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

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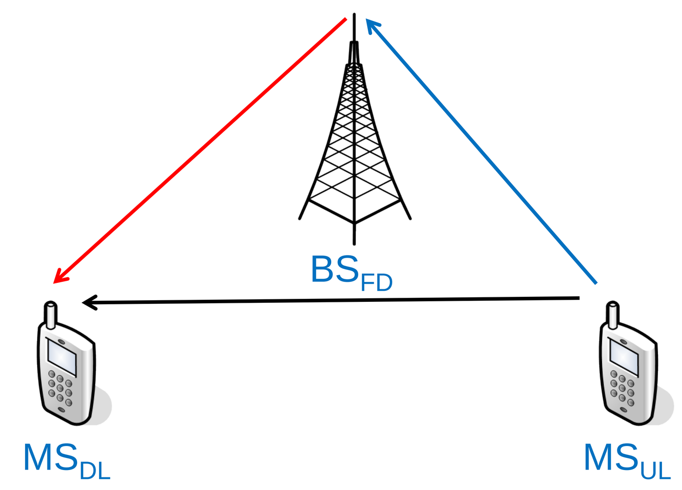
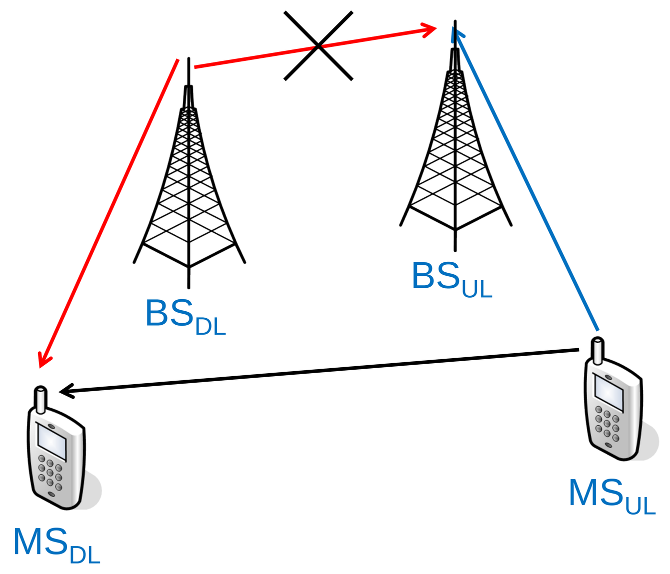
Introduction

- 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]



