



Report on candidate RIT self-evaluation simulation assumptions and results

IEEE 802.16 IMT-Advanced Evaluation Group
Coordination Meeting

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La Jolla, CA, USA

Outline

- Introduction
- Link budget template (LBT)
 - Simulation assumptions
 - Link-level simulation data
 - Link budget tables
- Performance Compliance Template (PCT)
 - Simulation assumptions
 - System-level simulator calibration
 - Simulation results for full-buffer and VoIP
- Summary

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IEEE 802.16m Self-Evaluation

- Conducted for all four test environments, for both TDD and FDD
- Evaluation in accordance to the following ITU-R documents:
 - Report ITU-R M.2133 (IMT.REST)
 - Report ITU-R M.2134 (IMT.TECH)
 - Report ITU-R M.2135 (IMT.EVAL) as amended by corrections in document IMT-ADV/3
- Contributions from the following 16 entities:
 - Alcatel Shanghai Bell, Clearwire, ETRI, Fujitsu, Hitachi, Intel Corporation, ITRI, KDDI R&D Laboratories, LG Electronics, MediaTek, Mitsubishi Electric, Motorola, NEC, Samsung Electronics, Toshiba, and UQ Communications

IEEE Submission – Contents of Part 3 and Part 4

Part 3: General description of the RIT, Description templates

- Characteristics
- **Link budget**
- Annex 1 – L1/L2 Overhead Calculation
- Annex 2 – Stage 2 Specification: IEEE 802.16m System Description Document

Part 4: Self-evaluation report, overview, evaluation results, compliance templates

- Services
- Spectrum
- **Technical performance**
- **Annex 3: Simulation Assumptions and Configuration Parameters**
- **Annex 4: Details of Simulation-related Results in the PCT**

***Items in bold font (blue color) are subject of this document**

IMT-Advanced Test Environments/Deployment Scenarios - Main Parameters

Test Environment/Deployment Scenario	Indoor/Indoor hotspot (InH)	Microcellular/Urban micro-cell (UMi)	Base Coverage Urban/Urban macro-cell (UMa)	High Speed/Rural macro-cell (RMa)
Layout	Indoor floor	Hexagonal grid	Hexagonal grid	Hexagonal grid
Inter-site distance	60 m	200 m	500 m	1732 m
Channel Model	Indoor hotspot model	Urban micro model	Urban macro model	Rural macro model
Carrier frequency	3.4 GHz	2.5 GHz	2 GHz	800 MHz
User speeds	3 km/h	3 km/h	30 km/h	120 km/h

IEEE 802.16m OFDMA Parameters

Description	RIT Parameters for InH		RIT Parameters for UMi, UMa, RMa	
	TDD	FDD	TDD	FDD
Carrier Frequency	3.4 GHz		UMi: 2.5 GHz	
			UMa: 2.0 GHz	
			RMa: 0.8 GHz	
Total bandwidth	40 MHz for data (2x20 MHz)	2x20 MHz for data	20 MHz for data	2x10 MHz for data
	10 MHz for VoIP	5 + 5 MHz for VoIP	10 MHz for VoIP	5 + 5 MHz for VoIP
Number of points in full FFT	2x2048 for data	2048 for data	2048 for data	1024 for data
	1024 for VoIP	512 for VoIP	1024 for VoIP	512 for VoIP
Sampling frequency	44.8 MHz for data	22.4 MHz for data	22.4 MHz for data	11.2 MHz for data
	11.2 MHz for VoIP	5.6 MHz for VoIP	11.2 MHz for VoIP	5.6 MHz for VoIP

IEEE 802.16m OFDMA Parameters (contd.)

