

# Analytical SIR for Cross Layer Channel Model

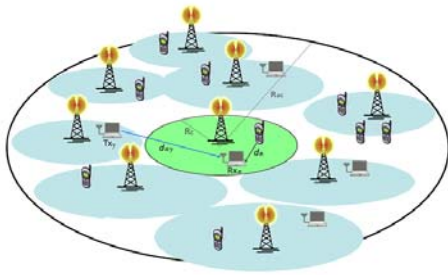
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## Abstract

- > A new **generalized path loss equation** that takes in to account both small-scale multipath fading as well as large-scale path loss including lognormal shadowing is presented
- > Pdf of the **SIR** for wireless networks with **Nakagami-m** channel model is analytically derived
- > SIR is an important parameter for Cross-Layer design

## System Mode

- > Circular cell layout
- > Random positioning of cells
- > Self-configuring and self-organising networks



- > Fixed and constant transmit power
- > One uniformly distributed interfering user

## Analytical Derivations

The generalized path loss is given as:

$$L = \underbrace{C \left( \frac{d}{d_0} \right)^\gamma e^{(\beta \xi_x)}}_{\text{large scale fading}} \cdot \underbrace{\frac{1}{|H(f,t)|}}_{\text{small scale fading}}$$

The path loss for the desired link is

$$L_x = \tilde{C} d_x^{\gamma_x} e^{(\beta \xi_x)} \frac{1}{|H_x|}$$

The path loss between the interfering transmitter and vulnerable receiver is:

$$L_{xy} = \hat{C} d_{xy}^{\gamma_{xy}} e^{(\beta \xi_{xy})} \frac{1}{|H_{xy}|}$$

## References

- [1] M.-S. Alouini and A. Goldsmith, "Adaptive Modulation over Nakagami Fading Channels," *Kluwer Journal on Wireless Commun.*, vol. 13, no. 1-2, pp. 119-143, May 2000.
- [2] A. Abdi, H. Hashemi, S. Nader-Esfahani, "On the PDF of the Sum of Random Vectors", *IEEE Transactions on Communications*, Vol. 48, Iss.1, pp. 7-12, Jan. 2000

This work was supported by DFG grant HA 3570/1-2 within the program SPP-1163 (Techniken, Algorithmen und Konzepte für zukünftige COFDM Systeme - TakeOFDM)

## Analytical Derivations

Key steps towards the derivation of the pdf SIR

Pdf of the ratio of the propagation loss

$$\Phi = \frac{d_x^{\gamma_x}}{d_{xy}^{\gamma_{xy}}}$$

$$f_\Phi(z) = \begin{cases} Yz^{2/\gamma_{xy}-1} & \text{for } 0 < z \leq \zeta \\ \tilde{Y}z^{-2/\gamma_x-1} & \text{for } \zeta < z < \infty \end{cases}$$

$$\text{where } \zeta = \frac{R_{ac}^{\gamma_{xy}}}{R_c^{\gamma_x}}$$

Pdf of the ratio of the lognormal shadowing

$$f_\Lambda(v) = \frac{e^{-1/2 \frac{(\ln(v)-\mu)^2}{\sigma^2}}}{v\sigma\sqrt{2\pi}}, \quad 0 \leq v < \infty$$

$$\text{where } \sigma = \beta \sqrt{v_x^2 + v_{xy}^2}, \quad \mu = 0$$

Pdf of the ratio of the Nakagami-m channel envelope

$$f_\Psi(\vartheta) = M \frac{g^{2m_x-1}}{\left( \frac{m_{xy}}{\Omega_x} + \frac{m_x}{\Omega_{xy}} g^2 \right)^{(m_{xy}+m_x)}} \quad 0 \leq \vartheta < \infty$$

$$\text{where } M = \frac{2\Gamma(m_{xy} + m_x)}{\Gamma(m_{xy})\Gamma(m_x)} \left( \frac{m_{xy}}{\Omega_x} \right)^{m_{xy}} \left( \frac{m_x}{2\sigma_{xy}^2} \right)^{m_x}$$