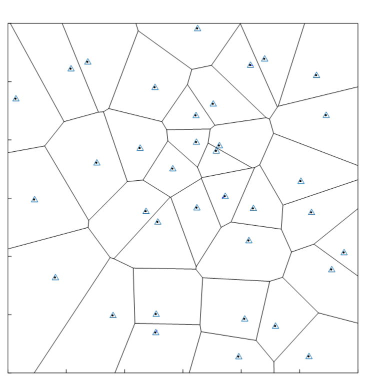
Full Duplex Emulation

- 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



Poisson Point Process

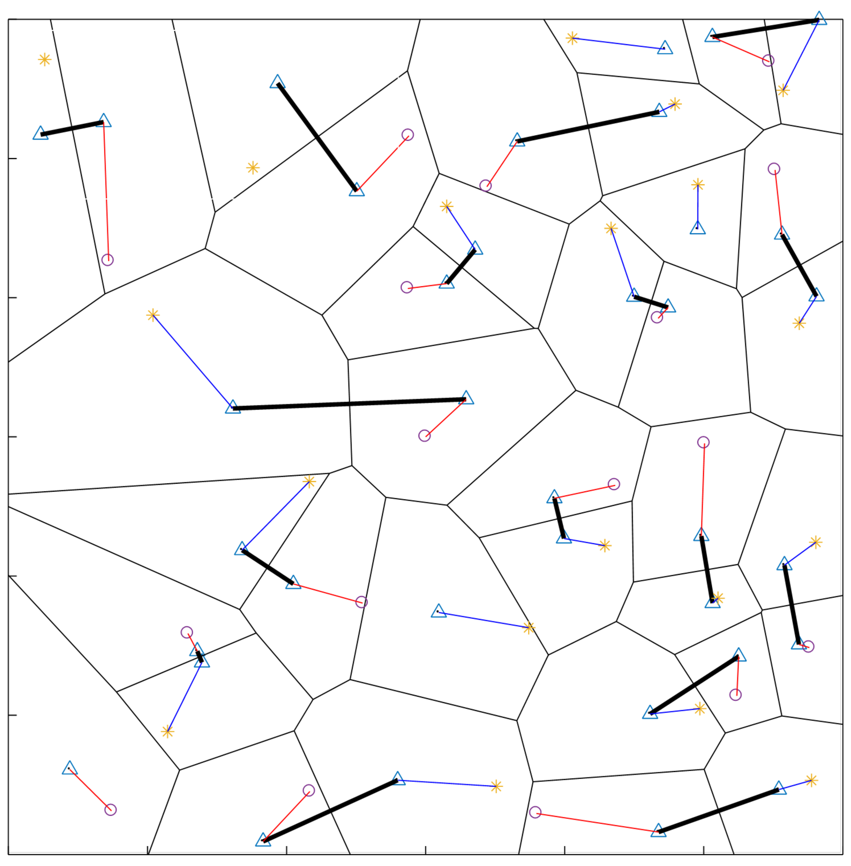
- Theoretical tool for performance analysis of cellular networks
- Deploy points randomly and independently in two dimensions
- Average number of points in a window is the density λ of the process.
- Can derive CDF $F_R(r)$ of R, the distance from a typical point to the nearest (other) point: $F_R(r)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



System Model and Assumptions

- Wireless channels Rayleigh faded
  - Pathloss model $\ell(r) = r^{-\alpha}$
  - Constant BS and MS transmission power P_B and P_M.
- Location of FD-BSs modeled as a PPP Φ_F with density λ_F.
- Location of CoMPflex BSs modeled as a PPP Φ_C with density λ_C.
- Approximate CoMPflex UL and DL BSs as thinned PPPs.
  - UL: $\Phi_{C,U}$ has density $\lambda_{C,U} = 0.5\,\lambda_C$
  - DL: $\Phi_{C,D}$ has density $\lambda_{C,D} = 0.5\,\lambda_C$
  - $\lambda_C = \lambda_{C,U} + \lambda_{C,D}$

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 PPPs, independent from BS PPP.
- Dependency in UL-DL pairing complicates direct derivation

