

OFDM (FFT 256) Fixed & Mobile System Considerations

Document Number:

IEEE S802.16e-03/07

Date Submitted: 2003-01-15

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21a HaBarzel Street, Tel Aviv, Israel

Venue:

Meeting 24, 13-16 Jan, 2003

Base Document:

Purpose:

Explain authors view on fix-mobile convergence and backward compatibility issues

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OFDM (FFT 256) Fixed & Mobile System Considerations

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Scope

- Identify the differences between the fixed and mobile environment
- Propose requirements for the 802.16e system, including target devices and data rates
- Propose deployment models
- Propose impulse response models

Regulatory requirements

- Channel spacing:
 - 1.25MHz..10MHz
 - Focus: 3.5MHz - 5MHz
- Both FDD and TDD

Operating environments

- **3GPP** (ETSI TR 101 112)has defined the following operating environments:
 - **Indoor environment** – served by **pico-cell**, indoor Base Station;
 - **Outdoor-to-indoor and pedestrian** – served by **micro-cell**;
 - **Vehicular and high antenna** – served by **macro-cell**;
 - **Mixed** - macro-cells overlaying micro-cells.
- The macro/micro/pico cell definition is:
 - Pico - cell hex radius $(r) < 100$ m;
 - Micro - $100 \text{ m} < (r) < 1000$ m;
 - Macro - $(r) > 1000$ m.

Indoor environment

- Indoor pico-cells
 - A lognormal shadow fading, standard deviation (sigma) of 12 dB
 - Both Rayleigh and Rician fading
 - Walking speed Doppler
- Indoor equipment should be similar to WLAN solution (low cost BS)
 - OFDM UL –OFDM DL
 - Target devices: PDA, Laptop with PCMCIA cards, Phones

Outdoor to Indoor and Pedestrian Environment

- Log-normal shadow fading with a standard deviation of 10 dB is reasonable for outdoors and 12 dB for indoor.
- Building penetration loss averages 12 dB with a standard deviation of 8 dB.
- Symmetrical traffic applications expected (e-mail, file exchange)
- Target devices: PDA, Laptops with PCMCIA cards, Phones, embedded antenna (0dBi)
 - UL OFDMA is necessary
 - Needed gain: 15dB (BS Power: 30dBm, PCMCIA card power: 14-17?dBm)

Vehicular and High Antenna Environment

- **larger cells and higher transmit power.**
- “Log-normal shadow fading with 10 dB standard deviation are appropriate in urban and suburban areas.” ETSI TR 101 112
- Full Doppler profile for vehicular speeds
- Target devices: PDA, Laptops, phones
- Stronger UL OFDMA need:
 - BS power: 10W (with 3G also 20W-40W)
 - At cell margin UL data rate will be lower

Mixed Environment

- a “vehicular environment” (macro cells) and an “outdoor to indoor environment” (micro cells) in the same geographical area.
 - fast moving terminals (vehicles) should probably be connected to the macro cells to reduce the handoff rate (number of hand-offs per minute)
 - slow moving terminals (pedestrians) should be connected to the micro cells to achieve high capacity

Repeater cells

- The **repeater-cells** are cells created by Repeaters, being possible in both **indoor** and **out-door** environment.
- The Repeater should be based on a SU solution, to allow for low-cost (symmetrical SU-AU solution). Only one stream should be used in UL or DL.

Path-loss models

- The “mobile” models are defined for freq $< 2\text{GHz}$
- Stanford model is:
 - Frequency scalable
 - Takes into consideration antenna height
 - Can be used in Rural and Suburban
 - **Still needed an urban path-loss model**
- 802.16e should chose:
 - a propagation model
 - values for shadowing standard deviation
 - Outdoor-to-indoor penetration loss
 - Wall loss

Channel Impulse Response Models

- ITU-R, 3GPP and ETSI: same models
- One tapped-delay model for each radio environment (3 models)
 - Up to 2 multi-path channels (A and B), with Doppler
 - Worst-case included
 - Long delay spread
 - Occur infrequently
- Design and evaluation focus:
 - Up to 70km/h
 - Indoor environment(A and B)
 - Outdoor-to-indoor and pedestrian (A and B)
 - Vehicular and high-antenna (only A)
- Informative performance
 - 120km/h and 250km/h
 - Vehicular and high antenna – (A and B)

The high antenna and vehicular model

- For indoor and pedestrian – see document C 80216e_03/07
 - (max delay: 3.9us, at -24dB)
- Vehicular and high antenna is:

