

Interference in Cognitive Radio Networks

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2nd Annual North American School of Information Theory,
Evanston, IL, August 10-13, 2009

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Model

- We consider a network which has two groups of users: primary users (PU) and cognitive users (CU).
- The locations of the primary users and the cognitive users follow two independent Poisson point processes (PPP) Φ_p and Φ_c with density λ_p and λ_c , respectively.
- Cognitive users are allowed to transmit only when there is no primary user within a distance D . Cognitive users who are transmitting: active cognitive users.

Motivation

- The interference in such network is hard to analyze because the process by the primary users (PPP) and the process formed by the active cognitive users (called “*hole process*” here) are not independent.
- Approximations for hole process need to be performed! Cluster process seems to be a good candidate.
- The overall process is approximated by two independent processes. In this way, the Laplace transform of the interference is simply the product of the Laplace transforms of these two independent processes.

Example

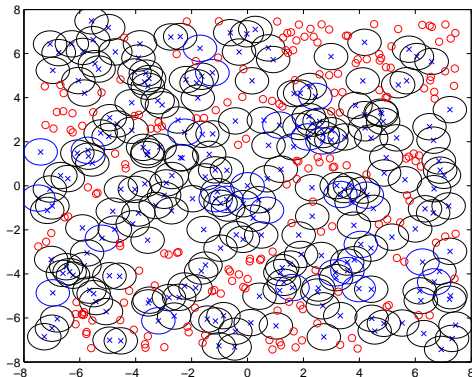


Figure: Example of hole process.

Hole Process vs. Cluster Process

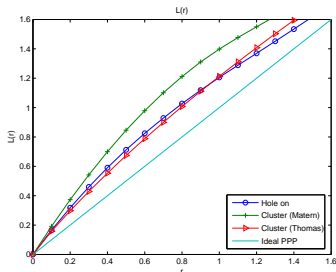


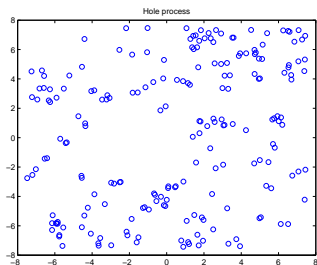
Figure: Modeling hole process using cluster process, $D = 0.6$, $\sigma = 1.5D$.

- Metric: L -function (normalization of K -function).

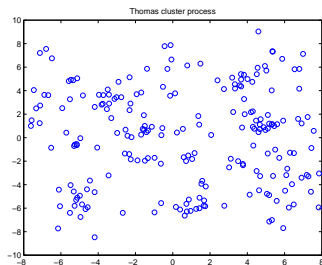
$$\lambda K(r) = \int \phi(B_0(r)P_0^!(d\phi), L(r) = \sqrt{\frac{K(r)}{\pi}}.$$

- Thomas process is a better choice than Matern process.

Hole Process vs. Cluster Process



(a)



(b)

Figure: Examples: (a) Nodes formed by hole process. (b) Nodes formed by Thomas cluster process.

Interference to Primary Users

- Interference from other primary users
 - Simply a PPP.
- Interference from cognitive users
 - Form a cluster process with a parent point at the origin.
 - Exclude nodes within range of $D - \|Z_p\|$, where Z_p is the location of the desired primary receiver.

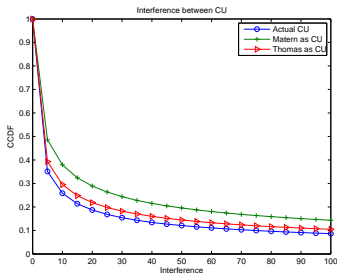
Interference to Cognitive Users

- Interference from primary users
 - PPP, except that there should not be any users within the range of D .
 - The same as CSMA-type MAC scheme.
- Interference from other cognitive users
 - Use cluster process.

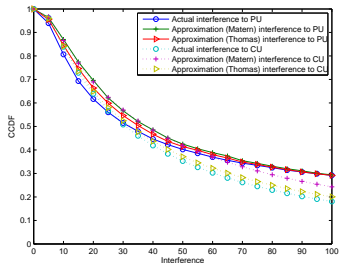
Simulation Setup

- The desired primary transmitter is placed at the origin, and the desired primary receiver is placed at $(0, D/2)$.
- We randomly pick one cognitive node as the receiver and other nodes as interfering transmitters.
- Setup:
 - $\lambda_p = 0.97$, $\lambda_c = 3$.
 - Transmission power of primary users = 1, and transmission power of cognitive users = 0.01.
 - Path loss factor $\alpha = 4$, and path loss model $g(x) = \|x\|^{-\alpha}$.
 - Mean amplitude of Rayleigh fading $E\{h\} = 1$.

Example 1



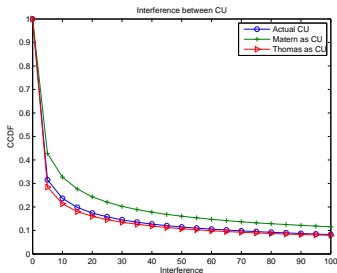
(a)



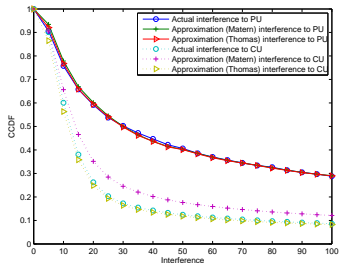
(b)

Figure: (a) CCDF of the interference between cognitive users when $D = 0.3$. (b) CCDF of the interference to primary users and cognitive users when $D = 0.3$.

Example 2



(a)



(b)

Figure: (a) CCDF of the interference between cognitive users when $D = 0.6$. (b) CCDF of the interference to primary users and cognitive users when $D = 0.6$.

Concluding Remarks and Future work

- Concluding remarks:
 - The cluster process gives good approximations of the hole process in the cognitive radio network. In particular, the Thomas cluster process models better than the Matern cluster process.
 - The overall interference can be well approximated by two independent processes.
- Future work:
 - Derive the bounds for this approximation.