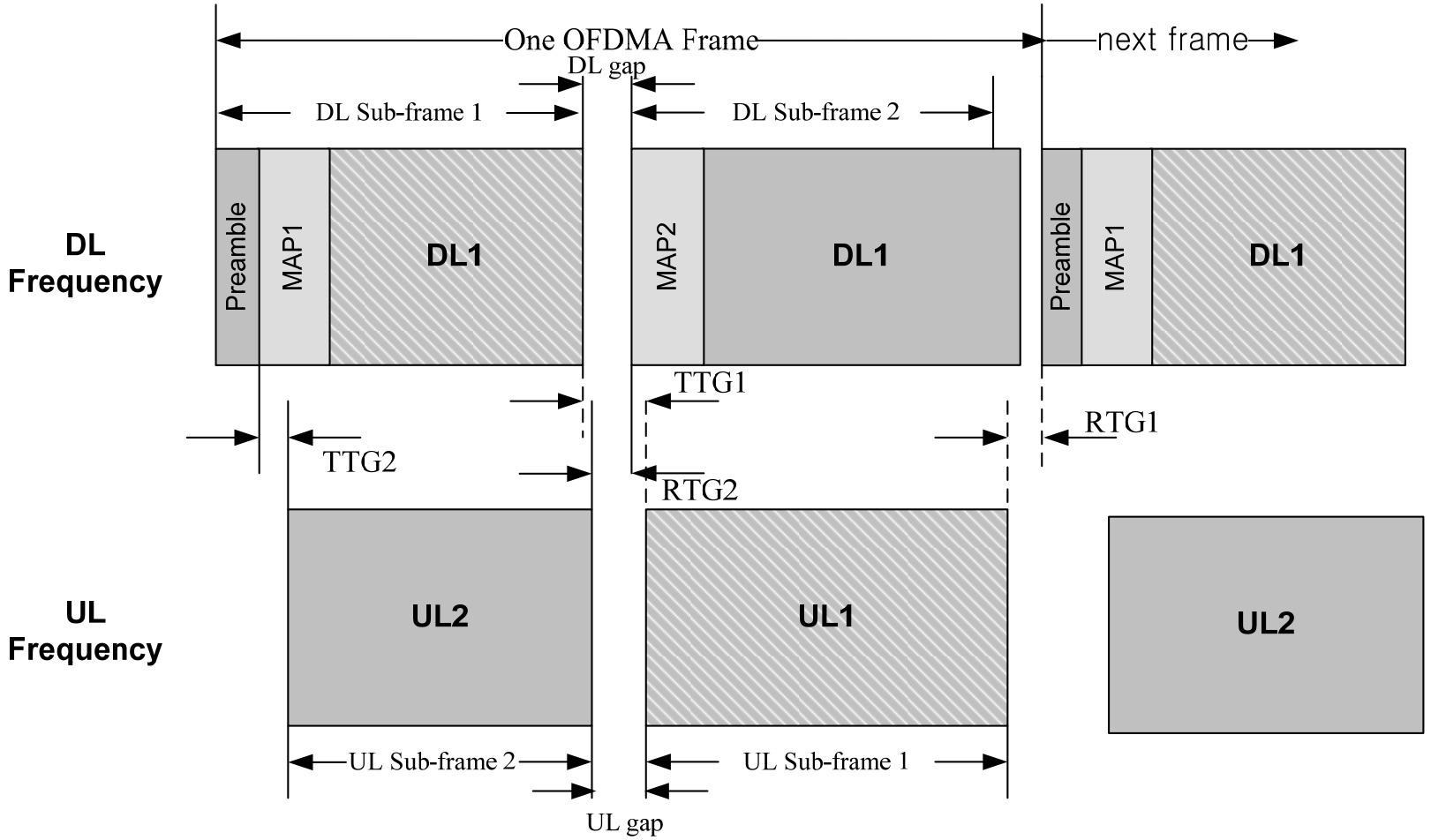
The System profile Release 1.5 is simply an extension of Release 1.0 without requiring major changes in the underlying IEEE 802.16 standards to address the following high level strategic goals:

1. To enable WiMAX deployment in paired spectrum by extending the TDD based system profile to FDD mode of operation
2. To add new system profile features and improvements needed to enable advanced services, such and location based services and improved multicast/broadcast services enabled in network Release 1.5.
3. To Improve MAC layer efficiency with focus on lowering MAP overhead especially for VoIP traffic and reducing latencies.
4. To include other optional enhancements, such as closed loop MIMO, to further improve coverage and capacity for low mobility usage.

Mobile WiMAX Release 1.5 Air interface Highlights

PHY and MAC Feature	Description
Frequency Domain Duplex Mode	Support for both Full Duplex and Half Duplex FDD
MIMO Enhancements	▪Downlink Open Loop MIMO in AMC ▪Downlink Closed Loop MIMO in AMC ▪Uplink Collaborative SM for two MS with single transmit antenna in AMC ▪Uplink Open Loop STC/SM MIMO in AMC and PUSC ▪Cyclic Delay Diversity
MAC Efficiency Enhancements	Downlink and uplink Persistent Allocation IE's to reduce MAP overhead for both persistent and non-persistent traffic
Hand Off Enhancements	Support for seamless Hand Off
Load Balancing	▪Load balancing using preamble index and/or downlink frequency override ▪Load balancing using ranging abort timer ▪Load balancing using BS initiated Hand Off
Location Based Services (LBS)	▪GPS-Based method ▪Assisted GPS (A-GPS) method ▪Non-GPS-Based method
Enhanced Multicast and Broadcast (MBS) Services	Optimizations/Clarification to MBS procedures such as group DSx and inter-MBS zone continuity messages
WiMAX-WiFi-Bluetooth Coexistence	▪Co-located coexistence Mode 1 ▪Co-located coexistence Mode 2 ▪Combined uplink Band AMC operation with co-located coexistence

OFDMA FDD Frame Structure Supporting HD-FDD Mobile Stations in Two Groups



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Mobile WiMAX Release 1.5 Band Classes

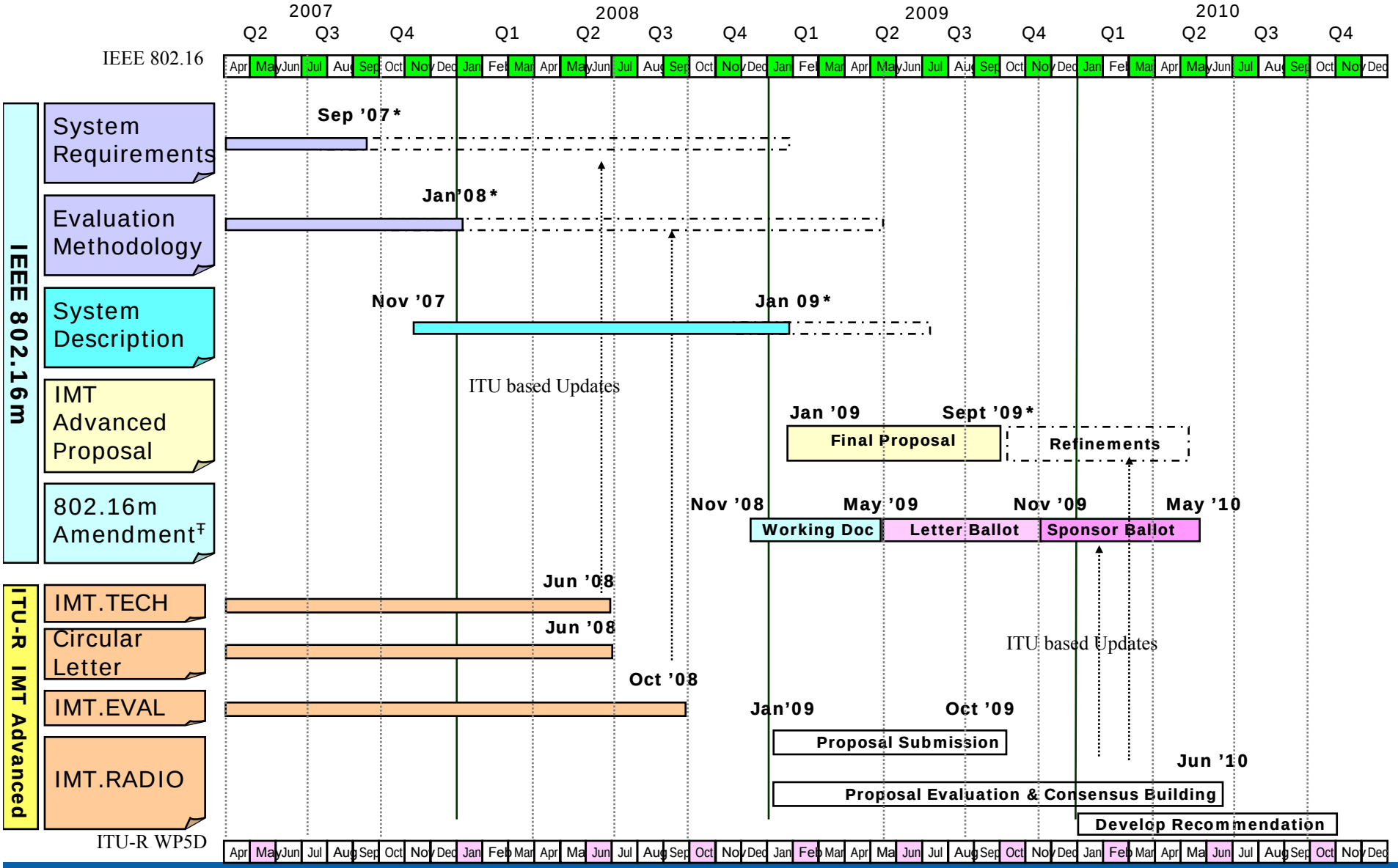
Band Class	Spectrum Range (GHz)BW (MHZ)	Duplexing Mode BS	Duplexing Mode MS	MS Transmit Band (MHz)	BS Transmit Band (MHz)	Bandwidth Certification Group Code (BCG)
2	**2.305-2.320, 2.345-2.360**					
	2x3.5 AND 2x5 AND 2x10	FDD	HFDD	2345-2360	2305-2320	2.E
	5 UL, 10 DL	FDD	HFDD	2345-2360	2305-2320	2.F
3	**2.496-2.690**					
	2x5 AND 2x10	FDD	HFDD	2496-2572	2614-2690	3.B
5	**3.4-3.8**					
	2x5 AND 2x7 AND 2x10	FDD	HFDD	3400-3500	3500-3600	5.D
6	**1.710-2.170 FDD**					
	2x5 AND 2x10	FDD	HFDD	1710-1770	2110-2170	6.A
	2x5 AND 2x10	FDD	HFDD	1920-1980	2110-2170	6.B
7	**0.698-0.862**					
	2x5 AND 2x10	FDD	HFDD	776-787	746-757	7.B
	2x5	FDD	HFDD	788-793 AND 793-798	758-763 AND 763-768	7.C
	2x10	FDD	HFDD	788-798	758-768	7.D
	5 AND 7 AND 10 (TDD), 2x5 AND 2x7 AND 2x10 (H-FDD)	TDD or FDD	Dual Mode TDD/H-FDD	698-862	698-862	7.E
8	**1.710-2.170 TDD**					
	5 AND 10	TDD	TDD	1785-1805, 1880-1920, 1910-1930, 2010-2025	1785-1805, 1880-1920, 1910-1930, 2010-2025	8.A