Description	RIT Parameters for InH		RIT Parameters for UMi, UMa, RMa	
	TDD	FDD	TDD	FDD
Subcarrier spacing	10.9375 kHz			
OFDMA symbol duration without CP	91.43 us			
CP length (fraction)	1/16			
OFDMA symbol duration with CP	97.143 us			
Frame length	5 ms			
#of OFDMA symbols in frame (excluding switching gaps)	50	51	50	51
Ratio of DL to UL (TDD mode)	5 DL subframes, 3 UL subframes for data	8 DL subframes for DL and UL	5 DL subframes, 3 UL subframes for data	8 DL subframes for DL and UL
	4 DL subframes, 4 UL subframes for VoIP	8 DL subframes for DL and UL	4 DL subframes, 4 UL subframes for VoIP	8 DL subframes for DL and UL
Duplex time	TTG+RTG = 142.85 μ s	N/A	TTG+RTG = 142.85 μ s	N/A

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LBT calibration and results generation

- Step 1: Selection of Data rates and Modulation and Coding Schemes (MCS)
- Step 2: Generation of required SNR values (NLRU, STC rate-1 closed-loop beamforming)
- Step 3: Compilation of link-budget tables

LBT – Step 1

Example: UMi, Downlink for CL SU-MIMO 1 stream

Code rate	DL Burst BW (#RU)	$I_{\text{SizeOffset}}$	DL Burst Size (bits)	DL MPDU Payload (bits)	DL MAC kbps (ReTX 0)	DL MAC kbps (max_ReTX)	DL MAC SE (ReTX 0) bps/Hz	DL MAC SE (max_ReTX) bps/Hz
0.462745098	8	15	3776	3696	739.200	622.107	0.751	0.632
0.456862745	4	15	1864	1780	356.800	300.281	0.725	0.610
0.078431373	4	0	320	240	48.000	40.397	0.098	0.082

Example: UMi, Uplink for CL SU-MIMO 1 stream

Code rate	DL Burst BW (#RU)	$I_{\text{SizeOffset}}$	DL Burst Size (bits)	DL MPDU Payload (bits)	DL MAC kbps (ReTX 0)	DL MAC kbps (max_ReTX)	DL MAC SE (ReTX 0) bps/Hz	DL MAC SE (max_ReTX) bps/Hz
0.462745098	4	16	1312	1232	246.400	207.369	0.834	0.702
0.456862745	2	16	640	560	112.000	94.259	0.759	0.638
0.078431373	2	3	136	56	11.200	9.426	0.076	0.064

Reference : attachment1.xls

LBT – Step 2

Example: UMi, Uplink and Downlink for CL SU-MIMO 1 stream

	Average Required SINR (dB) Downlink	Average Required SINR (dB) Uplink
TDD Data (Wideband Precoding)	-1.05	-0.96
FDD Data (Wideband Precoding)	-1.68	-1.14
Control (A-A-MAP QPSK 1/8)	-1.57	N/A
Control (PFBCH - 6bit)	N/A	-4.10

Reference : attachment2.xls

LBT – Step 3

- Comprehensive generation of link budget data covering
 - All test environments/deployment scenarios (InH, UMi, UMa, RMa)
 - TDD and FDD modes
 - Downlink and uplink
 - Data traffic and control channels
- Note: Cell range/coverage area are determined based on link budget inputs corresponding to data rates, cell-area reliability etc. No ITU requirement is specified for link budget inputs.

Reference : attachment3.doc

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PCT Calibration and Generation of Results

- Step 1: Geometry (downlink wideband SINR) calibration
- Step 2: SU-MIMO calibration for full-buffer data traffic
- Step 3: MU-MIMO calibration for full-buffer data traffic
- Step 4: Control overhead calculation full-buffer data traffic
- Step 5: Calibration for VoIP simulations
- Step 6: Mobility requirements
- Step7: Compilation of PCT results:
 - DL and UL full-buffer data cell and cell-edge user spectral efficiencies for TDD and FDD
 - DL and UL VoIP capacities for TDD and FDD
 - UL link-level and system-level results related to mobility requirement for TDD and FDD

PCT – Step 1: Geometry Calibration

- Calibration based on the following parameters/concepts:
 - User drop concept
 - Cell selection concept
 - Antenna pattern (azimuth/elevation) and antenna tilting angles
 - Cluster beam gain
 - Generation of large-scale parameters (LSPs)

