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1. Joint Power Optimization for D2D Communication in Cellular Networks With Interference Control

Authors: Ali Ramezani-Kebrya, Min Dong, Ben Liang, Gary Boudreau, and S. Hossein Seyedmehdi

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  - Uplink resource sharing
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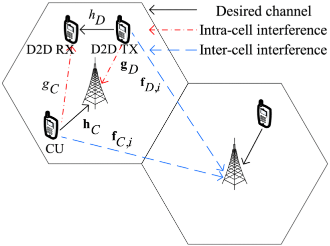
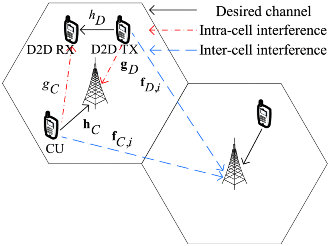
  - Perfect knowledge of all channels
- **Approach:** (i) Check for D2D admissibility under given constraints (ii) Joint power control under assumption of D2D admission.



- **SINR at D2D RX:**

$$\gamma_D = \frac{P_D |h_D|^2}{\sigma_D^2 + P_C |g_C|^2} \tag{1}$$



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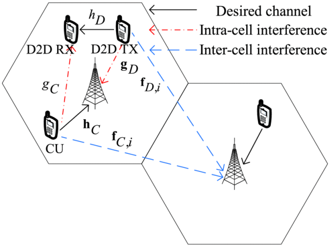

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- **Inter-Cell Interference (ICI)**

$$P_{\mathcal{I},i} = P_C\|\mathbf{f}_{C,i}\|^2 + P_D\|\mathbf{f}_{D,i}\|^2. \tag{3}$$

Sum rate optimization problem:

$$
\begin{aligned}
\textbf{P1:} \quad & \max_{P_D, P_C, \mathbf{w}} \quad \log(1+\gamma_C) + \log(1+\gamma_D) \\
& \text{s.t} \quad \gamma_C \geq \tilde{\gamma}_C, && (4) \\
& \quad\quad \gamma_D \geq \tilde{\gamma}_D, && (5) \\
& \quad\quad P_C \leq P_C^{\max},\ P_D \leq P_D^{\max}, && (6) \\
& \quad\quad P_{\mathcal{I},i} \leq \tilde{\mathcal{I}},\ i = 1, \cdots, b && (7)
\end{aligned}
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Objective: Optimize $(P_D, P_C, \mathbf{w})$

- Admissibility - For any given (P_D, P_C), find optimal beam vector $\mathbf{w}^o$
- Optimality - Let $x \triangleq P_D, y \triangleq P_C$. Evaluate $({P_D}^o, {P_C}^o)$ for $b = 1$ and $b > 1$ (approximation of ICI constraints)

Sum rate optimization problem:

$$\textbf{P2:} \quad \max_{(x,y)} \quad \log \mathcal{R}(x,y) \tag{8}$$

$$\text{s.t} \quad y\left(1-\frac{K_1 x}{K_2+x}\right) I \geq \tilde{\gamma}_C, \tag{9}$$

$$\frac{ax}{\sigma_D^2+K_3 y} \geq \tilde{\gamma}_D, \tag{10}$$

$$y \leq P_C^{\max}, \quad x \leq P_D^{\max}, \tag{11}$$

$$c_1 y + c_2 x \leq 1 \tag{12}$$

$$\text{where} \quad \mathcal{R}(x,y) \triangleq \left(1+\frac{ax}{\sigma_D^2+K_3 y}\right)\left(1+y\left(1-\frac{K_1 x}{K_2+x}\right) I\right),$$

Lemma: The optimal power solution pair (x^o, y^o) is at the vertical, horizontal, or tilted boundary of $\mathcal{A}_{xy}$, given by $x = P_D^{\max}, y = P_C^{\max}$, or $c_1 y + c_2 x = 1$, respectively.

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Contributions:

- Proposed algorithm is optimal when ICI to a single neighboring cell is considered. For multiple neighboring cells, we provide an upper bound on the performance loss.
- Formulate an offline (non convex) optimization problem and propose an iterative algorithm to solve it.
- Consider the scenario of multiple CUs and D2D pairs, and formulate the joint power control and CU-D2D matching problem.

