Statistical Modeling of Co-Channel Interference in a Field of Poisson Distributed Interferers

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Problem Statement

Model co-channel interference in wireless sensor, *ad hoc*, cellular, and dense Wi-Fi networks

Proposed Contributions

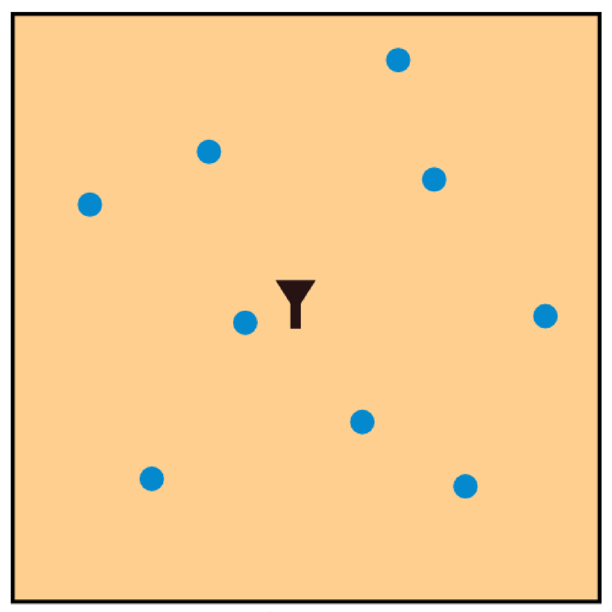
- Apply Symmetric Alpha Stable and Middleton Class A distributions for various interferer topologies
- Analyze conditions for which these distributions accurately model interference statistics

System Model

Sum Interference $\mathbf{Y} = \sum_{i \in \Upsilon} \mathbf{r}_i^{-\frac{\gamma}{2}} \mathbf{h}_i \mathbf{B}_i e^{j(\boldsymbol{\phi}_i + \boldsymbol{\theta}_i)}$

Υ	Poisson point process for interferer locations
γ	power pathloss exponent
$\mathbf{B}_i e^{\boldsymbol{\phi}_i}$	interferer emissions
$\mathbf{h}_i e^{\boldsymbol{\theta}_i}$	random fading