Tap	Channel A		Channel B		Doppler Spectrum
	Rel. Delay (nsec)	Avg. Power (dB)	Rel. Delay (nsec)	Avg. Power (dB)	
1	0	0.0	0	-2.5	CLASSIC
2	310	-1.0	300	0	CLASSIC
3	710	-9.0	8900	-12.8	CLASSIC
4	1090	-10.0	12900	-10.0	CLASSIC
5	1730	-15.0	17100	-25.2	CLASSIC
6	2510	-20.0	20000	-16.0	CLASSIC

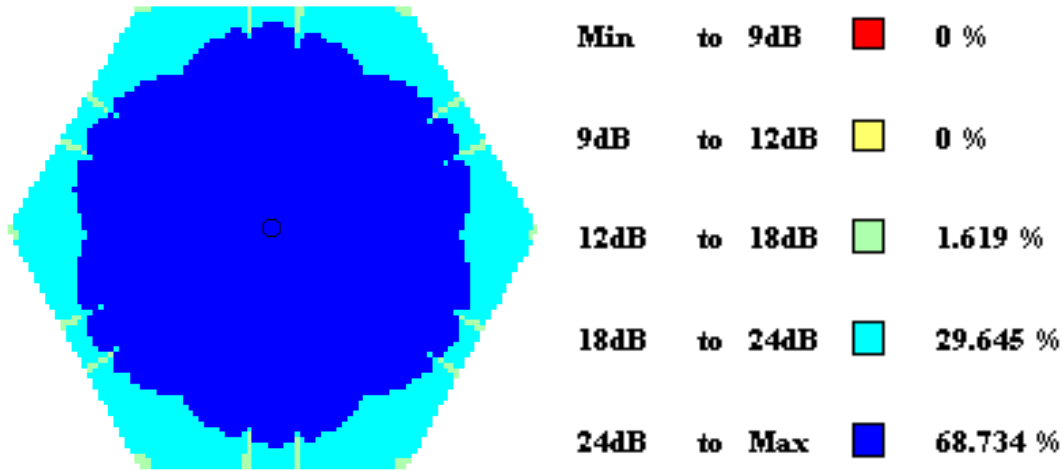
FWA versus mobile deployment

- Subscriber antenna
 - 0dB gain in indoor/pedestrian and 6-10dB if car mounted, instead of 8-20dB gain
 - No front to back isolation
- UL Tx power:
 - 14 – 17? dBm instead of > 20 dBm
- 4..6 frequency channels, instead of 1..3 channels

Cellular deployment simulation

- Scope: study interference limitations in DL
- Stanford B, shadowing margin of 10dB
- 3.5GHz, 3.5MHz
- Base Station antenna:
 - 35m, 4degree tilt
 - Gain of 14/ 17dBi, 120 /60 degrees beam width
- Subscriber antenna
 - 1m, 0dB gain, 360 degree

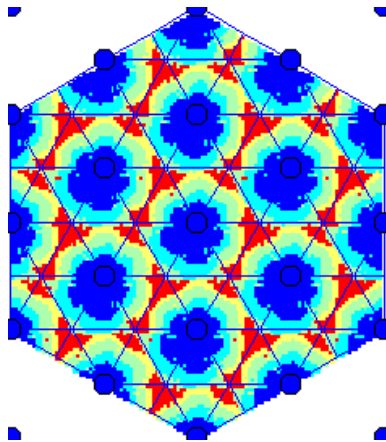
Single cell, 6 sectors, 6 channels



$T_x=10W$

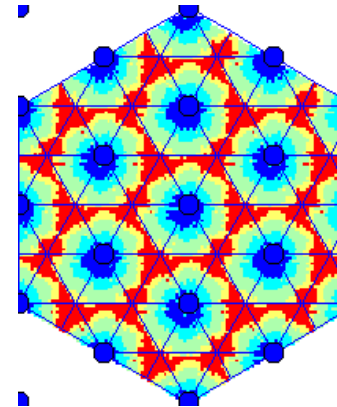
- Average data rate: 61.2Mb/s
- Spectral efficiency: 2.9bit/s/Hz

Multi-cell with mobile SS, 6 sectors, 6 channels



$T_x=10W$

Min	to 9dB	■	14.11 %
9dB	to 12dB	■	12.207 %
12dB	to 18dB	■	23.31 %
18dB	to 24dB	■	22.633 %
24dB	to Max	■	27.737 %



