Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**Draft Evaluation Methodology and Key Criteria for 802.16m - Advanced Air Interface**	
Date Submitted	**2007-03-05**	
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Re:	Response to call for contributions on Evaluation Methodology and Key Criteria for P802.16m – Advanced Air Interface	
Abstract	This contribution proposes a framework for an evaluation methodology applicable to assessment of candidate technologies for the 802.16m project. A set of baseline assumptions and guiding principles are outlined, designed to form the basis for an efficient yet simple evaluation methodology and simulation environment. Further, pragmatic extensions to the proposed framework are anticipated in the period leading up to Session#49 (Portland, May 2007).	

Purpose	For review and adaptation by TGm
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Contents

1.0 Introduction

This contribution proposes a framework for an evaluation methodology applicable to assessment of candidate technologies for the 802.16m project.

A set of baseline assumptions and guiding principles are outlined, designed to form the basis for an efficient yet simple evaluation methodology and simulation environment. Further, pragmatic extensions to the proposed framework are anticipated in the period leading up to Session#49 (Portland, May 2007).

2.0 System Simulation Methodology for Unicast Operation

2.1 System Deployment Model

A system simulation summary appears in Table 1. The model is applicable to any duplexing mode proposed to form part of the 802.16m amendment.

Parameters	**Value**
Number of Sites (3 sectored)	19
Operating Frequency	2500 MHz
BS-to-BS Distance	1.5 km
Minimum Mobile-to-BS Distance	35 m
Sector Orientation	Standard 60°, 180° and 300°
Antenna Pattern	70° (-3 dB) with 20 dB front-to-back ratio
BS Height	32m
Mobile Terminal Height	1.5m
Propagation Model	COST-231 Modified Hata (suburban) model, or Erceg model
Log-Normal Shadowing Standard Deviation (σs)	8.9 dB
BS shadowing correlation	0.5
BS Thermal Noise Figure	5 dB
Mobile Terminal Noise Figure	7 dB
Thermal Noise Density	-174 dBm/Hz
BS Antenna Gain w/ cable Loss	15 dB
MS Antenna Gain	-1 dBi
Other Link Losses (e.g. Penetration Loss)	10 dB (baseline)
BS Maximum PA Power	43dBm @ 5MHz bandwidth 46dBm @ 10MHz bandwidth 49dBm @ 20MHz bandwidth and similarly scalable for other bandwidths
Mobile Terminal Maximum PA Power	200mW (23dBm)
MS Antenna Correlation	0.5
MS Antenna Imbalance	2 dB
Frequency Reuse Factor	1x3x1 and 1x3x3

Signal Bandwidth	5-20 MHz
# of BS TX/RX Antennae	2 / 2
# of MT TX/RX Antennae	1 / 2 *Note: these represent minimum configurations. Additional configurations may be proposed consistent with 802.16m requirements.*
TDD DL/UL Resource Split	62:38% (29 symbols DL and 18 symbols for UL for reference 802.16e system @10MHz)
FDD	TBD
Allocation Ratio	DL/UL symbols
Channel Estimation	Non-ideal
MS Receiver Max. SINR	*TBD*
MS Transmitter EVM	*TBD*
BS Receiver Max. SINR	*TBD*
BS Transmitter EVM	*TBD*
Link to System Mapping (PHY Abstraction)	Mutual Information (MI), EESM, ECM, or equivalent
Scheduler	Proportional Fair with QoS
DL Permutation (Reference System)	PUSC/AMC
UL Permutation (Reference System)	PUSC/AMC
Reference BS/MS Receiver	Mode-specific – *TBD*
Data Traffic	Full buffer/VoIP/Traffic Mix
User Distribution	Spatially uniform. *Note: Unicast results shall be based on an average population of 10 users in the reference ('test') sector. 20 users may be specified for enhancement techniques.*
Multi-Cell Interference Modeling	Explicit (including MIMO channel effects)

Table 1 – Simulation environment summary.

2.2 Path Loss Model

The proposed path loss model is based on the well known COST-231 modified Hata model for systems supporting carrier frequencies less than or equal to 2.5GHz. The Erceg-Greenstein model [2] may also be used for carrier frequencies up to 3.5GHz. Path loss models applicable to carrier frequencies above 3.5GHz are for further study. Other potential path loss models that could be used are available in [5].