Multiple CUs and D2D pairs:

$$\textbf{P3:} \quad \max_{\mathbf{P},\mathbf{w},\mathbf{x}} \quad \sum_{k\in\mathcal{D}} \sum_{j\in\mathcal{C}} \log(1+\gamma_{C,j}) + x_{k,j}\log(1+\gamma_{D,k})$$

$$\text{s.t} \quad \frac{P_{C,j}|\mathbf{w}_j^H \mathbf{h}_{C,j}|^2}{\sigma^2 + x_{k,j} P_{D,k} |\mathbf{w}_j^H \mathbf{g}_{D,k}|^2} \geq \tilde{\gamma}_C, \quad \forall j\in\mathcal{C}$$

$$\frac{P_{D,k}|h_{D,k}|^2}{\sigma_{D,k}^2 + x_{k,j} P_{C,j} |g_{j,k}|^2} \geq \tilde{\gamma}_D, \ \forall k\in\mathcal{D}$$

$$P_{C,j} \leq P_C^{\max}, \ P_{D,k} \leq P_D^{\max}, \ \forall j\in\mathcal{C}, \ k\in\mathcal{D}$$

$$P_{\mathcal{I},i,j} \leq \tilde{\mathcal{I}}, \quad \forall j\in\mathcal{C}, \ i=1,\cdots,b$$

$$\sum_{k\in\mathcal{D}} x_{k,j} \leq 1, \quad \sum_{j\in\mathcal{C}} x_{k,j} \leq 1, \ \forall j\in\mathcal{C}, \ k\in\mathcal{D}$$

$$x_{k,j} \in \{0,1\}, \quad \forall j\in\mathcal{C}, \ k\in\mathcal{D}$$

2. To Motivate Social Grouping in Wireless Networks

Authors: Yu-Pin Hsu, and Lingjie Duan

- **Goal:** Employ social grouping (users with *common interest*) and obtain optimal equal-reciprocal scheme that maximizes the shared content and per-user utility.

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- **Motivation:** Exploiting the hybrid B2D and D2D networks for local content sharing by proposing a non-monetary incentive, assuming selfish users. Traditional incentive schemes are unicast-based.
- **Assumptions:**
  - Users with heterogeneous B2D channels (ON/OFF)
  - No user mobility
  - BS knows channel states
  - BS TX at most 1 packet/slot. Users cannot TX, RX simultaneously
  - B2D, D2D operate on different channels (half-duplex)
  - Users are rational, not malicious

N	Total number of users in consideration
$\mathbf{s}(t) = (s_1(t), \cdots s_N(t))$	Channel state vector at time slot t, where $s_i(t)$ is the channel state for user c_i.
$p_{e,i}$	B2D channel error probability for user c_i, while i is ignored for the symmetric networks.
$T_{\neq}^{(N)}$	Completion time for delivering a common packet employing the unicast communications, while N is ignored for $N = 2$.
$T_{=}^{(N)}$	Completion time for delivering a common packet employing the broadcast communications, while N is ignored for $N = 2$.
$T_{\cup}^{(N)}$	Completion time for delivering a common packet employing the broadcast communications along with social grouping, while N is ignored for $N = 2$.
$p_{i \to \mathbf{R}}$	Probability that user c_i shares the common packet with the users in $\mathbf{R}$.
λ	Arrival rate of common interests at the BS.
Λ	Equal-reciprocal stability region.

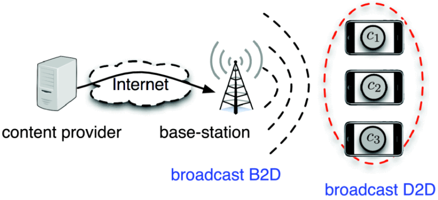


Figure : Hybrid Network Model

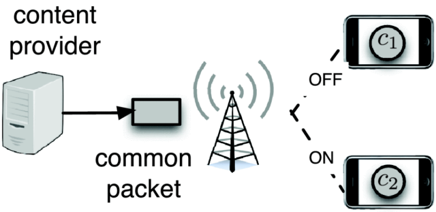
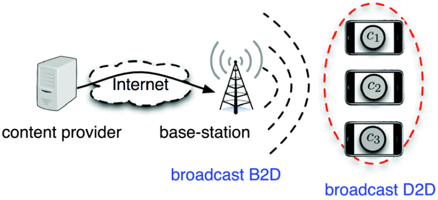


Figure : 2 users with common interest



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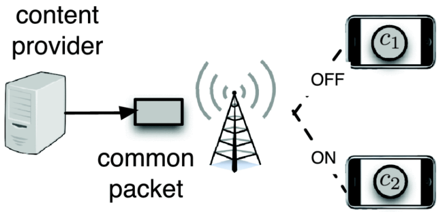