Documents Under Development in TGm

1. System Requirements Document (SRD, Stage 1)
2. Evaluation Methodology Document (EMD)
3. System Description Document (SDD, Stage 2)
4. 802.16m Amendment Working Document (AWD, Stage 3 details)

- This presentation uses some of the information provided in IEEE 802.16m documents as reference
- Only selected highlights of delta functionalities relevant to IEEE 802.16e are covered
- IEEE 802.16m stage 3 detail specifications are still under development

TGm Timelines



*System Requirements and Evaluation Methodology, System Description, IMT-Advanced Proposal Documents may be further updated based on ITU output (shown by dotted lines).

∓ 802.16m amendment is dependent on the 802.16Rev2 Project completion

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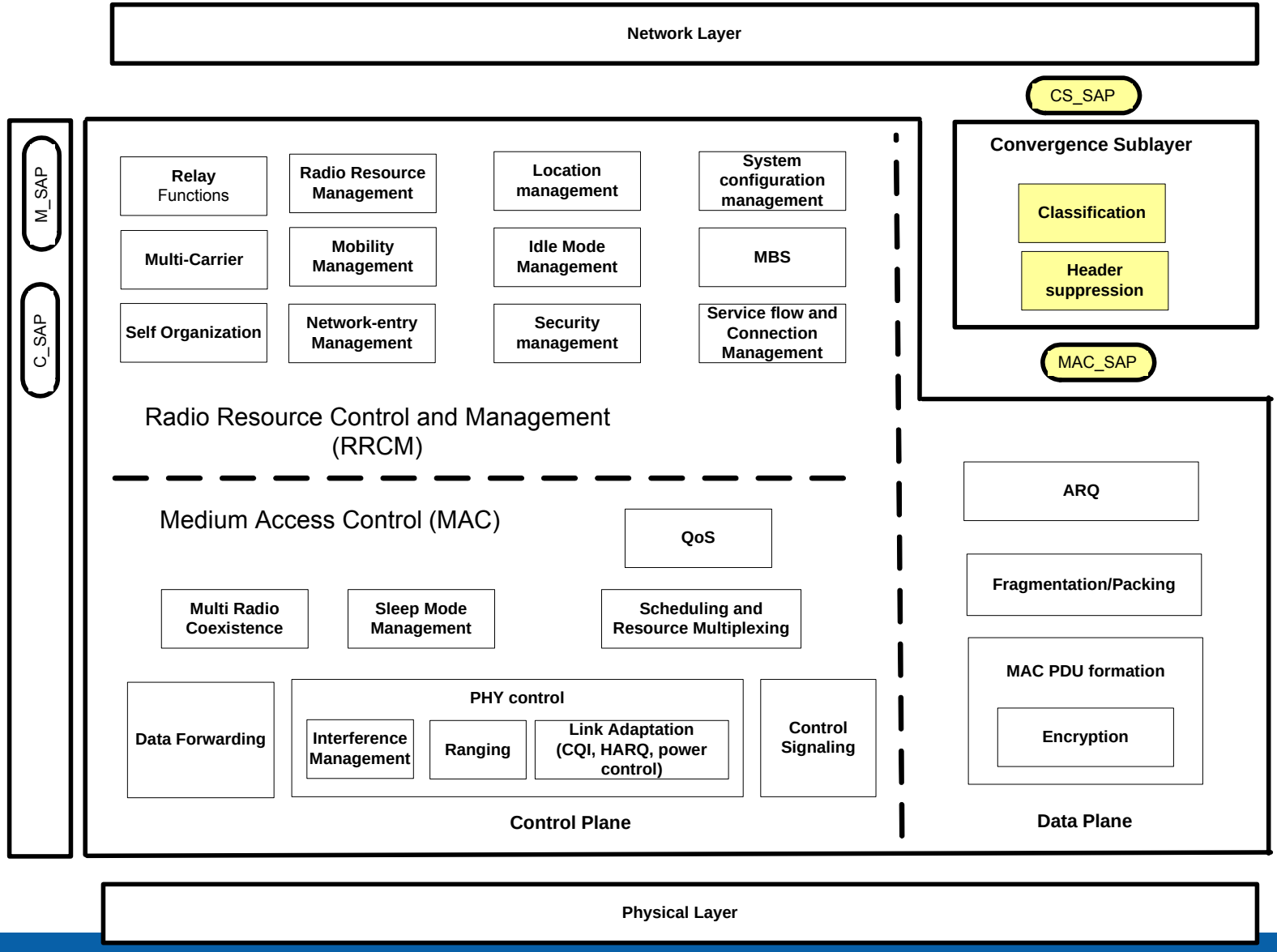
IEEE 802.16m Target Frequency Bands

- Can operate in RF frequencies less than 6 GHz and are deployable in licensed spectrum allocated to the mobile and fixed broadband services.
- Bands identified for IMT and/or IMT-2000 by WARC-92, WRC-2000 and WRC-07
  1. 450-470 MHz
  2. 698-960 MHz (Also R1.0 target)
  3. 1710-2025 MHz
  4. 2110-2200 MHz
  5. 2300-2400 MHz (Also R1.0 target)
  6. 2500-2690 MHz (Also R1.0 target)
  7. 3400-3600 MHz (Also R1.0 target)

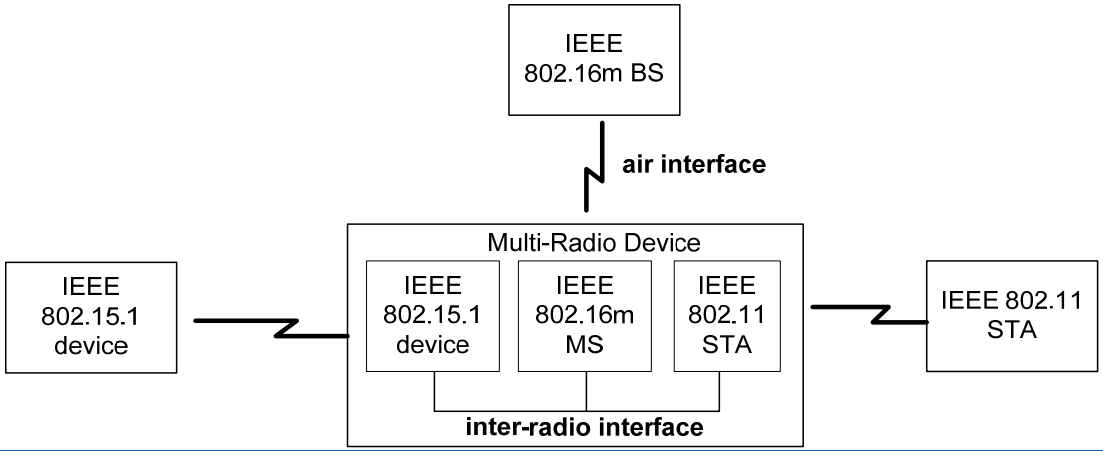
802.16m Protocol Structure*



* Figure extracted from IEEE 802.16 reference 8

Multi-Radio Coexistence Support *

- The multi-radio AMS (Advance Mobile Station) obtains the information about other co-located radio's activities, such as time characteristics, through inter-radio interface
- Management messages generated to report the information about AMS co-located radio activities internally,
- ABS (Advance Base Station) or ARS (Advance Relay Station) respond with corresponding actions to support multi-radio coexistence operation
- The multi-radio coexistence function can be used independently from sleep mode operation to enable optimal power efficiency with a high level of coexistence support.
- Alternatively, sleep mode based co-located coexistence support maybe used in which case, the multi-radio coexistence function may not be needed