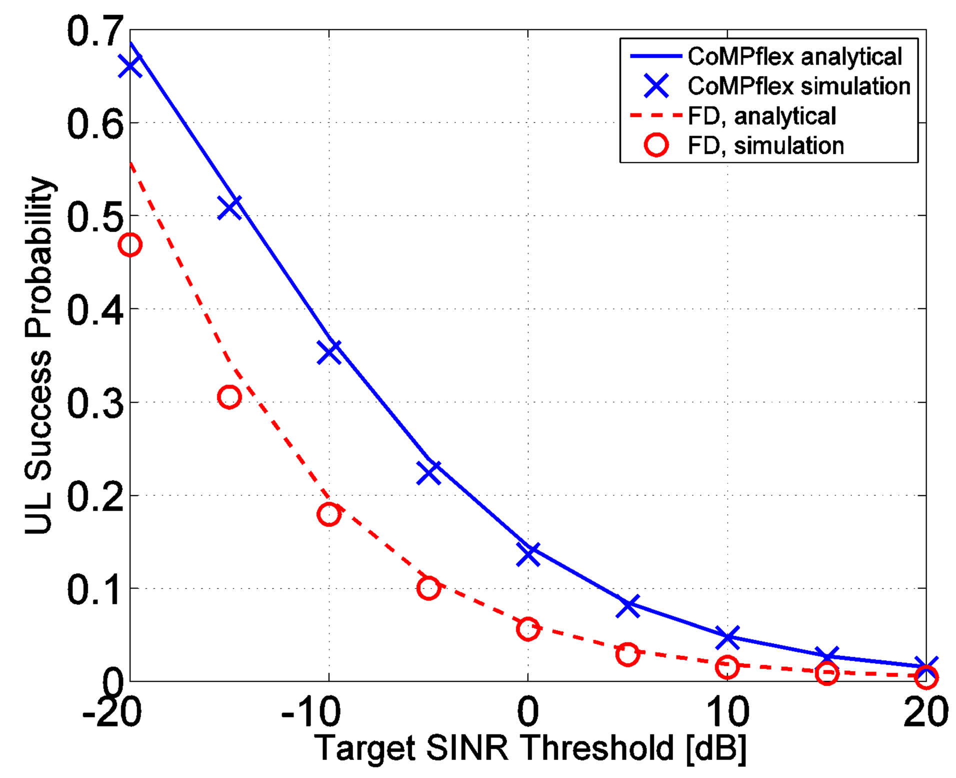
Signal Model

- UL SINR at BS:
  - $$\gamma_{B(i)} = \frac{g_{i,B(i)}\ell(r_{i,B(i)})P_M}{I^{\psi}_{B(i)} + I^{\varphi}_{B(i)} + \sigma^2}$$

    Aggregate interference from BSs — Aggregate interference from MSs
- DL SINR at MS:
  - $$\gamma_j = \frac{g_{B(j),j}\ell(r_{B(j),j})P_B}{I^{\psi}_j + I^{\varphi}_j + \sigma^2}$$

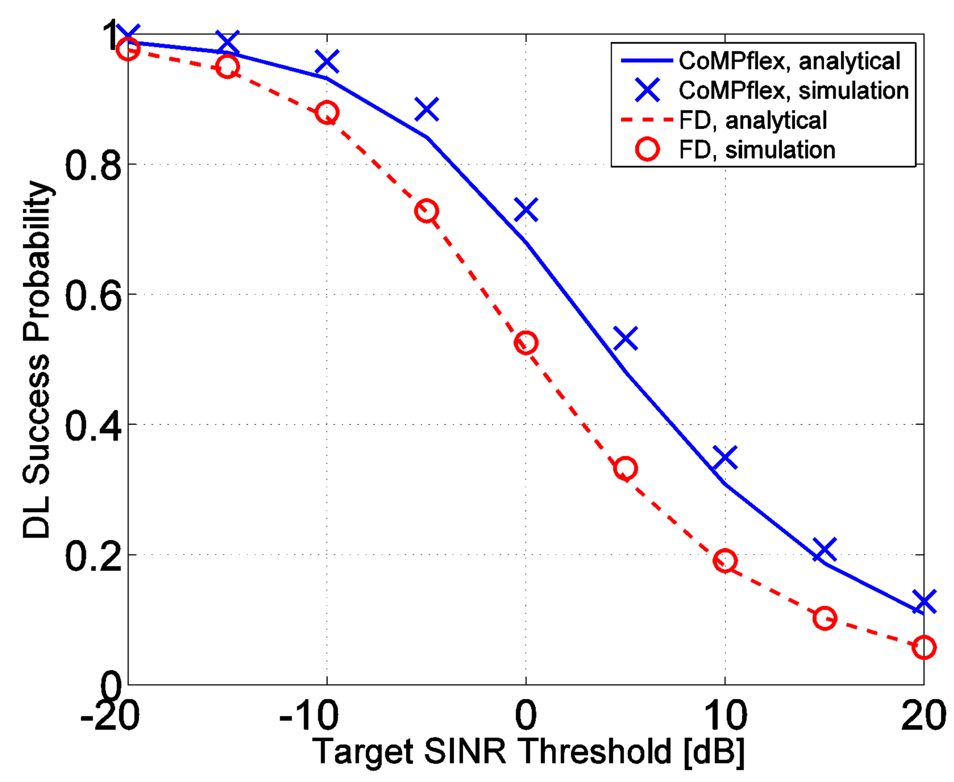
    Aggregate interference from BSs — Aggregate interference from MSs

