Downlink and Uplink Channel Modeling in OFDM/A system

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Introduction

- **Problem statement**
  - **SINR models of a MS can be different between downlink and uplink channels in OFDM/A system**
    - Downlink and uplink interference models are asynchronous
  - **Downlink and uplink service requirements can be quite different in the next generation communications systems**

- **Objective**
  - **Mathematical channel models for OFDM/A system are required to guarantee the required QoS level or link quality**
  - **We introduce downlink and uplink channel models of OFDM/A system**
    - Using geometrical method
    - Taking into consideration inter-cell interferences

Assumption

- System model of IEEE 802.16e
- One-tier cell structure
- Large-scale fading
  - Propagation loss and shadowing
- Uniformly distributed mobile stations
- Frequency reuse of one
- No intra-cell interference
- Maximum power transmission from each BS and MS

Propagation loss

Probability density functions for R_1, R_2 and R_2

$$f_{R_1}(r) = \frac{2r}{r_e^2}$$

$$f_{R_2}(r) \square \frac{r\phi}{\pi r_e^2} \square \frac{2x}{\pi r_e^2}$$

$$f_{R_3}(r) \square \frac{2r}{(r_e + d)^2 - (d/2)^2}$$

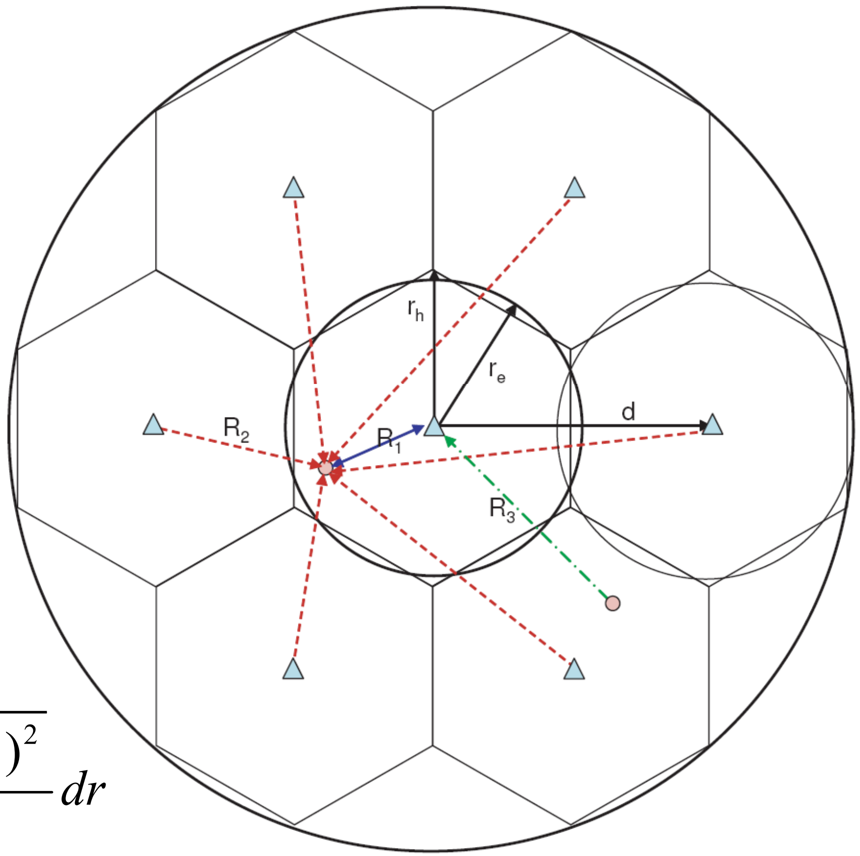


Fig 1. One inner cell and six outer cells

Expectations of γ -th moment

$$E\left[r_{b\leftrightarrow m}^{-\gamma}\right] = \int_{\varepsilon}^{r_e} \frac{2r^{-r+1}}{r_e^2} dr$$

$$E\left[r_{z\leftrightarrow m}^{-\gamma}\right] = \int_{d-r_e}^{d+r_e} \frac{r^{-\gamma}}{\pi \square r_e^2} \square \frac{\sqrt{4d^2 r_e^2 - (d^2 + r_e^2 - r^2)^2}}{d^2} dr$$

$$E\left[r_{b\leftrightarrow n}^{-\gamma}\right] = \int_{d/2}^{d+r_e} \frac{2r^{-\gamma+1}}{(r_e + d)^2 - (d/2)^2} dr$$

Shadowing

- **Expectation of log-normally distributed random variable**
  - **Mean of** $m_\zeta = 0$
  - **Variance of** σ_ζ^2

$$E\left[10^{-\zeta_{b\leftrightarrow m}/10}\right]=10^{-m_{\zeta_{b\leftrightarrow m}}/10}\cdot\exp\left\{\frac{\left(\frac{\ln 10}{10}\sigma_{\zeta_{z->m}}\right)^2}{2}\right\}$$

$$=\exp\left\{\frac{\left(\frac{\ln 10}{10}\sigma_{\zeta_{z->m}}\right)^2}{2}\right\}$$