Co-Located IEEE 802.16m AMS, IEEE 802.11 STA, and IEEE 802.15.1 device

* Figure extracted from IEEE 802.16 reference 8

Hand Over

- Four cases are considered for handover in IEEE 802.16m
  - Case-1: AMS handover from serving YBS to target YBS
  - Case-2: AMS handover from serving ABS to target YBS
  - Case-3: AMS handover from serving YBS to target ABS
  - Case-4: AMS handover from serving ABS to target ABS

Note: YBS and YMS are Yardstick BS and MS based on WirelessMAN-OFDMA Reference System (Mobile WiMAX Release 1.0)

Inter-RAT Support

- Inter-RAT Hand Over
  - Mechanisms for conducting inter-RAT measurements and reporting
  - Forwards handover related messages with other access technologies such as IEEE 802.11, 3GPP and 3GPP2
  - Handover messages may be defined elsewhere, e.g. IEEE 802.21
- Enhanced inter-RAT HO procedure
- Dual Transmitter/Dual Receiver Support
  - AMS with dual RF may connect to both WiMAX BS and BS from other RAT simultaneously during handover
  - The second RF is enabled when inter-RAT handover is initiated.
- Single Transmitter/Single Receiver Support
  - Connect to only one RAT at a time
  - AMS may switch from source RF to target RF and complete network entry in target RAT, once target RAT preparation is complete

OFDMA Parameters*

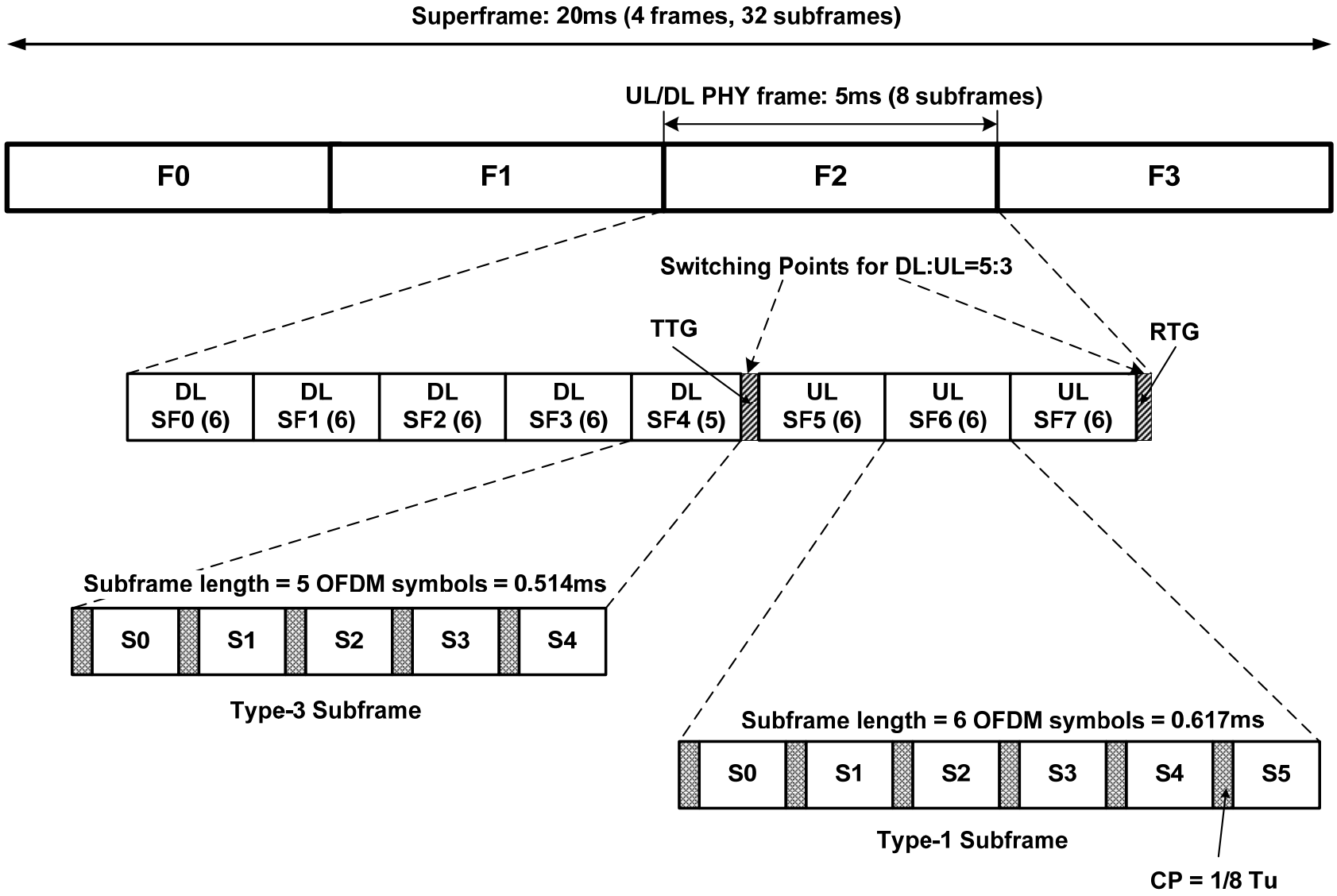
Nominal Channel Bandwidth (MHz)			5	7	8.75	10	20
Over-sampling Factor			28/25	8/7	8/7	28/25	28/25
Sampling Frequency (MHz)			5.6	8	10	11.2	22.4
FFT Size			512	1024	1024	1024	2048
Sub-Carrier Spacing (kHz)			10.937500	7.812500	9.765625	10.937500	10.937500
Useful Symbol Time T_u (µs)			91.429	128	102.4	91.429	91.429
Cyclic Prefix (CP) T_g=1/8 T_u	Symbol Time T_s (µs)		102.857	144	115.2	102.857	102.857
	FDD	Number of OFDM symbols per Frame	48	34	43	48	48
		Idle time (µs)	62.857	104	46.40	62.857	62.857
	TDD	Number of OFDM symbols per Frame	47	33	42	47	47
		TTG + RTG (µs)	165.714	248	161.6	165.714	165.714
Cyclic Prefix (CP) T_g=1/16 T_u	Symbol Time T_s (µs)		97.143	136	108.8	97.143	97.143
	FDD	Number of OFDM symbols per Frame	51	36	45	51	51
		Idle time (µs)	45.71	104	104	45.71	45.71
	TDD	Number of OFDM symbols per Frame	50	35	44	50	50
		TTG + RTG (µs)	142.853	240	212.8	142.853	142.853
Cyclic Prefix (CP) T_g=1/4 T_u	Symbol Time T_s (µs)		114.286			114.286	114.286
	FDD	Number of OFDM symbols per Frame	42			42	42
		Idle time (µs)	199.98			199.98	199.98
	TDD	Number of OFDM symbols per Frame	42			42	42
		TTG + RTG (µs)	199.98			199.98	199.98

*** Parameters are extracted from IEEE 802.16 reference 8**

Frame Structure

- 20 ms superframe begins with the superframe header
- Divided into four 5 ms frames
- For channel bandwidth of 5 MHz, 10 MHz, or 20 MHz, each 5 ms radio frame further consists of eight subframes
- A subframe is assigned for either DL or UL transmission
  - Type-1 subframe which consists of six OFDMA symbols,
  - Type-2 subframe that consists of seven OFDMA symbols
  - Type-3 subframe which consists of five OFDMA symbols.
- Frame structure is applied to FDD and TDD duplexing schemes, including H-FDD MS operation.
- Two switching points in TDD systems

TDD Basic Frame Structure*



* Figure extracted from IEEE 802.16 reference 8
FDD Frame Structure is according to the same concept

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Time Zones and Mix Mode Support

- Time zone: an integer number (greater than 0) of consecutive subframes.
- The concept is equally applied to TDD and FDD systems
- Downlink: The 802.16m Zones (MZone) and Legacy Zones (LZone) are time-multiplexed (TDM) across time domain
- Uplink: Transmissions both TDM and FDM approaches are supported for multiplexing of YMSs and AMSs.
- DL/UL traffic for the AMS can be scheduled in both zones
- DL/UL traffic for the YMS can only be scheduled in the LZones