Case I: Entire Plane



$r_l = 0, r_h \to \infty$

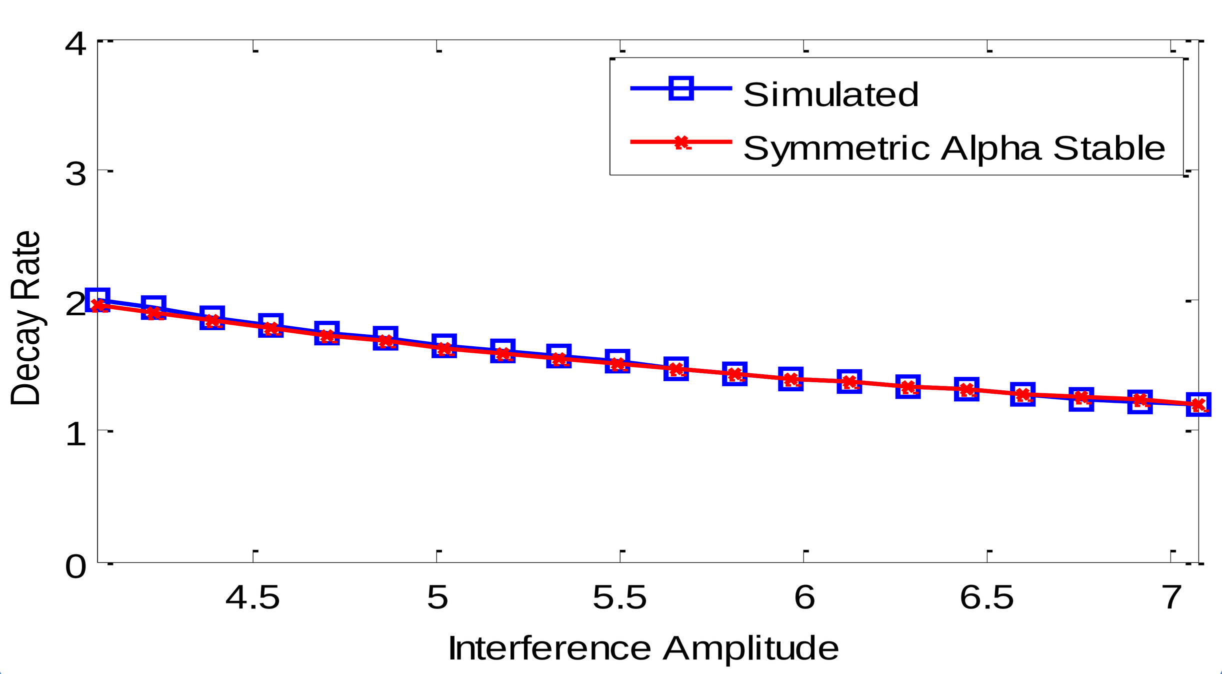
Sensor and *ad hoc* networks

Statistical Model: Symmetric Alpha Stable

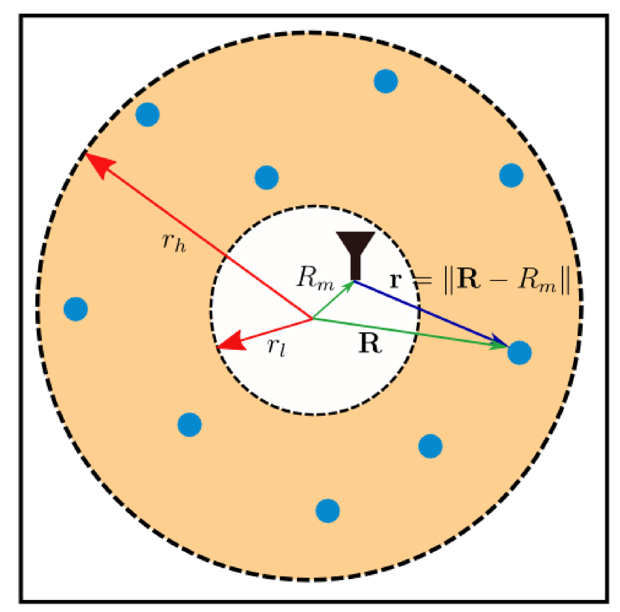
$$\alpha = \frac{4}{\gamma}$$

$$\sigma = \lambda \pi \mathbb{E}_{\mathbf{h},\mathbf{B}} \left\{ \mathbf{h}^{\alpha} \mathbf{B}^{\alpha} \right\} \int_0^{\infty} \frac{J_1(x)}{x^{\alpha}} dx$$

