9.3 Connectivity in the Interference Model

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Outline

- What are we looking for?
- The notion of path loss function
- STIRG model
- Attempt to define percolation
- Discussion
Formulating the scenario

- **STIRG** (Signal To Interference Ratio Graph) with node locations form a **homogeneous** Poisson point process.
- $\lambda$, intensity of the Poisson process
- Implies number of nodes in two non-overlapping areas are independent: i.e. area A has a Poisson Distribution of $A\lambda$. 
Realization factors of node location:
- $\gamma$, orthogonality factor
- $\beta$, SINR thresholds (constant)
- $P_i$, transmission power (constant)
- $WN_o$, receiver noise
- $L(\cdot)$, Path loss function

The STIRG graph depends on intensity and orthogonality only
Within a network of infinite nodes, we look for a connected component, a subgraph, with infinite nodes. This is called a Giant Component. Percolation happens when there is a Giant Component. Note decrease $\gamma$ increases number of edges.
Path Loss Function

- If node locations forms a Poisson process and all nodes transmit with the same power implies path loss function depends only on transmission distance.
- Then $\sum_{k \text{ transmitting}} L(d_{k,j})$ converge if $\int_{y}^{\infty} L(t) \, dt < \infty$, note that $\gamma > 0$
- Total Path loss is finite implies the total interference is finite ($\gamma$ is constant)
Define STIRG model

- Consider Node 0 as receiver
- Node 1 is furthest neighbor of Node 0
- In between we have Node 2, 3, .. \( V_0 \) such that

\[ P L(\|X_1 - X_0\|) \leq P L(\|X_k - X_0\|) \]
Cont.

For $k = 2, \ldots V_0$ we derive STIRG as

$$\frac{P L(\|X_1 - X_0\|)}{N_0 W + \gamma \sum_{k=2}^{\infty} P L(\|X_k - X_0\|)} \geq \beta$$
Derive constraint for neighboring nodes

\[ P \, L(\|X_1 - X_0\|) \geq \beta N_0 W + \beta \gamma \sum_{k=2}^{\infty} P \, L(\|X_k - X_0\|) \]

\[ \geq \beta N_0 W + \beta \gamma (v_0 - 1) \, P \, L(\|X_1 - X_0\|) \]

\[ + \beta \gamma \sum_{k=v_0+1}^{\infty} P \, L(\|X_k - X_0\|) \geq \beta \gamma (v_0 - 1)P \, L(\|X_1 - X_0\|) \]

\[ v_0 \leq 1 + \frac{1}{\beta \gamma} \]
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- From previous we derive numbers of neighbors upper bounded by the above expression when \( \gamma > 0 \).
- When \( \gamma > 1 / \beta \) each node has at most one neighbor.
- In narrow band system \( \gamma = 1, \beta > 1 \) then each node can decode at most one transmission.
• Upper bound for orthogonality factor is $1 / \beta$
• $\lambda^*$ is critical large value for possible percolation.
Thank You