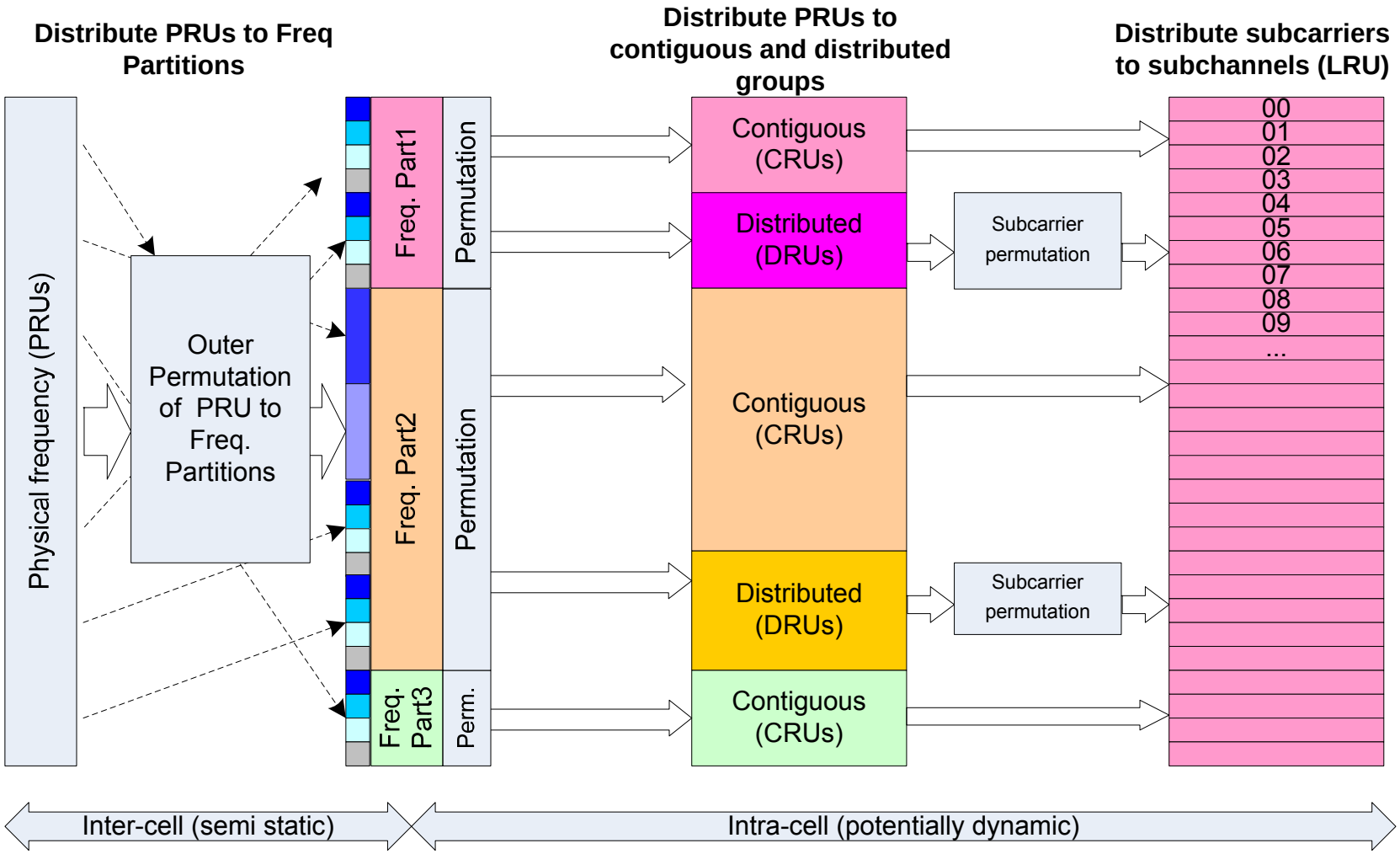
Inter Technology Coexistence Support in Frame Structure

- IEEE 802.16m downlink radio frame can be time aligned with reference timing signal from other technologies frame boundaries
- Symbol puncturing supported to minimize/eliminate the inter-system interference
  - Adjacent Channel Coexistence with E-UTRA (LTE-TDD)
  - Adjacent Channel Coexistence with UTRA LCR-TDD (TD-SCDMA)

Physical Structure: Downlink

- Downlink subframe is divided into a number of Frequency Partitions (FP),
- Each partition consists of a set of Physical Resource Units (PRU) across the total number of OFDMA symbols available in the subframe,
- Each FP can include contiguous (adjacent) and/or non-contiguous (distributed) PRU,
- Each FP can be used for different purposes such as Fractional Frequency Reuse (FFR) or Multicast and Broadcast Services (MBS),
- PRU is the basic physical unit for resource allocation
  - Psc (18) consecutive subcarriers by Nsym consecutive OFDMA symbols.
  - Nsym is 6 OFDMA symbols for type-1 subframes, and Nsym is 7 OFDM symbols for type-2 sub frames, and Nsym is 5 OFDMA symbols for type-3 subframes.
- Logical Resource Unit (LRU) is the basic logical unit for distributed and localized groups,
  - 18*6 subcarriers for type-1 subframes, 18*7 subcarriers for type-2 subframes, and 18*5 subcarriers for type-3 subframes.
- Distributed Resource Unit (DRU)
  - group of subcarriers which are spread across the distributed group within a FP by the subcarrier permutation.
  - Beneficial to achieve frequency diversity gain.
- Contiguous Resource Unit (CRU)
  - Group of subcarriers which are adjacent across the localized group within a FP.
  - Beneficial to achieve frequency-selective scheduling gain.

Downlink Physical Structure*



* Figure extracted from IEEE 802.16 reference 8
Uplink Frame Structure is according to the same concept

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Pilot Structure

- Pilot subcarriers in the downlink: necessary for enabling channel estimation, measurements of channel quality indicators such as the SINR, frequency offset estimation, etc,
- Supports both common and dedicated pilot structures to optimize the system performance.
  - The common pilots used by all AMSs,
  - Dedicated pilots used with both localized and distributed allocations targeting a specific resource allocation and relevant AMSs to specific resource allocation,
  - Can be precoded or beamformed in the same way as the data subcarriers of the resource allocation
- Defined to support up to eight transmission (Tx) streams
- Equal pilot density per Tx stream,
- Not necessarily equal pilot density per OFDMA symbol of the downlink subframe
- Equal number of pilots for each PRU of a data burst assigned to one AMS within the same subframe

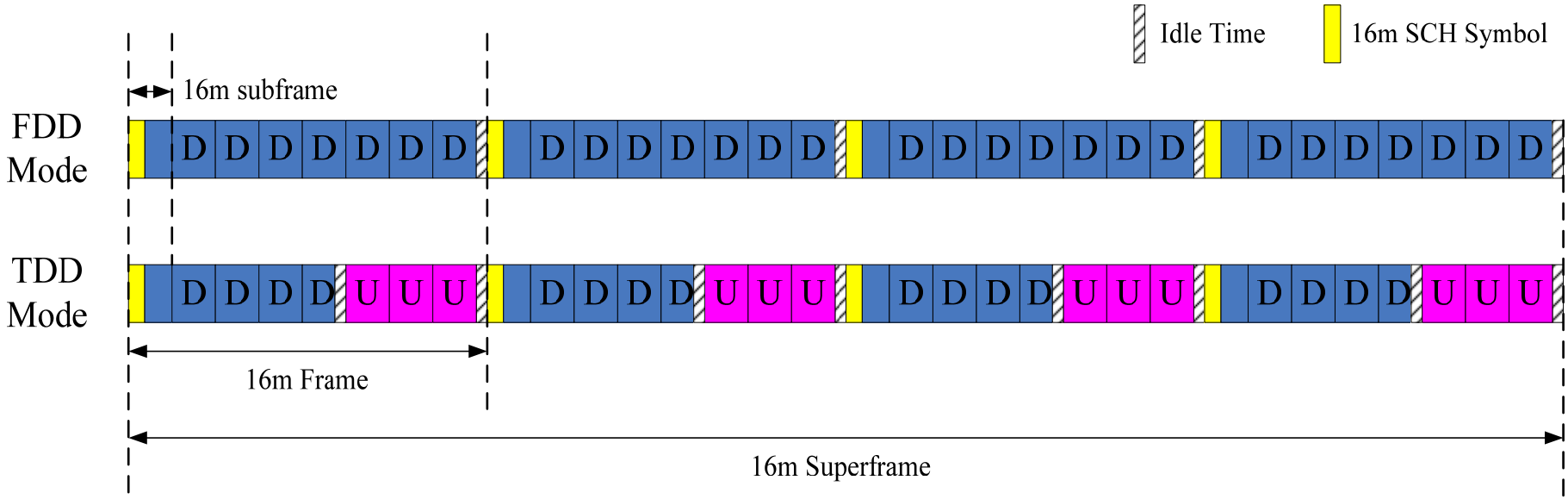
Downlink Control Structure

- Transmitted hierarchically over different time scales
  - From the superframe level to the subframe level
  - Reduce the overhead and network entry latency, and improve robustness
- Control information related to system parameters/ configuration: transmitted at the superframe level,
- Control and signaling related to traffic transmission/reception: is transmitted at the frame/subframe level,
- The first DL subframe of each frame contains one A:MAP