Accurately Models: Exact Statistics



Case II: Finite Area Annular Region



$0 \le r_l < r_h < \infty, R_m \notin \Gamma(r_l, r_h)$

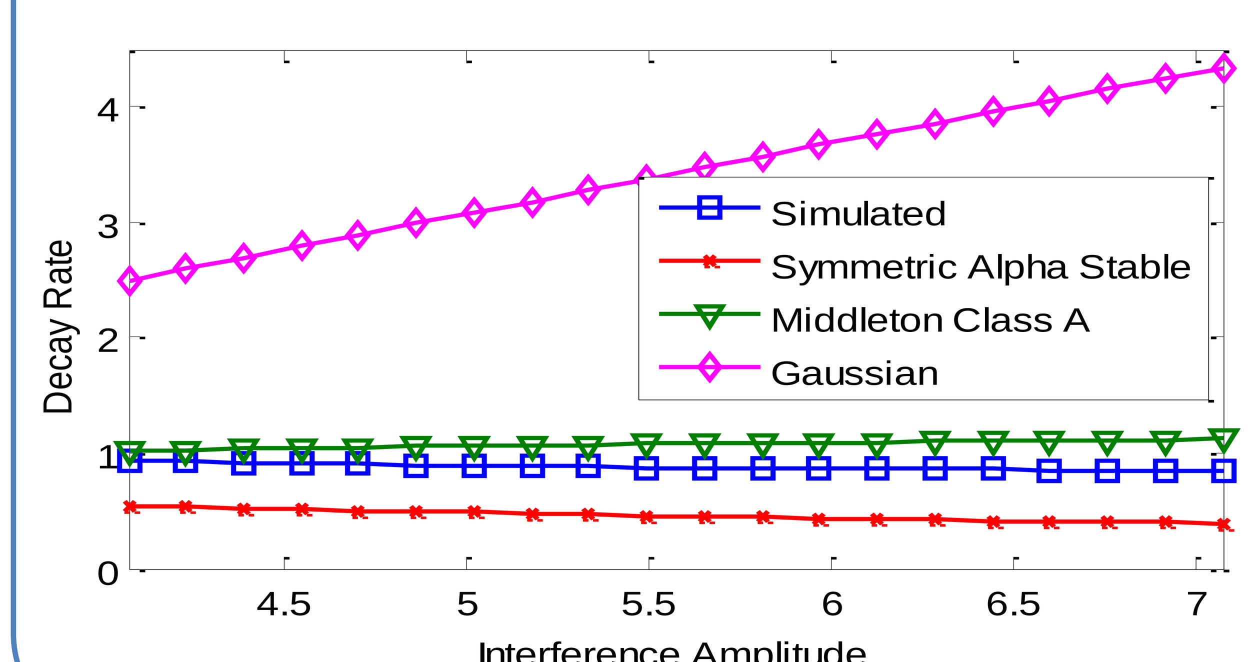
Cellular networks , Hotspot (e.g. café)

Statistical Model: Middleton Class A

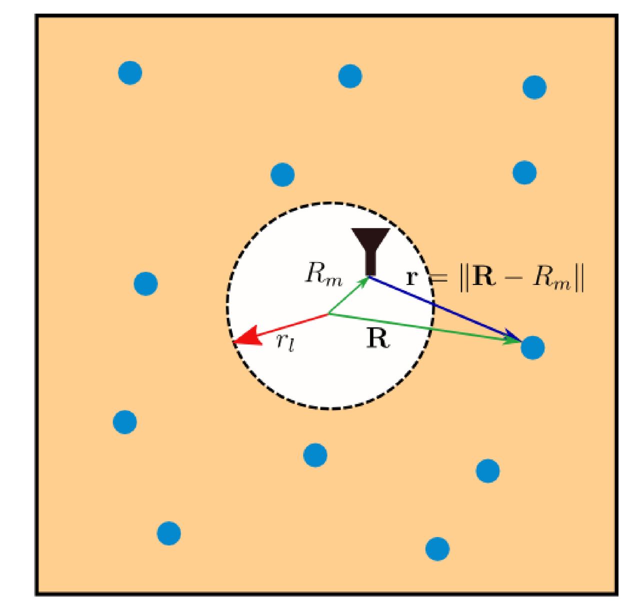
$$A = \lambda \pi \left(r_h^2 - r_l^2 \right)$$

$$\Omega_{2A} = \frac{A \times \mathbb{E}_{\mathbf{r},\mathbf{h},\mathbf{B}} \left\{ \mathbf{r}^{-\gamma} \mathbf{h}^2 \mathbf{B}^2 \right\}}{2}$$

