Modelling of Dependence in Impulsive Interference and Copual Theory

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1. Modeling of Interference
2. SCMA
3. Copula Theory
4. Simulations

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Modeling of Interference

Interference Model

I. Classic Gaussian Model:

1) Impulsiveness ---- low tail probability
2) Dependence --- i.i.d

II. Modeling of Impulsiveness

Alpha-stable Model --- long tail in PDF

III. Modeling of Dependence:

1) Sub-Gaussian Model
2) Copula Theory

Modeling of Interference

Two determinants of interference[1]**:**

1. **Path Law**
2. **Network Geometry**, i.e. the distribution of ’Interferers’ (nodes concurrently transmitting singals).

(1) the distribution of interfering nodes

(2) the multiple access scheme. E.g. SCMA

[2] Weber, Steven, and Jeffrey G. Andrews. "Transmission capacity of wireless networks." *Foundations and Trends® in Networking*5.2–3 (2012): 109-281.

Modeling of Interference

Alpha-stable model:

Network Geometry --- PPP (Poisson Point Process)

Aggregate interference --- α-Stable[2].

1) Characterizes impulsivness
2) Captures the characteristics of network geometry

[2] ILOW, Jacek et HATZINAKOS, Dimitrios. Analytic alpha-stable noise modeling in a Poisson field of interferers or scatterers. *IEEE transactions on signal processing*, 1998, vol. 46, no 6, p. 1601-1611..

Modeling of Interference

Question : Why there is dependence of interference in wireless network?

Two determinants of interference:

1. Path Law, e.g. SIMO – strong interference received on one antenna → strong one on another antenna.

2. **Network Geometry**, (concurrently transmitting nodes).

(1) the distribution of nodes

(2) the multiple access scheme. E.g. SCMA

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SCMA

Model (PPP with λ) **:**

1. Each device transmits over a subset of orthogonal bands

$$B = \{1, \ldots, K\}$$

2. Each device *j* transmits the message W_j uniformly drawn from the set $\omega_j = \{1, \ldots, M\}$

3. Encoder maps each message to a SCMA codeword in $\mathbb{C}^K$

$$\varepsilon_j : \omega_j \to \mathbb{C}^K$$

4. One SCMA codeword is composed of *m* non-zero elements selected from the set of all authorized subsets of

$$B = \{1, \ldots, K\}$$

SCMA

Scenario --- General SCMA codebook

The non-zero elements of each codeword are assumed to be independently chosen for each device, i.e. each device selects the ***m*** bands uniformly from $B=\{1,\dots,K\}$.

Interference is

$$Z_k(t)=\sum_{j\in\Phi_t} h_{j,k}(t)\, r_j(t)^{-\eta/2}\, x_{j,k}(t), \quad k=1,\dots,K \qquad \text{(2-1)}$$

$h_{j,k}(t)\sim CN(0,1)$ ---- rayleigh fading of device *j* on band *k*

$r_j(t)$ ---- distance to the access point

η ---- path-loss exponent

Φ_t ---- PPP with $p\lambda$,where $p=\frac{\binom{K-1}{M-1}}{\binom{K}{M}}$

SCMA

Scenario --- General SCMA codebook

1. $Z_k = z_{k,r} + i \cdot z_{k,i}$ is an isotropic complex α-stable variable, where α=4/η.

$$\vec{Z}_k = \left(z_{k,r}, z_{k,i} \right) = A^{1/2} \left(G_1, G_2 \right) \quad \text{(2-2)}$$

$\vec{Z}_k = A^{1/2} \left(G_1, G_2 \right)$ is sub-Gaussian, where

$A \sim S_{\alpha/2}\left(\cos\left(\frac{\pi}{4}\alpha \right)^{2/\alpha}, 1, 0 \right)$ ---- skewed α-stable

G_1 , G_2 ---- independent Gaussian variables, i.e

$\left(G_1, G_2 \right) \sim CN(0, \sigma^2 I)$