Advanced Preamble (A-PREAMBLE)

- Provides a reference signal for timing, frequency, and frame synchronization, RSSI estimation, channel estimation, and ABS identificatio
- Design Criteria: Convergence time, Correct detection, Coverage area, OverheadCell ID set, Multi-bandwidth support, Multi-carrier support
- Support maximum of two antenna
- Primary Advanced Preamble (PA-PREAMBLE) and Secondary Advanced Preamble (SA-PREAMBLE)
  - PA-PREAMBLE: initial acquisition, superframe synchronization and sending additional information
  - SA-PREAMBLE: fine synchronization, and cell/sector identification (ID)
- PA-PREAMBLE and SA-PREAMBLE are TDM
- A complete instance of the A-PREAMBLE exists within a superframe,
- Multiple symbols within the superframe allocated to A-PREAMBLE

Advanced Preamble (A-PREAMBLE)* : Four Symbol Example



* Figure extracted from IEEE 802.16 reference 8

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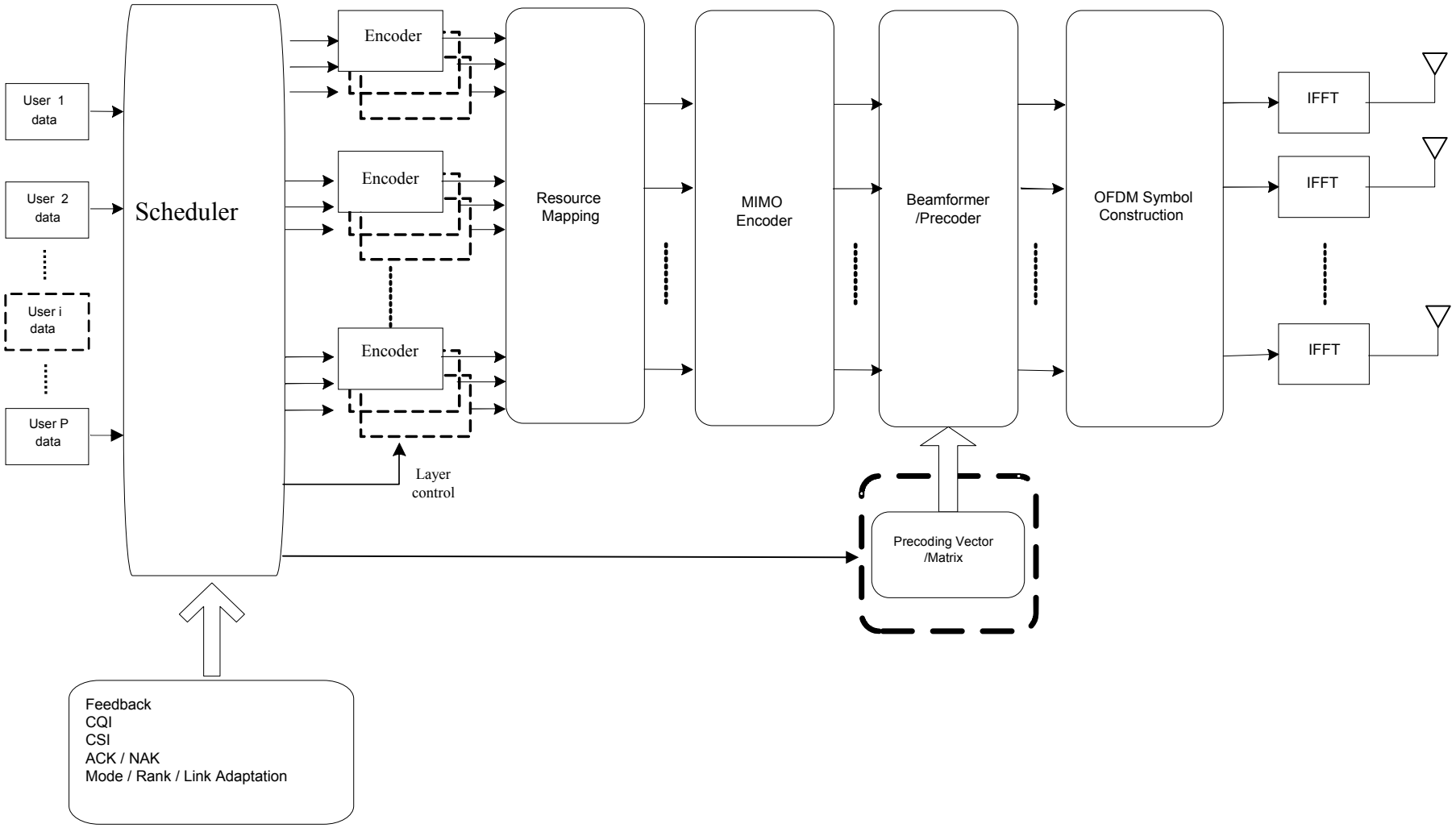
MIMO: Downlink

- Supports both Single User MIMO (SU-MIMO) and Multi-User MIMO (MU-MIMO)
  - SU-MIMO: only one user is scheduled in one Resource Unit (RU)
  - MU-MIMO: multiple users can be scheduled in one RU
- Encoder: channel encoder, interleaver, rate-matcher, and modulator for each layer
- Resource mapping: maps the modulated symbols to the corresponding time-frequency resources
- MIMO encoder: maps L (≥1) layers onto NS (≥L) streams, which are fed to the Beamformer/Precoder block
- Beamformer/Precoder: maps streams to antennas according to the selected MIMO mode
- OFDM symbol construction: maps antenna-specific data to the OFDM symbol
- Feedback: feedback information such as CQI and CSI from the AMS

*** Figure extracted from IEEE 802.16 reference 8**

MIMO Block Diagram: Downlink



- Figure extracted from IEEE 802.16 reference 8
- Vertical Encoding requires a single Encoder

MIMO: Downlink

- Open-Loop SU-MIMO
  - Various number of antenna configurations, transmission rates, SFBC, SM are supported
    - 2Tx, 4Tx, and 8Tx antennas with rate 1,
    - 2Tx, 4Tx, and 8Tx antennas with rate 2,
    - 4Tx and 8Tx antennas with rate 3,
    - 4Tx and 8Tx antennas with rate 4,
    - 8Tx antennas with transmission up to rate 8 (Spatial Multiplexing)
- Closed- Loop SU-MIMO
  - FDD and TDD: unitary codebook based pre-coding
  - TDD systems: sounding based pre-coding
- Multi-user MIMO
  - To enable higher throughput resource allocation to two or more AMSs.
    - One stream per user is supported for MU-MIMO,
    - 2Tx antennas to support up to 2 users,
    - 4Tx or 8Tx antennas to support up to 4 users.
- Multi-BS MIMO (Advance feature)