Reference : attachment4.xls

PCT – Step 2: SU-MIMO Calibration

Main Parameters

Parameter	Value
Duplex Mode	FDD
Environments	UMi
Bandwidth	DL: 10MHz
Scheduler	Proportional fair
Transmission scheme	SU-MIMO, 6bit codebook based
Antenna configuration	DL : 4x2, BS: co-polarized, 4λ spacing (illustration for 4 Tx:) UL: 2x4, MS: Vertical polarized, 0.5λ spacing
Receiver type	MMSE
HARQ	Chase combining, maximum of 4 retransmissions CQI measurement: perfect CQI feedback delay: 5ms No feedback transmission errors Every MS reports CQI, PMI for subbands (SLRU), 12 subbands with 4 PRUs each
Channel estimation	Ideal
Control overhead	Approximately 28.6%

PCT – Step 2: SU-MIMO Calibration Results

	Source 6	Source 9	Source 1	Source 7	Source 3	Average
Average SE	1.97	1.96	2.00	1.82	2.06	1.96
Cell-edge user SE	0.0827	0.0814	0.062	0.058	0.078	0.0724

Reference : attachment5.doc
(Summary of Step-1 and Step-2 calibration data)

PCT – Step 3: MU-MIMO calibration

- Transformed codebook (T-CBK) with SLRU selected for InH/UMi full-buffer data traffic simulations (DL/UL, TDD/FDD)
 - Significant gain (5%-10%) with T-CBK for the adopted antenna configuration (co-polarized ULAs, $\lambda/2$ antenna element spacing, calibrated arrays) in the low-mobility test environments (InH, UMi)
- Full PMI/CQI feedback selected for InH/UMi full-buffer data traffic simulations
 - Significant gain (> 15% on the average) with full PMI/CQI feedback compared to feedback for best-6 and best-4 subbands
- Long-term beamforming (LT-BF) with NLRU selected for UMa/RMa full-buffer data traffic simulations (DL/UL, TDD/FDD)
 - Significant advantage with LT-BF (with NLRU) over T-CBK (with SLRU) in the medium/high mobility test environments (UMa, RMa)
- MU-MIMO with maximum 4 streams selected for all downlink full-buffer data traffic simulations
 - Average gain of approximately 15% (including control overhead) for MU-MIMO with maximum 4 streams over maximum 2 streams for all test environments when either T-CBK or LT-BF was used.

PCT – Step 4: Control Overhead Calculation

Control Channel List

- Downlink control channels modeled:
 - DL Assignment A-MAP
 - UL Assignment A-MAP
 - Non-user specific A-MAP
 - HARQ Feedback A-MAP
 - Superframe Header
 - A-PREAMBLE
 - A-MIDAMBLE
- Uplink control channels modeled:
 - Primary fast feedback channel
 - UL MAC control messages
 - H-FBCH
 - Sounding channel
 - Initial ranging (IR) channel
 - Bandwidth request (BW-REQ) channel

PCT – Step 4: DL Control Overhead

- Long-TTI (2.5 ms for FDD, 5 ms for TDD, DL/UL ratio of 31/19) for all data traffic allocations
- DL A-A-MAP and UL A-A-MAP:
 - Dynamic overhead calculated from the DL/UL allocations in each frame
 - A-A-MAP element transmitted using QPSK 1/2 or QPSK 1/4; A-A-MAP IEs for all data allocations with SINR higher than 1 dB assigned QPSK 1/2
 - For S-CRU allocations, sub-band A-A-MAP IE which reduces DL control overhead
 - Average DL/UL A-A-MAP overhead used for spectral efficiency calculations
- Non-user specific A-MAP (NUS-A-MAP): 72 subcarriers (0.75 LRU)
- HF-A-MAP:
 - Average number of allocations used from the UL simulations
 - Each channel assumed to be occupy 8 tones (repetition 8)
- SFH: 20 LRUs every superframe
- A-PREAMBLE/A-MIDAMBLE: 1 symbol each per 5 ms frame

