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Re:	Call for contributions IEEE 802.16e-03/02: Call for Proposals on IEEE Project 802.16e: Mobility Enhancements to IEEE Standard 802.16/802.16a
Abstract	Simulations for cell size, capacity in cellular deployment, etc.
Purpose	To emphasize the differences between FWA and mobile systems
Notice	
Release	
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System level performance - simulations results for C802.16e-03_12

OFDM FFT-256 mode

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Alvarion

1. Introduction

This paper presents simulation results, for system related proposal evaluation criteria [1]. These simulations address:
Cell sizes
Coverage and efficiency in cellular deployment
Solution for up-link interference reduction
Solution for down-link interference reduction
Impact of introduction of the mobile service on fixed subscribers.

2. Cell Sizes

2.1. Pedestrian radio environment

The cell size has been calculated according to assumptions mentioned by PE8.

5MHz System/direction	**UL Pedestrian**	**UL Pedestrian**	**UL Pedestrian**	**DL Pedestrian**
Frequency (MHz)	2600	2600	2600	2600
BS height (m)	15	15	15	15
SU height (m)	1.5	1.5	1.5	1.5
Wall penetration (dB)	0	0	0	0
Sub-channel number	**24.0**	**12.0**	**6.0**	**1.0**
OFDMA gain	13.8	10.8	7.8	0.0
Tx power [dBm]	17	17	17	36
Tx antenna cable loss [dB]				
Tx Antenna Gain [dB]	0	0	0	17
Rx antenna gain [dB]	17	17	17	0
Rx antenna cable loss [dB]				
Rx Noise figure [dB]	4	4	4	4
Rx noise Bandwidth [MHz]	5	5	5	5
Rx noise power [dBm]	-103.0	-103.0	-103.0	-103.0
SNR at max rate	24.4	24.4	24.4	24.4
Sensitivity at max rate	-78.6	-78.6	-78.6	-78.6
SNR at med rate (16QAM 3/4)	18.2	18.2	18.2	18.2
Sensitivity at med rate	-84.8	-84.8	-84.8	-84.8
SNR at min rate(QPSK 1/2)	9.4	9.4	9.4	9.4
Sensitivity at min rate	-93.6	-93.6	-93.6	-93.6
System gain at max rate	126.4	123.4	120.4	131.6
System gain at med rate	132.6	129.6	126.6	137.8
System gain at min rate	141.4	138.4	135.4	146.6
Supplementary Fade Margin (antenn	13.0	13.0	13.0	13.0
Range[Km]				
Stanford, sub-urban terrain B (hilly intermediate)				
NLOS Range[Km] @max rate	0.61	0.51	0.43	0.83
NLOS Range[Km] @med rate	0.88	0.74	0.62	1.19
NLOS Range[Km] @min rate	**1.48**	1.24	1.04	**2.01**

The maximum cell size is obtained for the minimum rate. The cell size is limited by the up-link, and a high UL sub-channel number is critical for obtaining maximum cell sizes.

2.2. Outdoor to indoor radio environment

The cell size has been calculated according to assumptions mentioned by PE8.

5MHz System/direction	UL Outdoor-to	UL Outdoor-to	UL Outdoor-to-indoor	DL
Frequency (MHz)	2600	2600	2600	2600
BS height (m)	15	15	15	15
SU height (m)	1.5	1.5	1.5	1.5
Wall penetration (dB)	20	20	20	20
Sub-channel number	**24.0**	**12.0**	**6.0**	**1.0**
OFDMA gain	13.8	10.8	7.8	0.0
Tx power [dBm]	20	20	20	36
Tx antenna cable loss [dB]				
Tx Antenna Gain [dB]	0	0	0	17
Rx antenna gain [dB]	17	17	17	0
Rx antenna cable loss [dB]				
Rx Noise figure [dB]	4	4	4	4
Rx noise Bandwidth [MHz]	5	5	5	5
Rx noise power [dBm]	-103.0	-103.0	-103.0	-103.0
SNR at max rate	24.4	24.4	24.4	24.4
Sensitivity at max rate	-78.6	-78.6	-78.6	-78.6
SNR at med rate (16QAM 3/4)	18.2	18.2	18.2	18.2
Sensitivity at med rate	-84.8	-84.8	-84.8	-84.8
SNR at min rate(QPSK 1/2)	9.4	9.4	9.4	9.4
Sensitivity at min rate	-93.6	-93.6	-93.6	-93.6
System gain at max rate	126.4	123.4	120.4	131.6
System gain at med rate	132.6	129.6	126.6	137.8
System gain at min rate	141.4	138.4	135.4	146.6
Supplementary Fade Margin (antenn	24.0	24.0	24.0	24.0
Range[Km]				
Stanford, sub-urban terrain B (hilly intermediate)				
NLOS Range[Km] @max rate	0.32	0.27	0.22	0.43
NLOS Range[Km] @med rate	0.46	0.38	0.32	0.62
NLOS Range[Km] @min rate	**0.77**	0.65	0.54	**1.05**