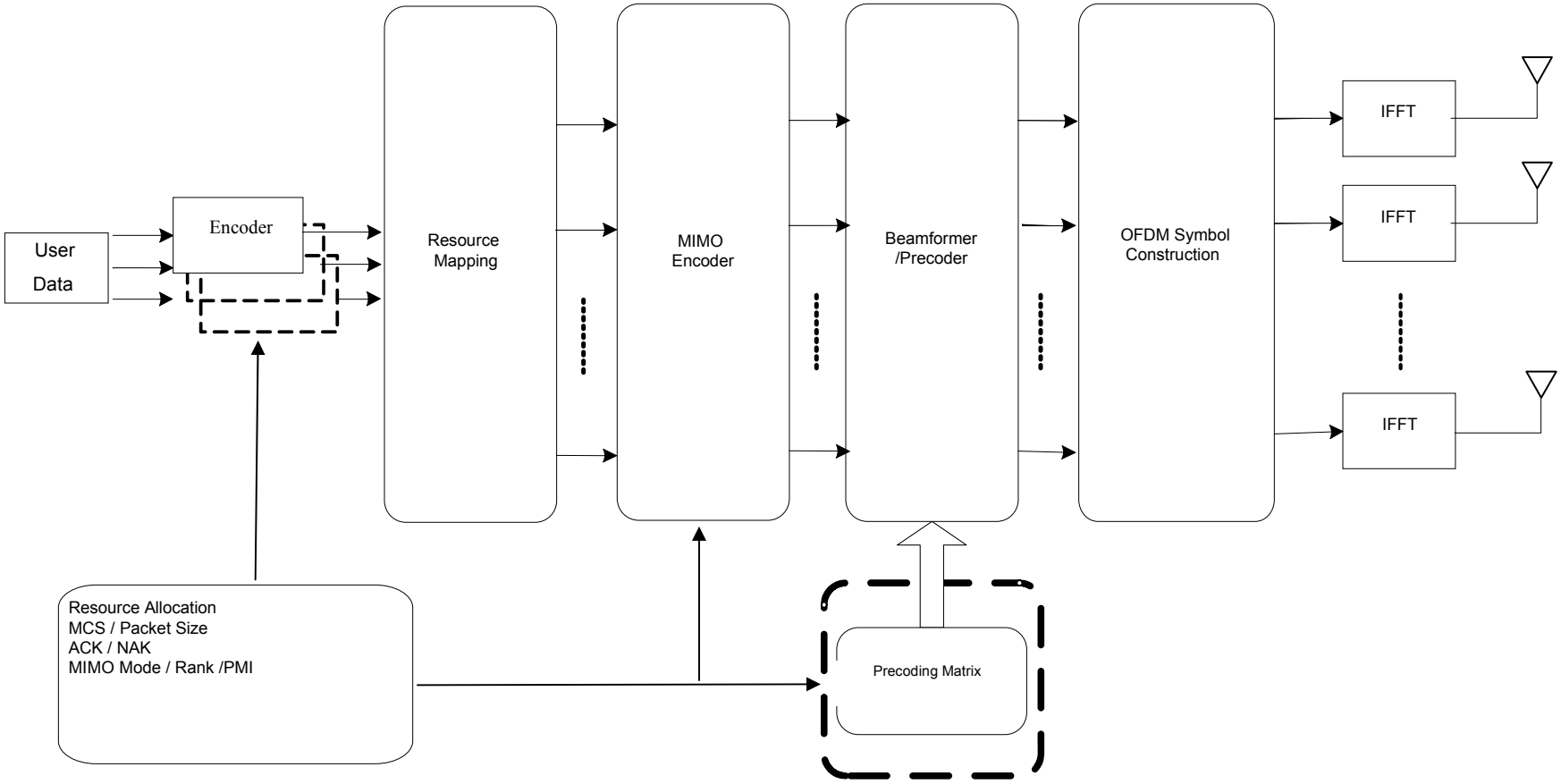
MIMO Mode and Rank Adaptation

- Optimally supports radio environments for IEEE 802.16m systems
- ABSs and AMSs adaptively switch between DL MIMO techniques
  - Antenna configurations
  - Channel conditions
  - Parameters may have slowly or fast varying dynamics
  - By switching between DL MIMO techniques an optimize throughput or coverage for a specific radio environment and antennna configuration
- MIMO Adaptation Modes
  - Open-loop MIMO (SFBC, SM)
  - Closed-loop MIMO
  - SU-MIMO
  - MU-MIMO
- Adaptation behaviors depends on system load, the channel information, AMS speed and average CINR

MIMO: Uplink

- Supports both Single User MIMO (SU-MIMO) and Multi-User MIMO (MU-MIMO)
  - SU-MIMO: only one user is scheduled in one Resource Unit (RU)
  - MU-MIMO: multiple users can be scheduled in one RU
- Open-Loop SU-MIMO
  - Various number of antenna configurations, transmission rates, SFBC, SM are supported
    - 2Tx and 4Tx antennas with rate 1,
    - 2Tx and 4Tx antennas with rate 2,
    - 4Tx antennas with rate 3,
    - 4Tx antennas with rate 4 (Spatial Multiplexing)
- Closed- Loop SU-MIMO
- Multi-user MIMO
  - To enable multiple AMSs spatially multiplexed on the same radio resources
  - Both Open-Loop and Closed-Loop MU-MIMO are supported.

MIMO Block Diagram: Uplink



* Figure extracted from IEEE 802.16 reference 8

Power Control

- Supported for DL and UL based on
  - Frame structure,
  - DL/UL control structures, and
  - Fractional frequency reuse (FFR)
- Downlink Power Control
  - ABS controlling the transmit power per subframe and per user.
  - Supports SU-MIMO and MU-MIMO applications
- Uplink Power Control
  - To compensate the path loss, shadowing, fast fading and implementation loss
  - To control inter-cell and intra-cell interference level
  - Open-loop power control (OLPC) and
  - Closed-loop power control (CLPC)

Link Adaptation

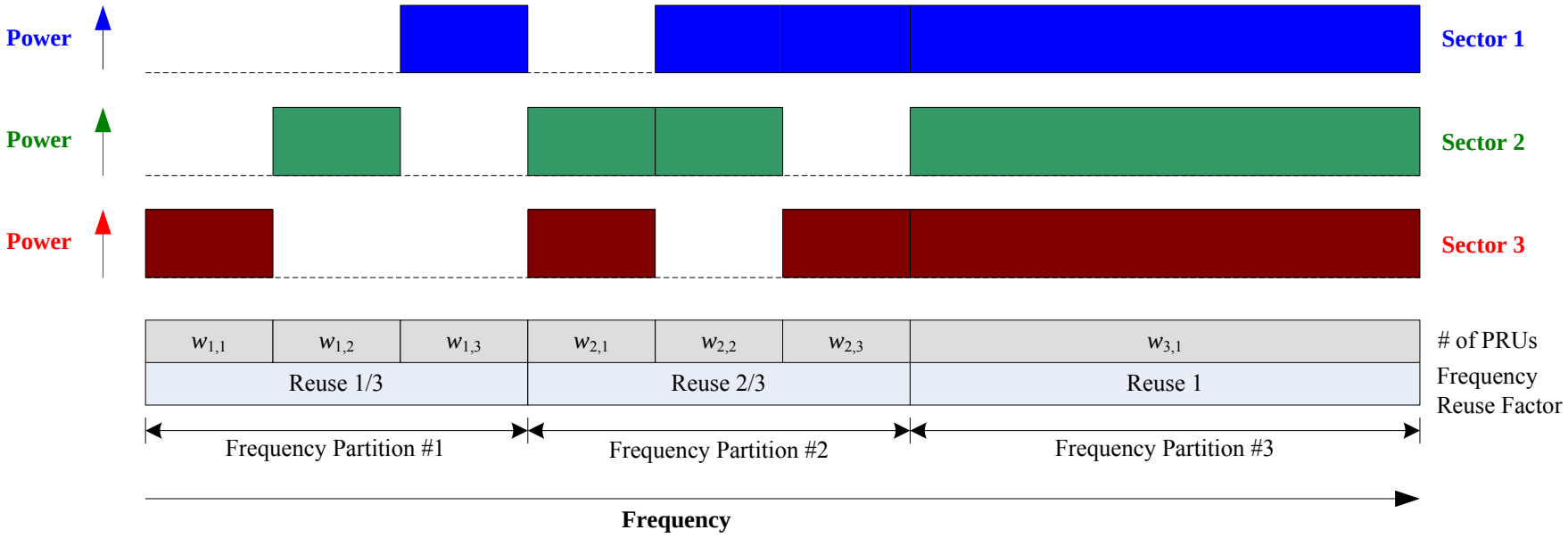
- QPSK, 16 QAM, and 64 QAM are supported as defined for the WirelessMAN OFDMA reference system (Mobile WiMAX Release 1.0)
- DL Link Adaptation
  - Adaptive modulation and channel coding (AMC) scheme for DL transmission
  - ABS adapts the modulation and coding scheme (MCS) level based on the DL channel quality indicator (CQI) reported from AMS
- UL Link Adaptation
  - Adaptive modulation and channel coding (AMC) scheme for UL transmission
  - ABS adapts the modulation and coding scheme (MCS) level based on the UL channel quality estimation and the maximum transmission power by AMS

HARQ

- Incremental redundancy Hybrid-ARQ (HARQ IR)
  - Chase Combining is supported and treated as a special case of IR primarily to support legacy Reference System
- Aggressive HARQ Transmission
  - BS can transmit coded bits exceeding current available soft buffer capacity
  - The exceeding ratio is negotiated by BS and MS
- Adaptive HARQ: Resource allocation/transmission in downlink and uplink can be adaptive according to control signaling
- HARQ using frequency diversity: re-transmissions and bits or symbols can be transmitted in a different order to exploit the frequency diversity
- HARQ Operation with Persistent/Group Allocation
  - If initial transmissions in persistent allocation, then retransmissions are supported in a non-persistent manner (dynamically)
  - Asynchronous HARQ operation is supported
  - HARQ retransmissions in Group Allocation may be dynamically or fixed allocated