PCT – Step 4: UL Control Overhead

- Long-TTI (2.5 ms for FDD, 5 ms for TDD, DL/UL ratio of 31/19) for all data traffic allocations
- PFBCH (UMa/RMa): 1 channel/user (1/3 LRU); 5 ms reporting period
- UL MAC Control Messages (for InH, UMi):
 - Overhead calculation based on data from UL link-level simulations (required SNR) and UL system-level simulations (UL SINR distributions)
- Long-term covariance matrix (LT-CM):
 - 1 LRU per user; 20 ms reporting period, 10% HARQ retransmission rate
 - Total LT-CM overhead of 2.75 LRUs per 5 ms frame
- H-FBCH:
 - Average number of allocations from the DL simulations
 - Each channel assumed to occupy 6 tones
- Sounding channel:
 - 2 symbols (FDD) and 1 symbol (TDD) per 5 ms frame to enable similar sounding capability for FDD and TDD
- Initial ranging (IR)-Bandwidth request (BR):
 - 4 LRUs per superframe per channel
 - Total IR+BR overhead of 2 LRUs per 5 ms frame

PCT – Step 4: Average control overhead

TDD Control Overhead

Test Environment	Downlink (%)	Uplink (%)
Indoor (InH)	9.19	7.85
Microcellular (UMi)	12.33	12.60
Base coverage Urban (UMa)	11.17	9.23
High speed (RMa)	11.15	8.34

FDD Control Overhead

Test Environment	Downlink (%)	Uplink (%)
Indoor (InH)	9.74	6.02
Microcellular (UMi)	16.28	10.58
Base coverage Urban (UMa)	13.77	8.01
High speed (RMa)	13.63	6.51

PCT – Step 5: VoIP calibration

- Calibration of MIMO transmission scheme, VoIP speech source model, persistent scheduling, dynamic overhead calculations and required DL/UL ratio for bidirectional VoIP.
- Average capacity of 295 active users/sector well aligned for DL TDD for UMi using 4x2 SFBC with non-adaptive precoding
- Calibrated DL VoIP capacity with DLRU exceeded the ITU requirement (40 users/MHz/sector), significant increase in DL VoIP capacity for NLRU
- SU-MIMO with long-term beamforming (STC rate 1) selected for DL for all test environments
- SU-MIMO with 2x4 open-loop SFBC selected for UL, average UL VoIP capacity better than DL (for both DLRU and NLRU)

PCT – Step 6: Mobility requirement

- Assumptions for the IMT-Advanced mobility requirements:
 - 10 km/h for InH, 30 km/h for UMi, 120 km/h for UMa, and 350 km/h for RMa
- Generated UL link-level and system-level simulation results
- Generated the spectral efficiency vs. SNR curves accounting for the impact of HARQ and control channel overhead link-level simulations
- Generated UL SINR distributions based on scheduled allocations from system-level simulations
 - The same power control settings as for the UL full-buffer data SLS were used
- Calculated the achieved link-level spectral efficiency corresponding to the median SINR of the UL SINR distribution.

IEEE 802.16m System Configuration for PCT

- Antenna configuration DL: 4x2 , UL : 2x4
- MIMO transmission format:
 - Full-buffer data traffic:
 - DL: MU-MIMO with adaptive switching from 1 stream to 4 streams
 - UL: MU-MIMO with adaptive switching between 1 stream and 2 stream transmissions
 - VoIP traffic:
 - DL: SU-MIMO with 1 stream transmissions
 - UL: SU-MIMO with SFBC
- Subchannelization:
 - Full-buffer data traffic:
 - DL and UL : Subband LRU (SLRU) with Transformed Codebook (T-CBK) for InH and UMi (low mobility)
 - DL and UL : Miniband LRU (NLRU) with LT-BF for UMa and RMa (medium/high mobility)
 - VoIP traffic:
 - DL: Miniband LRU with LT-BF
 - UL: DLRU (open-loop SFBC)
- Control overhead accurately modeled, dynamic modeling as required.

PCT – Step 7: Compilation of PCT results

Reference : attachment6.doc
(Summary of PCT results)

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Summary

- IEEE 802.16m supports advanced features and provides flexibility for optimized operation in all IMT-Advanced test environments.
- Representative system configuration was chosen to facilitate calibration among 16 participating entities and simplify the evaluation process.
- IEEE 802.16m self-evaluation based on extensive calibration and comprehensive link and system level simulations using the selected system configuration.
- IMT-Advanced requirements shown to be met for all test environments in the RIT self-evaluation report.
- Further performance improvement expected from higher order antenna configurations, advanced antenna techniques etc. that are supported by the IEEE 802.16m draft standard.