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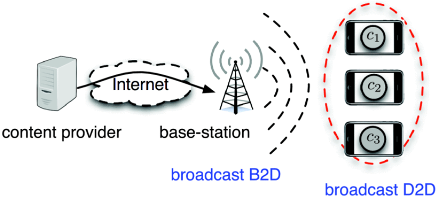
$$T_{=} = p_e^2(1 + T_{=}) + (1 - p_e)^2 \cdot 1 + 2p_e(1 - p_e)\left(1 + \frac{1}{1 - p_e}\right) = \frac{2p_e + 1}{1 - p_e^2},$$

$$T_{\neq} = p_e^2(1 + T_{\neq}) + (1 - p_e^2)\left(1 + \frac{1}{1 - p_e}\right) = \frac{p_e + 2}{1 - p_e^2},$$



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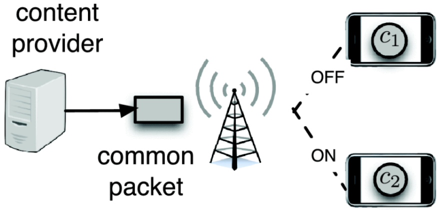

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$$R_{\neq/=} := \frac{T_{\neq}}{T_{=}} = \frac{p_e + 2}{2p_e + 1}.$$

$$R_{=/\cup} := \frac{T_{=}}{T_{\cup}^*} = \frac{2p_e + 1}{-2p_e^2 + 2p_e + 1}.$$

$$T_{=}^{(n)} = \sum_{i=0}^{n} \binom{n}{i} p_e^i (1-p_e)^{N-i} (1 + T_{=}^{(i)}),$$

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Lemma: The optimal equal reciprocal scheme for the large symmetric network is to pick a user for sharing with the equal probability, i.e., for user c_i , the sharing probability is

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Lemma: When $p_e < 0.5$, $T_{\cup}^*$ increases in N . When $p_e > 0.5$, $T_{\cup}^*$ decreases in N . When $p_e = 0.5$, $T_{\cup}^* = 2$ for all N . Moreover, $T_{\cup}^* \to 2$ when $N \to \infty$, independent of p_e.

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Lemma: The incentivized social group has a performance loss compared with the full cooperation

$$T^*_{\cup} - T_f = \frac{\Delta}{1 - (p_{e,2} - \Delta) p_{e,2}} \left(\frac{1}{1 - p_{e,2}} - 1 \right),$$

where $\Delta = p_{e,2} - -p_{e,1}$

Approach:

- Evaluate completion time for different scenarios. Compute improvement ratios.
- Employ equal-reciprocal incentives and illustrate performance for symmetric and asymmetric cases.

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Contributions:

- Consider a practical *MicroCast* network scenario and propose the equal-reciprocal incentive scheme to motivate social grouping, which improved network performance.
- The optimal equal-reciprocal mechanism is a win-win policy that improves the performance of both BSs and local users.
- Propose on-line scheduling algorithms that dynamically select a user to share content (additional 1-bit information).

3. Analytical Characterization of Device-to-Device and Cellular Networks Coexistence

Authors: Ashraf Al-Rimawi and Davide Dardari

Goal: Evaluate the amount of (downlink) traffic offloaded through D2D communications while considering the effect of power control, users spatial distribution, shadowing and random base station deployment.

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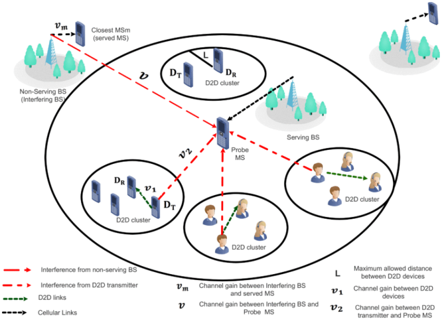

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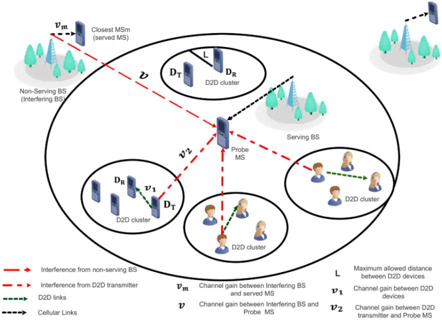

- **Motivation:**
  - HetNets Interference Mgmt
  - Hex cells → Sto-Geo
  - HPPP unrealistic for D2D
- **Assumptions:**
  - One D2D link active at a time, without violating $SINR_{min}$ constraint
  - D2D groups → HPPP. D2D users → arbitrary spatial model