$T_x=1W$

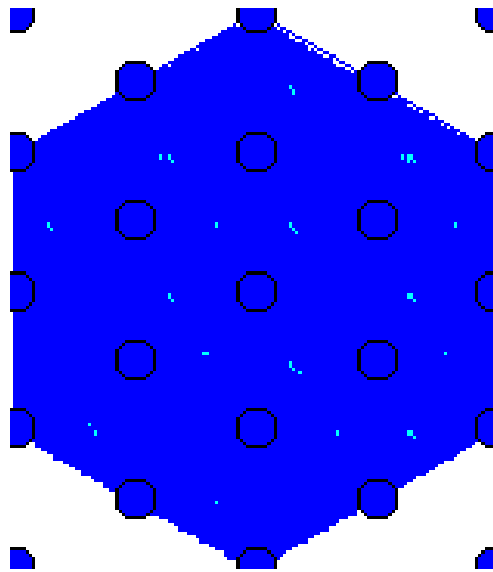
Min	to 9dB	■	24.076 %
9dB	to 12dB	■	17.505 %
12dB	to 18dB	■	30.309 %
18dB	to 24dB	■	17.182 %
24dB	to Max	■	10.925 %

Multi-cell with mobile SS

- 6 sectors, 6 channels
 - 28% of the covered area will work at high rates, at $T_x=1$
 - 50% of the covered area will operate at high rate at $T_x=10W$:
 - Capacity: 30Mb/s
 - Spectral efficiency: 1.4 bit/s/Hz/cell
- 6 sectors, 3 channels
 - Capacity: 24.6Mb/s
 - Spectral efficiency: 2.3 bit/s/Hz/cell
- 3 sectors, 3 channels
 - Capacity: 15Mb/s
 - Spectral efficiency: 1.4bit/s/Hz./cell

Multi-cell with FWA subscriber

- Antenna gain: 17dBm
- 1W DL transmitted power



Min	to	9dB		0 %
9dB	to	12dB		0 %
12dB	to	18dB		0 %
18dB	to	24dB		0.395 %
24dB	to	Max		99.604 %

Interference reduction

- How to resolve the interference problem?
 - Larger number of narrower channels
 - Lower peak-rate
 - Careful cellular planning
 - DL OFDMA
 - Lower peak-rate
 - Higher implementation complexity
 - Issue for further study and discussion
 - UL OFDMA
 - Lower peak rates are not a problem with asymmetrical traffic
 - Lower implementation complexity

Optimum number of frequency channels

- The most spectrum demanding situation is mixed deployment
 - 3 channels for macro-cell
 - 3 channels for micro-cell
 - 1 channel for isolation
- The best cell spectral efficiency is obtained with 6 channels
- Conclusion: 7 channels will fulfill all the situations

Combined FWA and Mobile deployment

- Alvarion view:
 - same MAC frame shall include 2 burst profiles, fixed and mobile
 - Each burst profile will include its own MAP
 - details in the submission: “**Co-existence of Fixed and Mobile Services**” – C80216e_03/02

Mobile Services

- Multimedia streaming;
- Browsing;
- E-mail;
- Games;
- Video conference;
- Voice.

Traffic and delays

	Max. DL	Min. DL	Max. UL	Min. UL	Max. Delay
IP Streaming	1.5Mb/s	128kb/s	384kb/s	32kb/s	300ms
Internet	6Mb/s	128kb/s	1.5kb/s	32kb/s	See [1],sec.1.2.2
E-mail	1.5Mb/s	64kb/s	1.5Kb/s	32kb/s	See [1],sec.1.2.2
Games	1.5Mb/s	384kb/s	384kb/s		50ms
Video-conf	384kb/s	32kb/s	384kb/s	32kb/s	50ms
IP Voice	40kb/s	12kb/s	40kb/s	12kb/s	50ms

Traffic and Delays – we need an 802.16e common view

- Maximum DL / user?
- Minimum DL / user?

- Maximum UL / user?
- Minimum UL / user?

- Relation between channel size and traffic requirements?

QoS – ITU-R/3GPP view

- Mobile IP services, QoS classes:
 - Conversational class (real time reach media conversation);
 - Streaming class (relaxed delay requirements);
 - Interactive class (e.g. WEB browsing);
 - Background class (e.g. e-mail).
- Should we improve 802.16 MAC? Fast ARQ needed?

Power saving support

- Add the power saving (sleeping) related messages
- Define the power control at wake-up
- Define the ranging at wake-up
- Define suitable OFDMA UL:
 - Low PAPR

How to move fast towards a good solution?

- Define 802.16e requirements
 - this meeting
- Define parameters for simulations, as needed for PHY/MAC proposal evaluation
 - this meeting
- After all the contribution presentations, discuss the participants views on possible PHY/MAC changes
- Work in teleconferences between meetings