Success Probability in UL



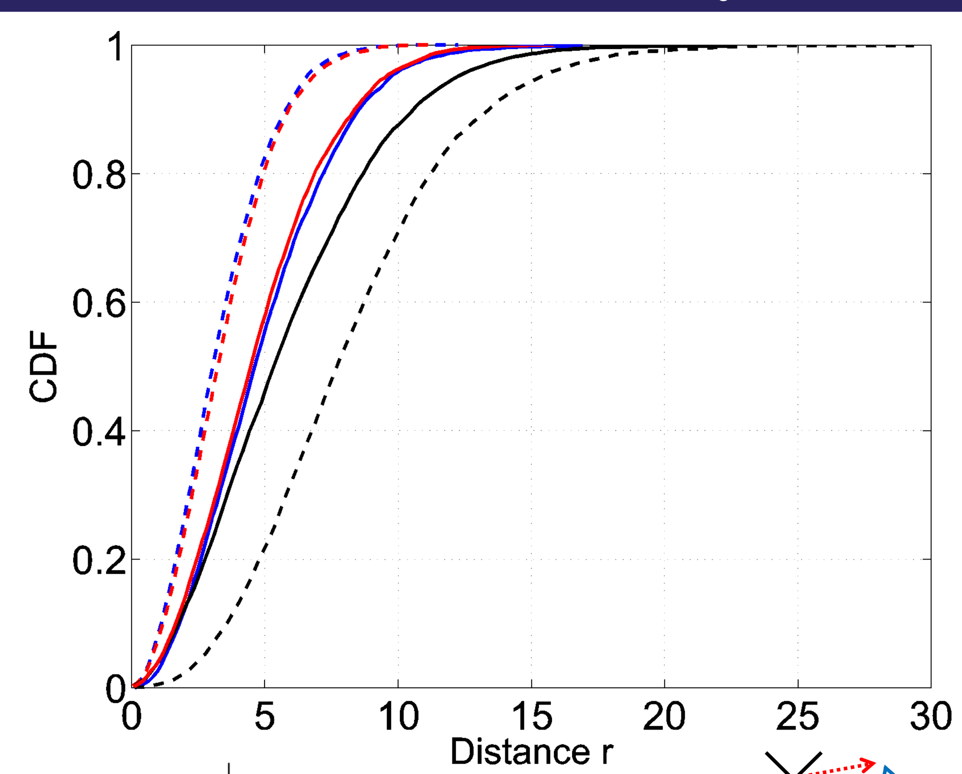
$$P^C_U = 2\pi\lambda_C \int_0^{\infty} r \cdot \exp(-\pi\lambda_C r^2 - s\sigma^2)\mathcal{L}_{\psi}(s)\mathcal{L}_{\varphi}(s)\, dr$$

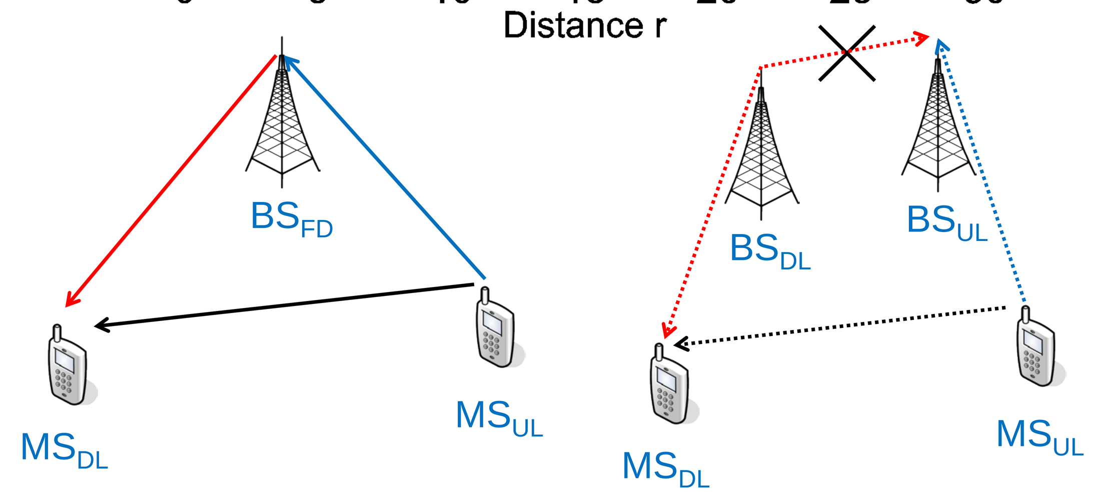
Success Probability in DL



$$P^C_D = 2\pi\lambda_C \int_0^{\infty} r \cdot \exp(-\pi\lambda_C r^2 - s\sigma^2)\mathcal{L}_{\psi}(s)\mathcal{L}_{\varphi}(s)\, dr$$

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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