The site-to-site distance used in the simulation should be based on a path loss model and a link budget which closes for both uplink and downlink, and this is reflected in the proposed value of Table 1. As an example, the COST-231 modified Hata model (suburban mode) at 2.0GHz (L=126.2+36log10(R)) may be used when simulating the reference 802.16m system with carrier frequency of 2.5GHz.

2.3 Spatial Channel Model

Modeling of fast fading (i.e. time and frequency-dispersive fading, including spatial correlation effects), could be based on the models originally applicable to ITU IMT-2000 (i.e. Vehicular

A/B, Pedestrian A/B) assessment. Alternatively, mature spatial channel models – such as the Spatial Channel Model (SCM [3]), or extensions thereof (e.g. SCM-E) and WINNER [5] could also be applied. In order to simplify modeling the spatial channel in a system simulation, however, the fast fading channel matrix can also be generated by

$$\mathbf{H}(t,\tau) = \mathbf{Q}_r \hat{\mathbf{H}}(t,\tau) \mathbf{Q}_t^T \quad (1)$$

where $\mathbf{Q}_r$ and $\mathbf{Q}_t$ are the square roots of the transmit and receive antenna correlation matrices respectively. Simplified methods for computing $\mathbf{Q}_r$ and $\mathbf{Q}_t$ can be used and are for further study. $\hat{\mathbf{H}}(t,\tau)$ is a temporal fading matrix where each element of $\hat{\mathbf{H}}(t,\tau)$ corresponds to a independent Rayleigh fading process.

2.4 Traffic Model and Reference Codecs

Data traffic modeling for both the WiMAX Release-1 reference system and systems conformant to 802.16m should include at least the following models:

a) file transfer (FTP)
b) web browsing (HTTP)
c) speech source (VoIP)
d) near real time video (NRTV)
e) gaming

The complete specification of each model – including activity characteristics, object sizes, read times etc.) is for further study.

In certain cases, such as VoIP, traffic overhead attributable to upper layer protocols (such as IP, UDP, RTP and including header compression) can be significant and should be defined. This is for further study. In addition, specific linkage to data rates associated with reference multimedia codecs (such as AMR-NB codecs in the case of VoIP and H.264/AAC+ combinations in the case of 'mobile TV' applications) may be included.

3.0 Performance Evaluation Cases and Metrics

Performance evaluation shall be based primarily on [4], and shall focus on:

a) a reference system assessment based primarily on peak rate analysis
b) a full queue (buffer) analysis focused on area rate coverage and spectral efficiency
c) a realistic traffic model analysis, similar to b) but based on more complex source traffic models

In all cases overhead (control channels, pilots, guard interval, …) shall be estimated and included in performance assessments.

3.1 Reference System Performance Assessment

The achievable downlink and uplink peak rates as a function of system bandwidth and MIMO configuration.

3.2 Full Queue System Performance Assessment

The objective of full queue system evaluation is to assess 802.16m performance compared to the reference system in terms of throughput and spectrum efficiency. All metrics shall be provided in terms of both absolute performance and performance gain relative to the WiMAX Release-1 reference system.

System performance evaluation shall be based on Table 1, assuming a realistic load on interfering cells. At least the full-load case shall be assessed. Other cases are for further study.

The performance metrics summarized in Table 2 shall be reported.

Metric	Units	Comment
Cell Throughput	bits/s/cell	Mean sector throughput.
Cell Spectrum Efficiency	bits/s/Hz/cell	Mean sector throughput per unit bandwidth.
User Throughput	bits/s/user	Mean user session throughput.
User Spectrum Efficiency	bits/s/Hz/user	Mean user session throughput per unit bandwidth.
5%-tile User Throughput	bits/s/user	5%-ile user session throughput.
5%-tile User Spectrum Efficiency	bits/s/Hz/user	5%-ile user session throughput per unit bandwidth.
Maximum no. Satisfied VoIP Users	Users	Number of users must be satisfied in both downlink and uplink and meet a TBD delay with a specified outage criterion. As a baseline assumption, bundling of VoIP packets shall not be assumed, but results including bundling may be provided.