## Pdf of SIR

$$f_{\text{SIR}}(\zeta) = M \zeta^{2m_x-1} \int_0^\infty \frac{A_1 \chi^{q_1} \left( \text{erf} \left[ \frac{2}{\gamma_{xy}} \sigma^2 + \ln \left( \frac{\chi}{R_{ac}^{\gamma_{xy}} R_c^{\gamma_x}} \right) \right] - 1 \right) + B_1 \chi^{q_2} \left( -1 - \text{erf} \left[ \frac{-2}{\gamma_x} \sigma^2 + \ln \left( \frac{\chi}{R_{ac}^{\gamma_{xy}} R_c^{\gamma_x}} \right) \right] \right)}{\left( \frac{m_{xy}}{\Omega_x} + \frac{m_x}{\Omega_{xy}} \left( \frac{\zeta}{\chi} \right)^2 \right)^{(m_{xy}+m_x)}} d\chi$$

## Simulation

$R_c$	Cell radius
$R_{ac}$	Accessibility radius
$\gamma_x$	The path loss exponent for the desired link
$\gamma_{xy}$	The path loss exponent for the interference link
$\Omega_x$	The average received power at the desired receiver
$\Omega_{xy}$	The average received interference power
$\sigma$	Standard deviation of $\Phi$

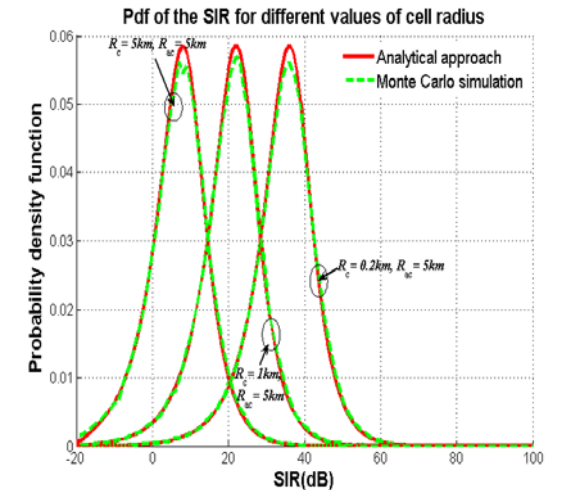
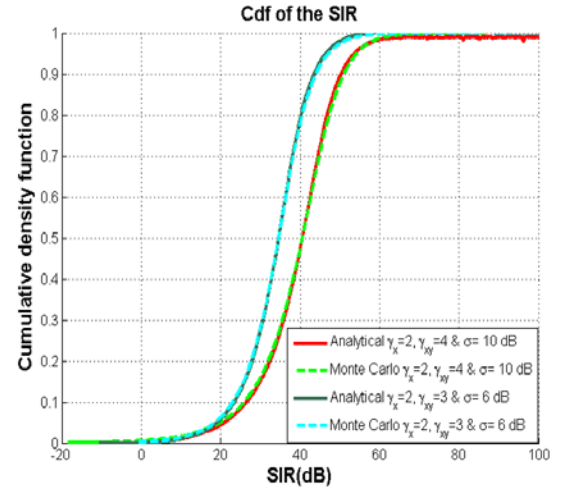
TABLE I  
FOR FIG: DIFFERENT VALUES OF CELL RADIUS

$\gamma_x$	$\gamma_{xy}$	$\Omega_x$	$\Omega_{xy}$	$\sigma$
2	3	9 dB	8 dB	6 dB

TABLE II  
FOR THE CDF OF THE SIR

$R_c$	$R_{ac}$	$\Omega_x$	$\Omega_{xy}$
0.2 km	5 km	9 dB	8 dB

## Results



## Conclusion

- > A **generalized path loss** model is presented
- > This model was used to **analytically derive** the pdf of the SIR
- > Results show **excellent agreement** with the Monte Carlo based results
- > The derivations can be **used in applications** such as **link adaptation algorithms**, **cognitive radio design** and determination of **capacity bounds**
- > The pdf from a single interferer in this paper lays a solid foundation to calculate the statistics from multiple interferers