Full Duplex Emulation via Spatial Separation of Half Duplex Nodes in a Planar Cellular Network

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Introduction

- Full Duplex is seen as a way of enhancing rate performance in a cellular network
- Complex processing at FD transceiver
- Other approaches:
  - Having physical channels overlap[1]
  - Having UL and DL timeslots overlap[2]

System Model and Assumptions

- Wireless channels Rayleigh faded
  - Pathloss model \( f(r) = r^{-\alpha} \)
  - Constant BS and MS transmission power \( P_B \) and \( P_M \).
- Location of FD-BSs modeled as a PPP \( \Phi_F \) with density \( \lambda_F \).
- Location of CoMPflex BSs modeled as a PPP \( \Phi_C \) with density \( \lambda_C \).
- Approximate CoMPflex UL and DL BSs as thinned PPs.
  - UL: \( \Phi_{C,UL} \) has density \( \lambda_{C,UL} = 0.5 \lambda_c \)
  - DL: \( \Phi_{C,DL} \) has density \( \lambda_{C,DL} = 0.5 \lambda_c \)
  - \( \lambda_C = \lambda_{C,UL} + \lambda_{C,DL} \)

Poisson Point Process

- Theoretical tool for performance analysis of cellular networks
- Deploy points randomly and independently in two dimensions
- Average number of points in a window is the density \( \lambda \) of the process.
- Can derive CDF \( F_R(r) \) of \( R \), the distance from a typical point to the nearest (other) point: \( F_R(r) = 1 - \exp(-\lambda \pi r^2) \)
- Choosing each point in PPP randomly and independently with probability \( p \) results in a thinned PPP \( \Phi_{thin} \) with density \( p \lambda \).

Full Duplex Emulation

- Main idea: Emulate FD by spatial separation of HD devices
- Avoids complexity of FD transceivers
- One UL- and one DL-BS are cooperating
- CoMPflex: CoMP for In-Band Wireless Full Duplex

BS Pairing

- Each UL BS is connected to an adjacent DL BS, where neighbor is chosen at random.
- Unpaired BSs are assigned UL and DL at random
- One MS scheduled in each cell
- MS positions approximated by PPs, independent from BS PPP.
- Dependency in UL-DL pairing complicates direct derivation

Signal Model

- UL SINR at BS:
  \( \gamma_B(r) = \frac{g_B(r) \lambda C,UL}{P_M} \cdot \frac{f_B(r) \lambda C,DL}{P_M} + \sigma^2 \)
- DL SINR at MS:
  \( \gamma_f = \frac{g_f(r) \lambda C,UL}{P_B} \cdot \frac{f_f(r) \lambda C,DL}{P_B} + \sigma^2 \)

Success Probability in UL

\( P_U = 2 \pi \lambda_C \int_0^r r \cdot \exp(-\pi \lambda \pi r^2 - \sigma^2) \text{CDF}(r) \text{CDF}(r) \text{dr} \)

Success Probability in DL

\( P_D = 2 \pi \lambda_C \int_0^r r \cdot \exp(-\pi \lambda \pi r^2 - \sigma^2) \text{CDF}(r) \text{CDF}(r) \text{dr} \)

Distance CDF analysis

Conclusion and Future Work

- CoMPflex brings benefits over FD, via usage of HD BSs
- Gives improved performance for HD MSs in UL and DL
- By spatially separating HD BSs, we can emulate FD operation
- Ongoing study into comparing with CoMP, and clustering more BSs

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