System model

- **SINR at probe MS:**

$$\text{SINR} = \frac{P_{\text{u}}}{\sum_{i=0}^{n} P_i + \sum_{j=0}^{m} P_{\text{j}}^{(d)} + \sigma_0^2},$$

System model

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$$\mathrm{SINR} = \frac{P_{\mathrm{u}}}{\sum_{i=0}^{n} P_i + \sum_{j=0}^{m} P_{\mathrm{j}}^{(d)} + \sigma_0^2},$$

- **Coverage Probability:**

$$\begin{aligned} P_c =& \mathrm{Prob}\left(\mathrm{SINR} > \eta\right) = \mathrm{Prob}\left(\sum_{i=0}^{n} P_i + \sum_{j=0}^{m} P_{\mathrm{j}}^{(d)} < \gamma\right) \\ =& \mathrm{Prob}\left(10\log_{10}\left(P_I\right) < 10\log_{10}\gamma\right) \\ \approx& \mathrm{Prob}\left(\max_{i,j}\left(P_i\,(\mathrm{dBm})\,, P_j^{(d)}\,(\mathrm{dBm})\right) < 10\log_{10}\gamma\right), \end{aligned}$$

System model

- **Coverage Probability averaged over n, m:**

$$
\begin{aligned}
P_{c_0} &= \mathbb{E}[P_{c_0}|_{n,m}] \\
&= \sum_{m=0}^{\infty}\sum_{n=0}^{\infty} P_{c_0}|_{n,m} \frac{\left(\rho_{\text{BS}}\pi R_0^2\right)^n}{n!}\frac{\left(\rho_{\text{D}}\pi R_0^2\right)^m}{m!} \\
&\quad \times \exp\left(-(\rho_{\text{BS}}+\rho_{\text{D}})\pi R_0^2\right) \\
&= \exp\left(-\rho_{\text{D}}\pi R_0^2(1-F_{\text{D}}(\gamma)) - \rho_{\text{BS}}\pi R_0^2(1-F_{\text{I}}(\gamma))\right),
\end{aligned}
$$

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& \times \exp\left(-(\rho_{\text{BS}} + \rho_{\text{D}}) \pi R_0^2\right) \\
=& \exp\left(-\rho_{\text{D}} \pi R_0^2 (1 - F_{\text{D}}(\gamma)) - \rho_{\text{BS}} \pi R_0^2 (1 - F_{\text{I}}(\gamma))\right),
\end{aligned}
$$

- **Coverage Probability over the entire area:**

$$
P_c = \lim_{R_0 \to \infty} P_{c_0} = \exp\left(-\lambda_{\text{BS}}(\gamma) - \lambda_{\text{D}}(\gamma)\right).
$$

Contributions:

- Presented a new analytical framework for analyzing the coverage probability in coexisting cellular and D2D networks.
- Characterizing channel gain statistics of serving, non-serving BSs, and D2D links.
- The reciprocal impact of D2D and cellular communications on the downlink coverage is investigated as a function of the D2D links maximum range and density.

4. Phase Retrieval Motivated Nonlinear MIMO Communication With Magnitude Measurements

Authors: Shengchu Wang, Lin Zhang, and Xiaojun Jing

- **Goal:** Solve the quantized PR problem (inherently - CE and MUD) for a NL-MIMO scheme.

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  - In the uplink TX, MO-MIMO must complete CE and MUD based on the quantized magnitude measurements at the BS
  - Developed CE and MUDs tested for various noise conditions, ADC resolutions, lengths of channel training sequences, and numbers of BS antennas

Contributions:

- Propose a low-power and low-cost NL-MIMO scheme (MO-MIMO).

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- Propose a low-power and low-cost NL-MIMO scheme (MO-MIMO).
- Practical CEs and MUDs were developed for MO-MIMO by categorizing the two problems as a quantized phase retrieval (PR) problem.
- Solved the PR problem by constructing two algorithms under the framework of generalized approximate message passing (GAMP).

Other Interesting Papers

- Mobility-Aware Caching in D2D Networks.
- Full-Duplex Massive MIMO Relaying Systems With Low-Resolution ADCs.
- Distributionally Robust Collaborative Beamforming in D2D Relay Networks With Interference Constraints.
- On the Performance of Beam Division Nonorthogonal Multiple Access for FDD-Based Large-Scale Multi-User MIMO Systems.
- Feedback Mechanisms for FDD Massive MIMO With D2D-Based Limited CSI Sharing.
- Secret Key Generation Based on Estimated Channel State Information for TDD-OFDM Systems Over Fading Channels
- Millimeter-Wave Channel Estimation Based on 2-D Beamspace MUSIC Method