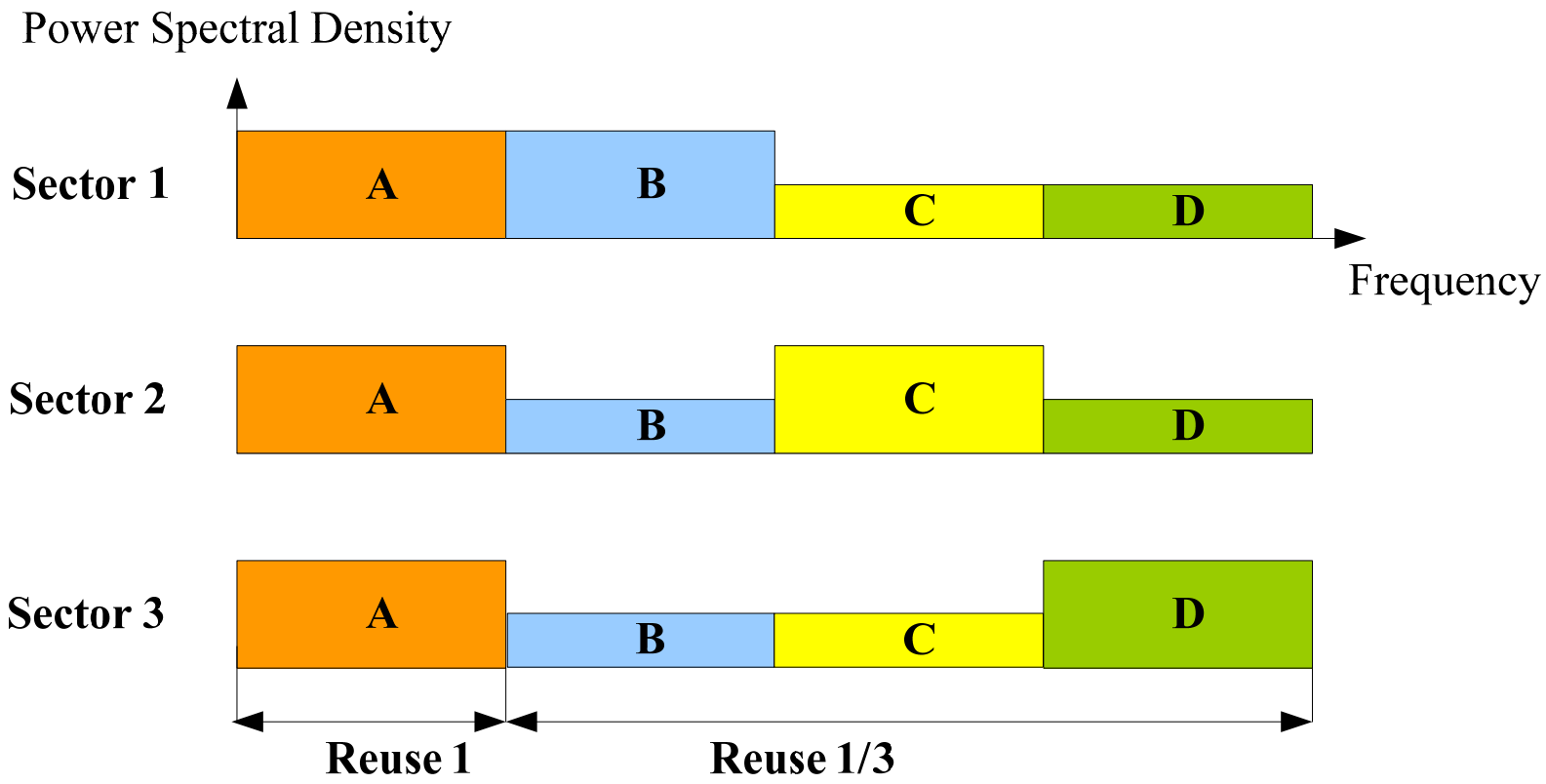
Fractional Frequency Reuse (FFR) for Interference Mitigation

- To allow different frequency reuse factors to be applied over different FPs during the designated period for both DL and UL transmissions
- The operation is typically combined with other functionalities such as power control and/or antenna technologies



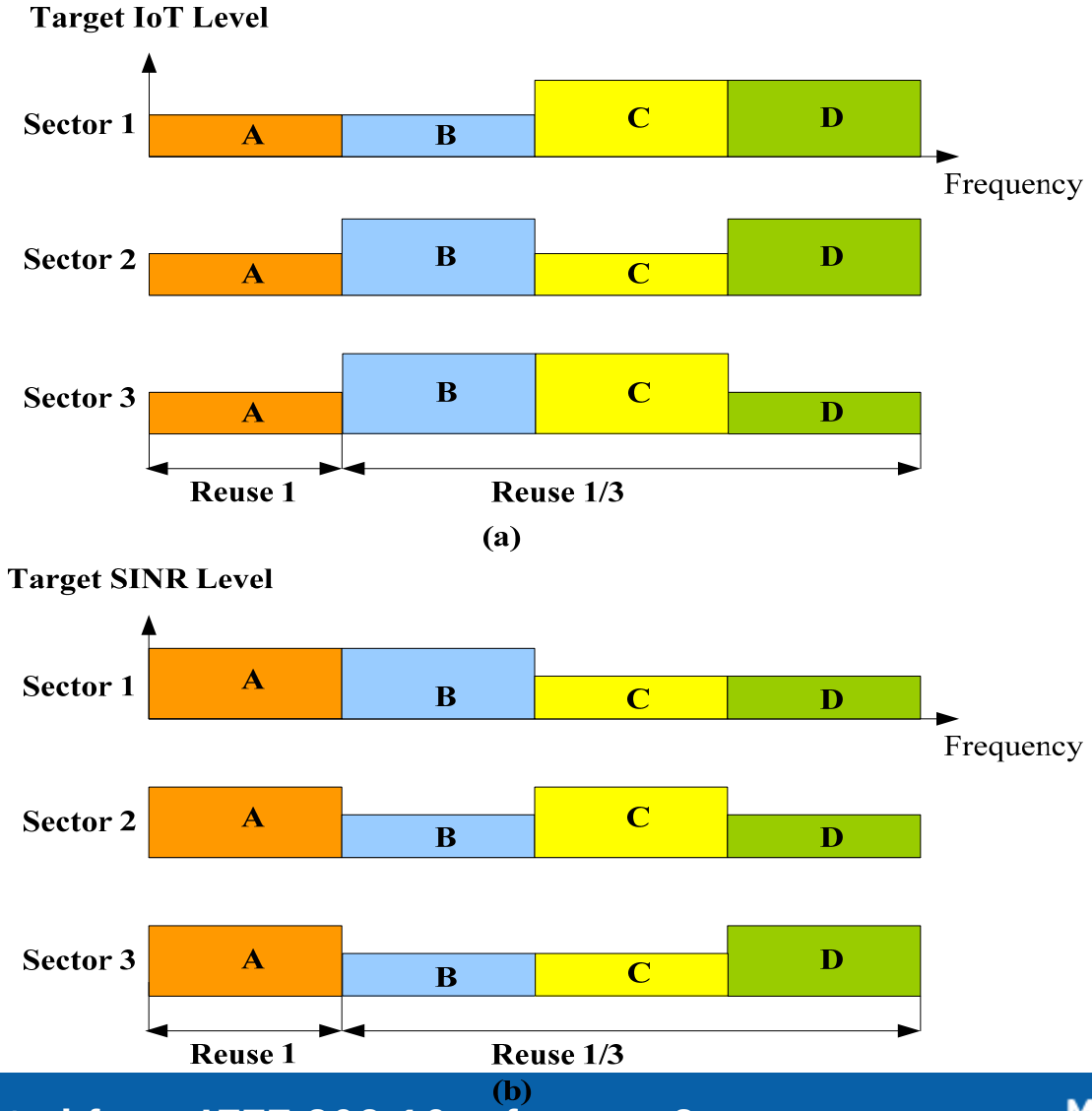
* Figure extracted from IEEE 802.16 reference 8

Downlink FFR based on Power Spectral Density



* Figure extracted from IEEE 802.16 reference 8

Uplink FFR Based on Interference over Thermal Noise and SINR



* Figure extracted from IEEE 802.16 reference 8

Location Based Services

- GPS-Based Method
- Assisted GPS (A-GPS) Method
  - Includes the integrated GPS receiver and network components,
  - Assists a GPS device to speed up GPS receiver “cold startup” procedure
- Non-GPS-Based Method
  - Works based on the role of the serving and neighboring ABSs/ARSs
  - May be supported in the DL and UL

Support for Femtocells

- Typically operate in licensed spectrum in the same or different frequency as macro-cells
- Femtocell types:
  - CSG (Closed Subscriber Group) Femtocell BS: accessible only to the MSs, which are member of the CSG
  - OSG (Open Subscriber Group) Femtocell BS: accessible to any MSs
- Femtocell and macro BSs are differentiated using Cell IDs obtained from the A-PREAMBLE
- Femtocell BSs synchronize with the network to common timing and frequency
- Femtocell BSs may use different schemes for synchronization with the network
  - May synchronize with the overlay BS's A-PREAMBLE to automatically adjust its DL synchronization
- During network entry, Femtocell BS obtains/determines its location and configures radio transmissions parameters before any transmission
- Handover
  - Femtocell to Macro cell
  - Macro cell to Femtocell
  - Femtocell to Femtocell

Self-organization (SON)