Downlink SINR

Downlink signal to interference and noise ratio

$$\Gamma^{(r)}_{b->m} = \left[P^{(t)}_{\max,BS} \cdot \overline{\alpha} \cdot \int_{\varepsilon}^{r_e} \frac{2r^{-\gamma+1}}{r_e^{2}} dr \cdot \exp\left\{ \frac{\left(\frac{\ln 10}{10} \sigma_{\zeta_{z->m}} \right)^2}{2} \right\} \right]$$

$$/ \left[\frac{P^{(t)}_{\max,BS} \cdot 6 \cdot \overline{M} \cdot \overline{\alpha}^{2} \cdot \theta}{360^{o}} \cdot \int_{d-r_e}^{d+r_e} \frac{r^{-\gamma}}{\pi \cdot r_e^{2}} \cdot \frac{\sqrt{4d^2 r_e^2 - (d^2 + r_e^2 - r^2)^2}}{d^2} dr \cdot \exp\left\{ \frac{\left(\frac{\ln 10}{10} \sigma_{\zeta_{z->m}} \right)^2}{2} \right\} + N_o \right]$$

$P^{(t)}_{\max,BS}$: *Maximum BS transmission power*

$\overline{\alpha}$: *Downlink mean resource allocation ratio*

$\overline{M}$: *Average number of active MSs in a cell*

Uplink SINR

Uplink signal to interference and noise ratio

$$\Gamma^{(r)}_{b->m} = \left[P^{(t)}_{\max,BS} \cdot \overline{\beta} \cdot \int_{\varepsilon}^{r_e} \frac{2r^{-\gamma+1}}{r_e^{2}} dr \cdot \exp\left\{ \frac{\left(\frac{\ln 10}{10}\sigma_{\zeta_{z->m}}\right)^2}{2} \right\} \right]$$

$$/ \left[\frac{P^{(t)}_{\max,BS} \cdot 6 \cdot \overline{M} \cdot \overline{\beta}^{2} \cdot \theta}{360^{o}} \cdot \int_{d/2}^{d+r_e} \frac{2r^{-\gamma+1}}{(r_e + d)^2 - (d/2)^2} dr \cdot \exp\left\{ \frac{\left(\frac{\ln 10}{10}\sigma_{\zeta_{z->m}}\right)^2}{2} \right\} + N_o \right]$$

$P^{(t)}_{\max,MS}$: *Maximum MS transmission power*

$\overline{\beta}$: *Uplink mean resource allocation ratio*

$\overline{M}$: *Average number of active MSs in a cell*

Parameters for numerical example

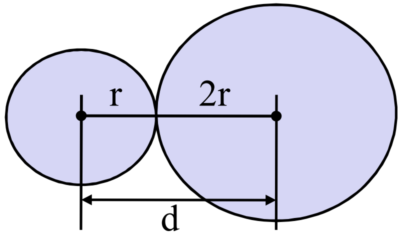
Parameter	Symbol	Value
Downlink mean resource allocation ratio	$\bar{\alpha}$	0.01
Uplink mean resource allocation ratio	$\bar{\beta}$	0.01
Power spectral density of additive white Gaussian noise	N_o	-174[dBm]
Transmission antenna main lobe width	θ	120°
Maximum MS transmission power	$P_{\max,MS}$	30[dBm]
Maximum BS transmission power	$P_{\max,BS}$	42[dBm]
Shadowing variance	σ_{ζ}	8[dB]
Minimum distance between an MS and a BS	ε	10[m]
Propagation loss factor	γ	4
Number of active MSs in a cell	$\bar{M}$	100

Numerical results (1/2)

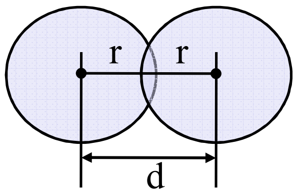
Case 1

A reversal of UL & DL SINR by distance of BSs

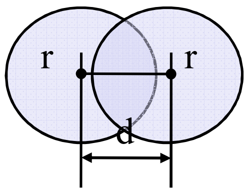
- Star mark(d=3r)