The cell size is once again limited by the up-link. 24 sub-channels still give a up-link cell size lower than the down-link cell size.

2.3. Vehicular, high antenna radio environment

The cell size has been calculated according to assumptions mentioned by PE9.

5MHz System/direction	**UL Vehicular**	**UL Vehicular**	**UL Vehicular**	**DL Vehicular**
Frequency (MHz)	2600	2600	2600	2600
BS height (m)	30	30	30	30
SU height (m)	1.5	1.5	1.5	1.5
Wall penetration (dB)	15	15	15	15
Sub-channel number	**24.0**	**12.0**	**6.0**	**1.0**
OFDMA gain	13.8	10.8	7.8	0.0
Tx power [dBm]	27	27	27	46
Tx antenna cable loss [dB]				
Tx Antenna Gain [dB]	3	3	3	17
Rx antenna gain [dB]	17	17	17	3
Rx antenna cable loss [dB]				
Rx Noise figure [dB]	4	4	4	4
Rx noise Bandwidth [MHz]	5	5	5	5
Rx noise power [dBm]	-103.0	-103.0	-103.0	-103.0
SNR at max rate	24.4	24.4	24.4	24.4
Sensitivity at max rate	-78.6	-78.6	-78.6	-78.6
SNR at med rate (16QAM 3/4)	18.2	18.2	18.2	18.2
Sensitivity at med rate	-84.8	-84.8	-84.8	-84.8
SNR at min rate(QPSK 1/2)	9.4	9.4	9.4	9.4
Sensitivity at min rate	-93.6	-93.6	-93.6	-93.6
System gain at max rate	139.4	136.4	133.4	144.6
System gain at med rate	145.6	142.6	139.6	150.8
System gain at min rate	154.4	151.4	148.4	159.6
Supplementary Fade Margin (antenna	13.0	13.0	13.0	13.0
Range[Km]				
Stanford, sub-urban terrain B (hilly intermediate)				
NLOS Range[Km] @max rate	1.40	1.17	0.97	1.92
NLOS Range[Km] @med rate	2.04	1.70	1.42	2.80
NLOS Range[Km] @min rate	**3.48**	2.90	2.41	**4.76**

2.4. Cell radius – conclusions

The following table summarizes the cell radius conclusions, PE8 and PE9:

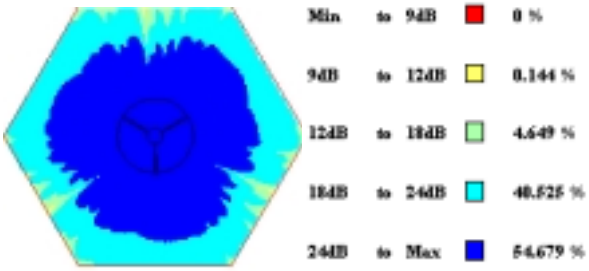
	DL	UL – 6 sub-channels	UL-12 sub-channels	UL – 24 sub-channels
Pedestrian	2km	1km	1.2km	1.5km
Outdoor to indoor	1.05km	0.54km	0.65km	0.77km
Vehicular, high antenna	4.7Km	2.9km	2.4km	3.5km

3. Single cell deployment scenario

The next simulation shows the coverage percentage for different modulation states, according to PE 17.