- Macro, Relay, Femtocell BSs to automate the configuration of BS parameters and to optimize network performance
- Adjustments of BS parameters based on the measurement and reporting of air interface performance metrics from MS/BS
- BS self-configuration: Automatic initialization/configuration
  - Cell initialization: If not pre-configured, Air-interface parameters (e.g. CP and OFDM symbol length, DL/UL ratio, channel bandwidth and preamble sequence) may be configured
  - The initial of neighbor list is obtained from core network automatically. Change/updates to the neighbor environment/list automatically trigger the BS to generate an updated neighbor list
  - Through inter-BS communication, a database, or through the measurement by ABS/AMS/ARS
- BS Self-optimization: analyzing the SON measurement from the BS/MS and optimizing the BS parameters for network performance (e.g. QoS, network efficiency, throughput, cell coverage and cell capacity)
  - Coverage and Capacity Optimization
  - Interference Management and Optimization
  - Load Management and Balancing
  - Fractional Frequency Reuse Optimization

Multi-carrier Support

- Common MAC entity may control PHY spanning over multiple frequency channels
- Some MAC messages sent on one carrier may also apply to other carriers
- Channel may have different bandwidth sizes (e.g. 5, 10 and 20 MHz), contiguous or non-contiguous from the same or different bands
- May mix duplexing modes, e.g. FDD, TDD, Broadcast
- Primary Carrier: Used to exchange traffic and PHY/MAC control information and main control functions such as network entry
- Secondary Carrier: Used for traffic; allocation commands and rules typically received on the primary carrier. May also include control signaling required to support multi-carrier operation
- Fully Configured carrier: All control channels (e.g. synchronization, broadcast, multicast and unicast control signaling) are configured.
  - Supports both single carrier AMS and multi-carrier AMS
- Partially Configured carrier: Only downlink transmission in TDD or a downlink carrier without paired UL carrier in FDD mode
  - Support multi-carrier AMS only

Multi-carrier Operation (cont'd)

- The common MAC may utilizes one or more of Secondary Carriers; maintains control of AMS, state and context through the Primary Carrier
  - For each AMS, one Fully Configured carrier is assigned as Primary Carrier per cell.
  - Fully Configured Secondary Carrier for an AMS may serve as Primary Carrier for other AMS
- AMS access on multiple carriers:
  - Carrier aggregation: AMS shall always maintains its PHY layer connection and monitor the control information on the Primary Carrier
  - Carrier switching: AMS can switch its PHY layer connection from the Primary to the Secondary Carrier per ABS's instruction
    - AMS connects to Secondary Carrier (when PHY layer connection to Primary Carrier not needed) for the specified time period and then returns to the Primary Carrier

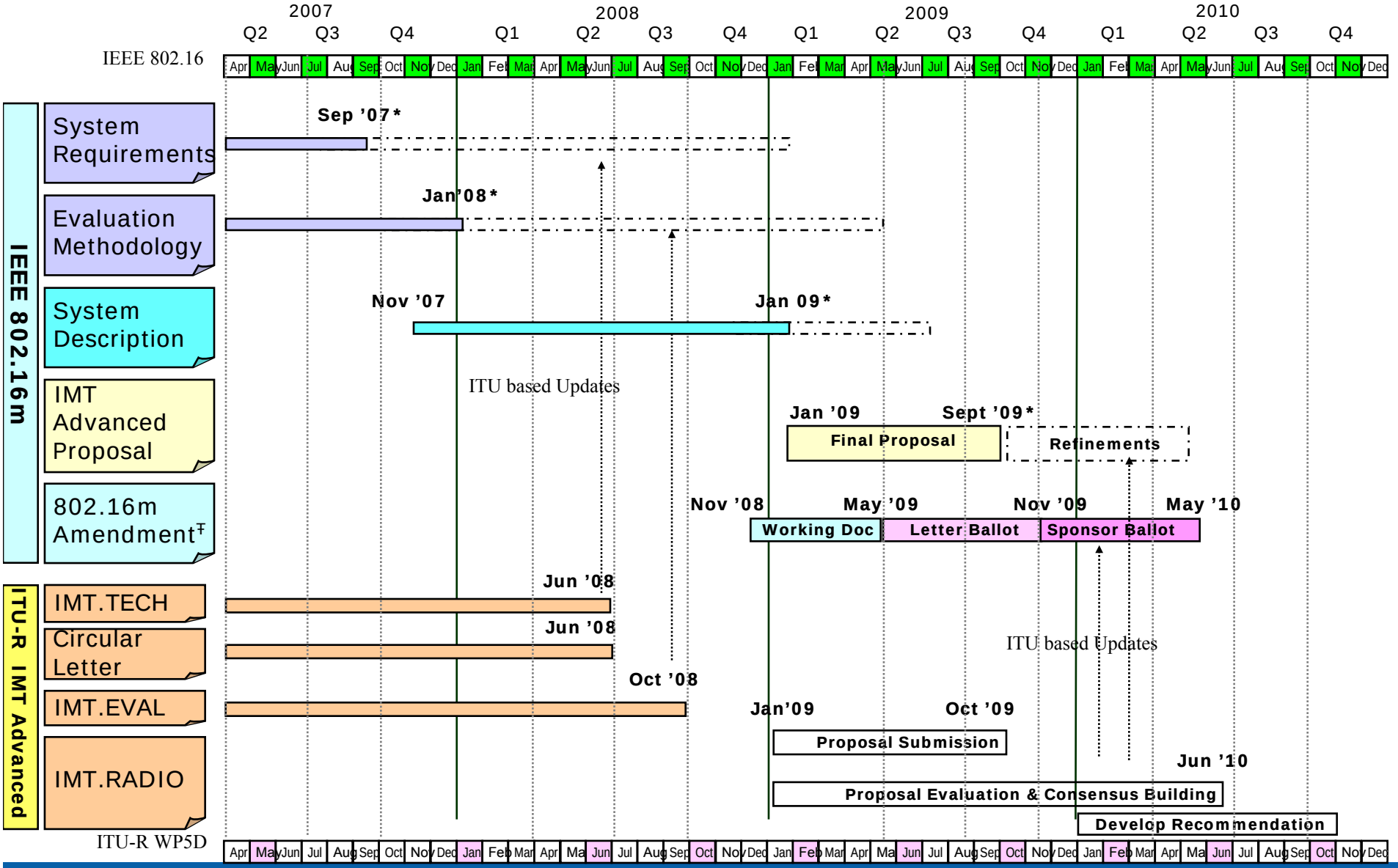
Enhanced Multicast and Broadcast Services

- Enhanced Multicast and Broadcast Services (E-MBS): offered on multicast connection using specific (E-)MBS features to improve performance and operation in power saving modes
- Both Static and Dynamic Multicast are supported
- E-MBS Access Types
  - Single-ABS access: implemented over multicast and broadcast transport connections within one ABS
  - Multi-ABS access: implemented by transmitting data from service flow(s) over multiple ABSs (PDUs are transmitted by all BSs in the same MBS zone)
- Diversity mode
  - Non-Macro Diversity: Synchronized in frame level without symbol/allocation level coordination
  - Macro Diversity: Synchronized at the symbol/allocation level enabling macro-diversity combining of signals for higher performance
- E-MBS service may be delivered via either a dedicated carrier or a mixed unicast-broadcast carrier.

IEEE 802.16/Mobile WiMAX R2.0: Candidate for IMT-ADvance

- Technology Description Template – Characteristics Template (TDT)
- Technology Description Template – Link Budget Template (LBT)
- Working Document on Compliance Templates
  - Compliance template for services
  - Compliance template for spectrum
  - Compliance template for technical performance
- Simulation Assumptions and Configuration Parameters for IMT-Advanced Test Environments

TGm Timelines



*System Requirements and Evaluation Methodology, System Description, IMT-Advanced Proposal Documents may be further updated based on ITU output (shown by dotted lines).

∓ 802.16m amendment is dependent on the 802.16Rev2 Project completion

Mobile Wireless Group

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References

1. **IEEE Standard 802.16e-2005,** Amendment to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems- Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands
2. **IEEE Standard 802.16/Rev2**, Local and metropolitan area networks, Part 16: Air Interface for Broadband, Wireless Access Systems
3. **WiMAX Forum™ Mobile System Profile**, Release 1.0
4. **WiMAX Forum™ Mobile System Profile**, Release 1.5 Common Part
5. **WiMAX Forum™ Mobile System Profile**, Release 1.5 FDD Specific
6. **WiMAX Forum™ Mobile System Profile**, Release 1.5 TDD Specific
7. IEEE 802.16m **System Requirements Document** (SRD)
8. IEEE 802.16m **System Description Document** (SDD) [Draft]
9. IEEE 802.16m **Evaluation Methodology Document** (EMD)
10. IEEE 802.16m **Amendment Working Document** (AWD)

Backup

Mobile WiMAX Release 1.0 Band Classes

Band Class	Spectrum Range (GHz) BW (MHZ)	Bandwidth Certification Group Code (BCG)
1	**2.3-2.4**	
	8.75	1.A
	5 AND 10	1.B
2	**2.305-2.320, 2.345-2.360**	
	3.5 AND 5 AND 10	2.D
3	**2.496-2.69**	
	5 AND 10	3.A
4	**3.3-3.4**	
	5	4.A
	7	4.B
	10	4.C
5	**3.4-3.8**	
	5	5.A
	7	5.B
	10	5.C
7	**0.698-0.862**	
	5 AND 7 AND 10	7.A
	8 MHz	7.F


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