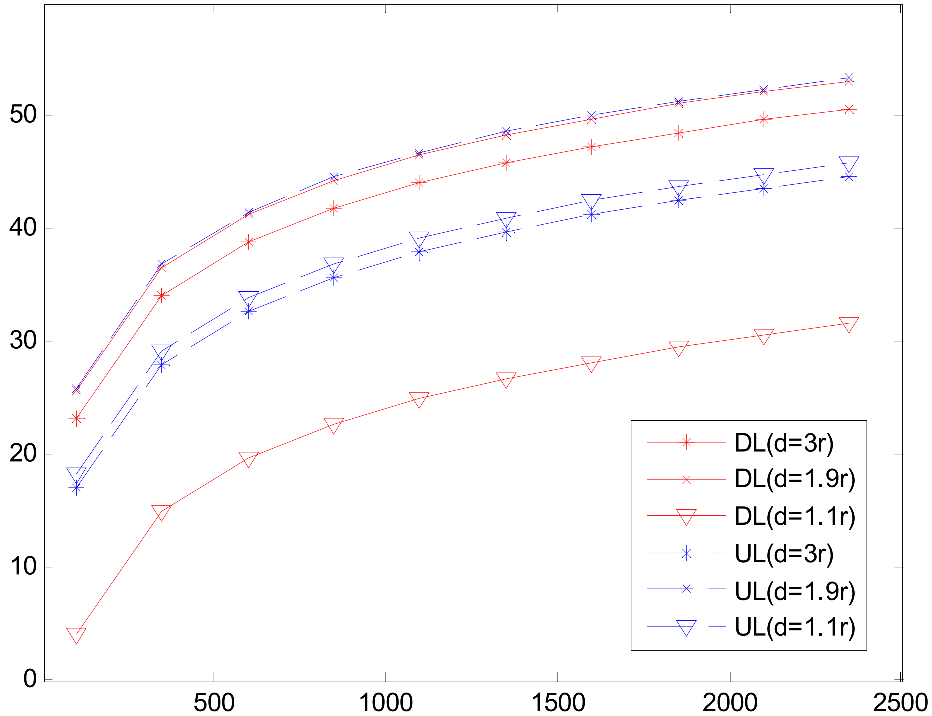


- Ex mark(d=1.9r)



- Triangle mark(d=1.1r)

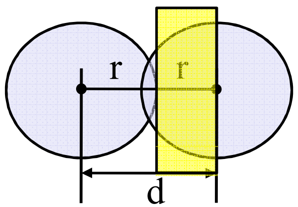




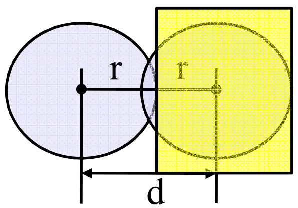
Numerical results (2/2)

Case 2

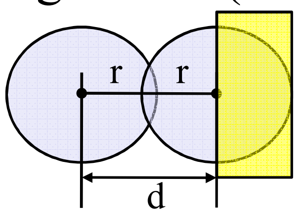
- **A reversal of UL & DL SINR by MSs allocation**
- **d=1.9r**
  - Star mark(r<x<d)

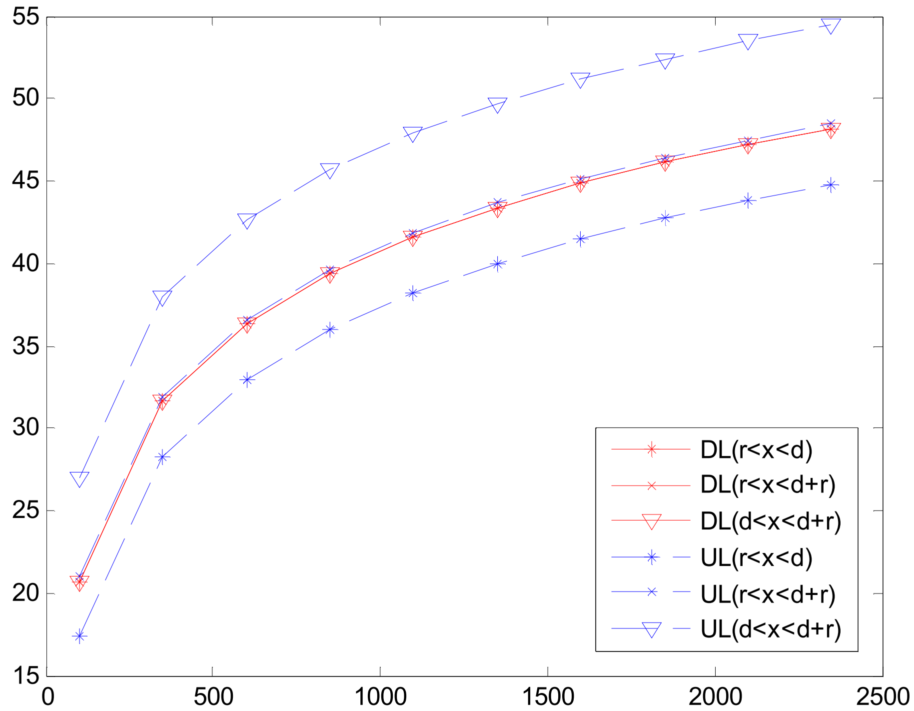


  - Ex mark(r<x<d+r)



  - Triangle mark(d<x<d+r)





Conclusion

- Downlink and uplink channels can be asymmetric in OFDM/A system
  - Cell implementation
  - Neighbor cell users location
- Need a new channel quality management scheme to satisfy the required service quality

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Thank you!

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