Table 2 – Performance metric summary.

The supporting information listed in Table 3 shall be provided in order to calibrate results reported by different sources.

Metric	Units	Comment
User throughput CDF normalized by the average user throughput.	CDF (kbps)	Data shall be provided at least for the 10 user case.
For downlink: CDF of user SINR's (i.e. serving cell to sum of interfering cell power)	CDF (dB)	

For uplink: CDF of user interference over thermal noise.	CDF (dB)	Depends on power control scheme.

Table 3 – Supporting data summary.

3.3 Realistic Traffic Model Performance Assessment

Simulations with the realistic traffic models listed in Section 2.4 shall be provided in order to fully assess 802.16m performance under typical traffic and load conditions. System performance shall be evaluated using the traffic mixes defined in Table 4.

Simulation Scenarios	% Full Buffer users	% FTP users	% HTTP users	% NRTV users	% VoIP users	% Gaming users
1 (DL/UL)	100					
2 (DL)		10	20	20	30	20
3 (DL/UL)					100	

Table 4 – Traffic mix and mobility summary.

4.0 System Simulation Methodology for Enhanced Multicast Broadcast (E-MBS) Operation

The system simulation assumptions listed in Table 1 shall also be applied to E-MBS evaluation, with the following additional considerations:

1. **Simulcasting Mode**: all sectors (cells) of each of the 19 sites comprising the simulated system shall be assumed to operate in a multicast broadcast single frequency network (MBSFN) mode
    a. Ideal inter-cell time and frequency synchronization shall be assumed.
    b. MBS Site Locations: sites contributing to the MBSFN shall be co-located with the sites specified for unicast operation.
    c. Models applicable to enhanced broadcast modes optimized for single-cell or limited-cell operation may be specified in future, but this for further study.
2. **Dedicated Carrier Mode**: dedicated carrier mode operation may be assessed as part of the study, but the total radiated power level and base station antenna height shall conform to that specified for unicast system deployment (i.e. Table 1 above).
    a. Further dedicated E-MBS deployment modes may be defined, but this is for further study.
3. **Coverage Area**: the coverage area of the E-MBS system shall correspond to the nominal (hexagonal cell geometric) coverage area of the center site and the first tier of sites (i.e. a total of 7 sites).
4. **Traffic Definition**:

   a. A single 'infinite queue' MBS stream shall be applied.
      i. Multimedia codec packetization (e.g. NAL abstraction, codec profile specific modes etc.) and MBS MAC PDU modeling and packing shall not be applied.
   b. In addition, the further enhanced MBS traffic models are for further study.

5. **Packet Error Rate (PER) Definition**:
   a. Outer coding shall not be applied in the simulation. Rather, an MBS packet shall be considered in error if any of the component inner codewords are in error.
6. **Outage and Performance Criteria**:
   a. A location within the coverage area shall be considered to be 'in outage' if the simulated long-term PER associated with the location exceeds 1%.
   b. The operational spectral efficiency is defined as the spectral efficiency (bps/Hz) at which an area outage of 95% is observed.
      i. Applicable overheads consistent with e.g. TDD frame split, pilot symbols etc. consistent with Table 1 shall be included in the spectral efficiency computation.
7. **MIMO and Layering**
   a. A single stream shall be assumed, without codec layering for the reference system.
      i. Layering and MIMO modes applicable to enhanced operation may be specified in future, but are for further study.

5.0 References

[1] IEEE 802.16m-007/002r1, "Draft IEEE 802.16m Requirements"

[2] V. Erceg, et al., "Channel Models for Fixed Wireless Applications. IEEE 802.16 Broadband Wireless Working Group, July 2001

[3] 3GPP TR 25.996, Spatial channel model for Multiple Input Multiple Output (MIMO) Simulations

[4] R1-070674, "LTE physical layer framework for performance verification", Orange *et.al*, RAN1#48, Feb. 2007

[5] IST-WINNER II Deliverable D1.1.1 v1.0, "WINNER II Interim Channel Models", December 2006.