Accurately Models: Tail Probability



Case III: Infinite Area with Guard Zone



$r_l > 0, r_h \to \infty, R_m \notin \Gamma(r_l, r_h)$

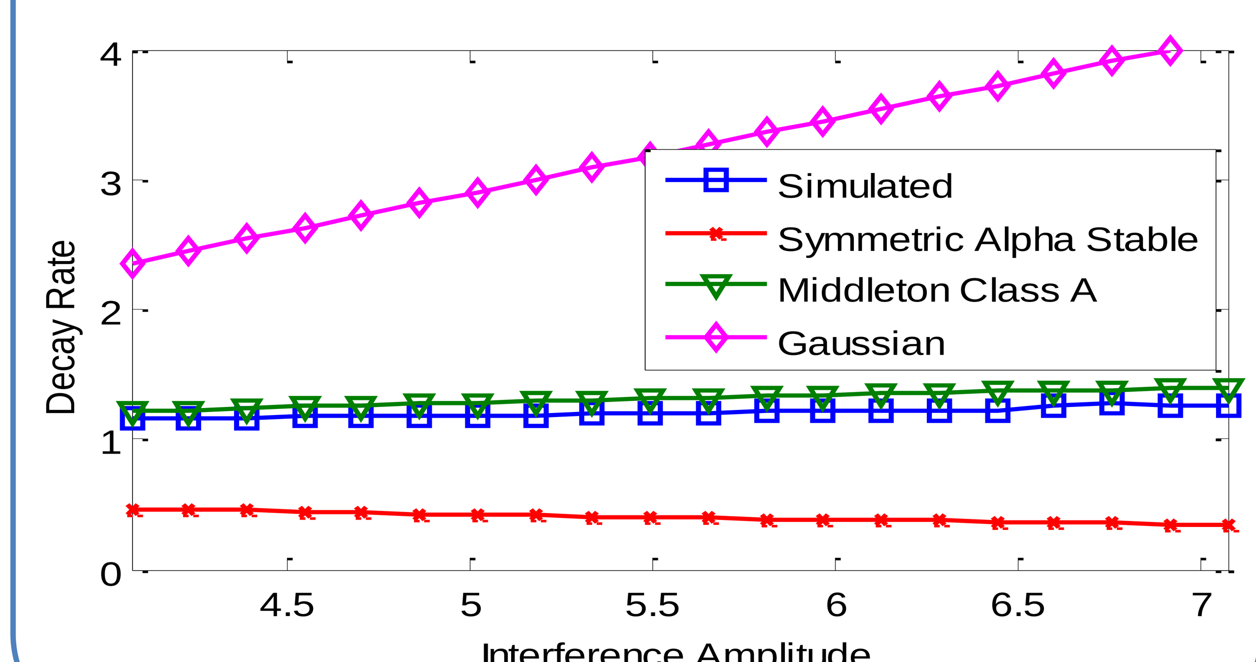
Networks with contention-based MAC

Statistical Model: Middleton Class A

$$A = \lambda \pi r_l^2 \eta$$

$$\Omega_{2A} = \frac{A \times r_l^{-\gamma} e^{\beta} \mathbb{E}_{\mathbf{h},\mathbf{B}} \left\{ \mathbf{h}^2 . \mathbf{B}^2 \right\}}{2}$$

Accurately Models: Tail Probability



Statistical Models

Symmetric Alpha Stable

- Characteristic function

$$\Phi_{\mathbf{Y}_I,\mathbf{Y}_Q}(\omega_I, \omega_Q) = e^{-\sigma \left| \sqrt{\omega_I^2 + \omega_Q^2} \right|^{\alpha}}$$

α: Characteristic exponent
σ: Dispersion parameter

Middleton Class A

- Amplitude distribution

$$f_{\mathbf{Y}_I,\mathbf{Y}_Q}(y_I, y_Q) = \sum_{m=0}^{\infty} \frac{e^{-A} A^m}{m!} \frac{1}{\sqrt{2\pi \frac{m\Omega_{2A}}{A}}} e^{-\frac{y_I^2 + y_Q^2}{2\frac{m\Omega_{2A}}{A}}}$$

A: Overlap index
Ω_{2A}: Mean intensity

Benefits of Statistical Modeling

Physical (PHY) Layer

- Design receivers to mitigate RFI
- 10x – 100x reduction in bit error rates [Spaulding *et al.*, 1977, Nassar *et al.*, 2009]

Medium Access Control (MAC) Layer

- Derive MAC protocol parameters to improve network performance
- 2x – 100x increase in capacity using Guard zones [Hasan *et al.*, 2007]

RFI Modeling and Mitigation Toolbox available at: http://www.ece.utexas.edu/~bevans/projects/rfi/software/

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