3.1. Down-link, 4km

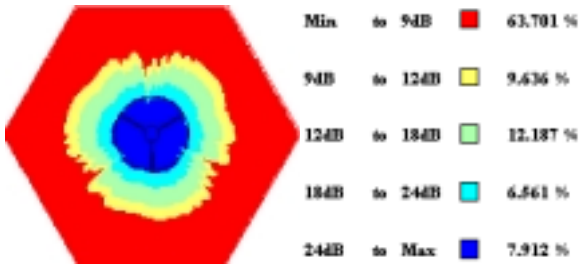
The down-link coverage percentage is shown in the next figure.



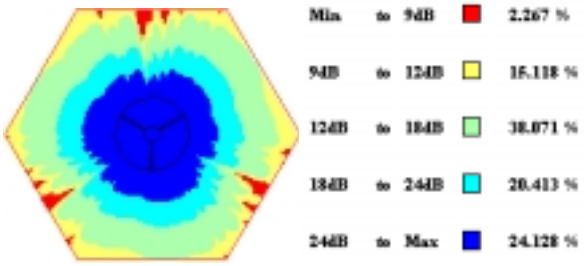
3.2. Up-link, 4km

The up-link coverage depends on up-link OFDMA gain, as shown below:

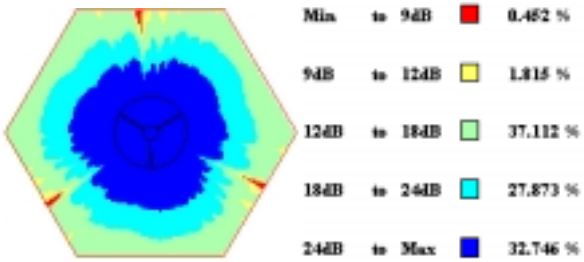
No UL OFDMA



12 OFDMA sub-channels



24 OFDMA sub-channels



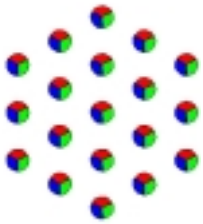
3.3. Single cell deployment – conclusions

The following table summarizes the performance in single cell deployment according to PE17.

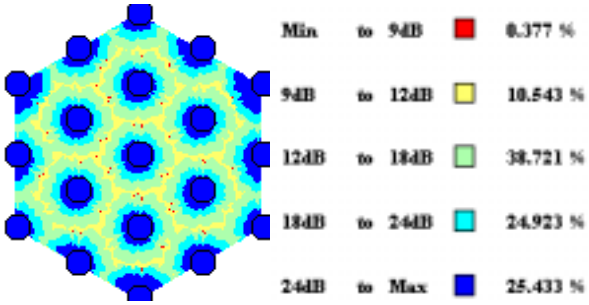
	DL	**UL-12 sub-channels**	**UL – 24 sub-channels**
Average data rate	13.5Mb/s	7.2Mb/s	9Mb/s
Average spectral efficiency (bit/s/Hz/sector)	2.7	1.4	1.8

4. Multi-cell cell deployment scenario

The next simulation shows the coverage percentage for different modulation states, according to PE 18.
The deployment scenario (3 channels, 3 sectors) and frequency allocation is shown below:

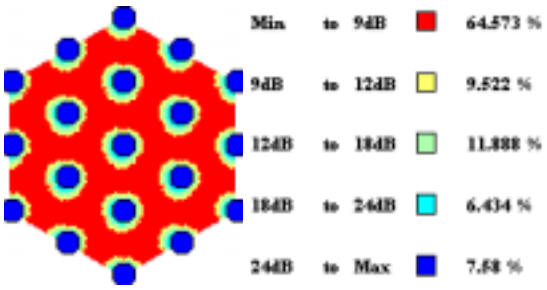


4.1. Down-link, 4km

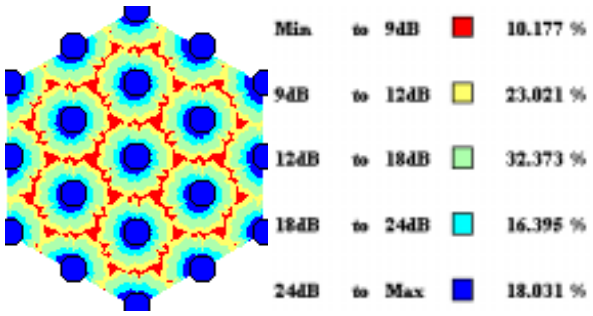


4.2. Up-link, 4km

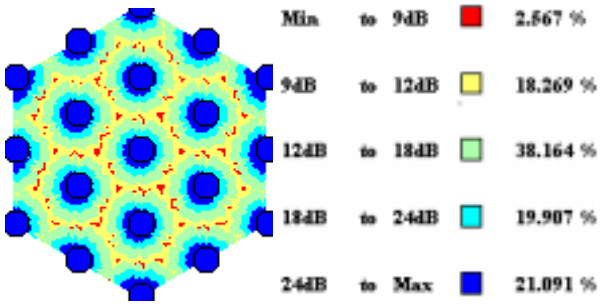
No UL OFDMA



12 UL OFDMA sub-channels



24 UL OFDMA sub-channels



4.3. Multi cell deployment – conclusions

The following table summarizes the performance in single cell deployment according to PE18.

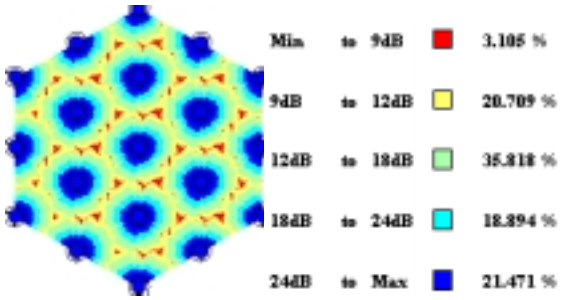
	DL	**UL-12 sub-channels**	**UL – 24 sub-channels**
Average data rate	7.7Mb/s	6.5Mb/s	6.9Mb/s
Average spectral efficiency (bit/s/Hz/sector)	1.5	1.3	1.4

5. Inter-cell interference reduction

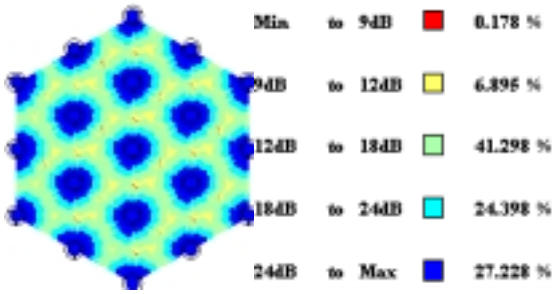
5.1. Solution for up-link

The proposed solution, in response to PE11, is to split the up-link sub-channels into 2 orthogonal groups, and to distribute the resulted 6 groups according to the following cellular deployment:

12 UL OFDMA sub-channels

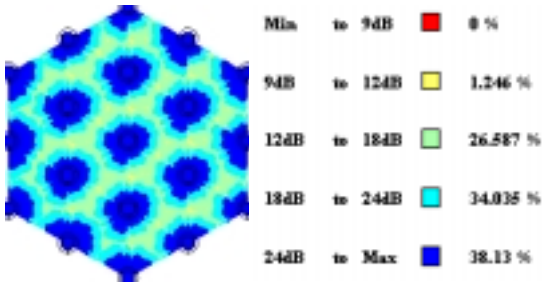


24 UL OFDMA sub-channels



5.2. Solution for down-link

Same channel splitting in two groups has been checked.



5.3. Conclusion – inter-cell interference reduction

The interference effect is improved by bandwidth splitting; nevertheless the bit rate is divided by two, and the improvement due to interference reduction is relatively small, compared with the rate reduction.

This makes the BW splitting solution not attractive.

6. Impact of introduction of the mobile service on fixed subscribers

The mobile users will have generally omni-directional antennae, which create UL inter-cell interference.
This interference can affect the fixed users, if the mobile users will transmit in UL in the same time with fixed users, by reducing their S(N+I) ratio and lowering their UL data rates. In order to eliminate this interference, the Base Stations should synchronize their UL transmissions.

Bibliography

[1] IEEE802.16e-03/02: Call for Proposals on IEEE Project 802.16e: Mobility Enhancements to IEEE Standard 802.16/802.16a.