NOMA-based D2D Communications: Towards 5G

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Outline

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3. Problem Formulation
4. Proposed Algorithm
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Background

- **D2D** communications underlaying cellular networks
- **Non-Orthogonal Multiple Access (NOMA)** protocol: facilitate the access of multiple users in the power domain
- **New framework**: NOMA-enhanced D2D, to further improve the spectrum utilization
- **Challenge**: Complicated co-channel interference environment

$$\Downarrow$$

Intelligent resource allocation design is needed

System Description

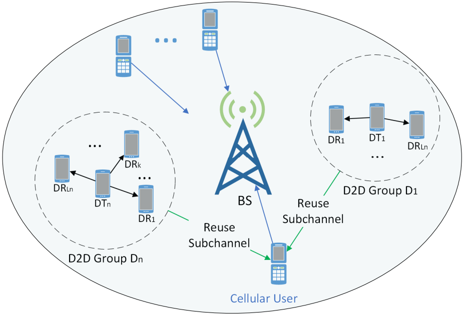


Figure: System model.

- Single-cell uplink scenario
- Set of traditional cellular users: $\mathcal{C} = \{C_1, ..., C_M\}$
- Set of D2D groups: $\mathcal{D} = \{D_1, \ldots, D_n, \ldots, D_N\}$

Channel Model

- Received signal at the BS corresponding to subchannel SC_m:

$$y_m = \underbrace{\sqrt{P_c} h_{m,b} x_m}_{\textbf{desired signal}} + \underbrace{\sum\nolimits_n \eta_{n,m} \sqrt{P_d} g_{n,b} t_n}_{\textbf{interference from D2D links}} + \underbrace{\zeta_m}_{\textbf{noise}}, \quad (1)$$

- Received signal at the k-th receiver in the n-th D2D group:

$$z_{n,k} = \underbrace{f_{n,k} \sqrt{a_{n,k} P_d} s_{n,k}}_{\textbf{desired signal}} + \underbrace{f_{n,k} \sum\nolimits_{k'=k+1}^{L_n} \sqrt{a_{n,k'} P_d} s_{n,k'}}_{\textbf{interference from NOMA users}} + \underbrace{\zeta_{n,k}}_{\textbf{noise}}$$

$$+ \underbrace{\sum\nolimits_{n* \neq n} \eta_{n*,n} \sqrt{P_d} g_{n*,n,k} t_{n*}}_{\textbf{interference from other D2D groups}} + \underbrace{\sqrt{P_c} h_{m,n,k} x_m}_{\textbf{interference from CU}}, \quad (2)$$

Problem Formulation

Maximize the sum rate:

$$\max_{\eta_{n,m}} R_{sum}, \tag{3a}$$

$$s.t. \quad \gamma_{n,k}^{k} \geq \gamma_{n,k}^{thr}, \quad \forall n, k, \tag{3b}$$

$$\gamma_m \geq \gamma_m^{thr}, \quad \forall m, \tag{3c}$$

$$\eta_{n,m} \in \{0, 1\}, \quad \forall n, m, \tag{3d}$$

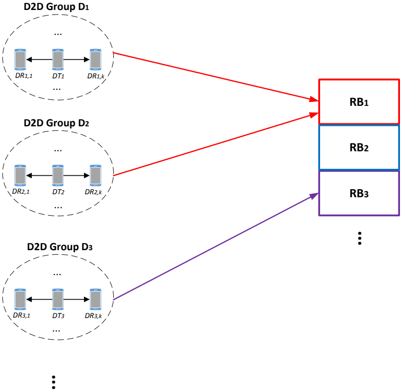
$$\sum\nolimits_m \eta_{n,m} \leq 1, \quad \forall n. \tag{3e}$$

Solution:

- NP-hard $\Longrightarrow$ High complexity
- Solution: Many-to-one matching theory

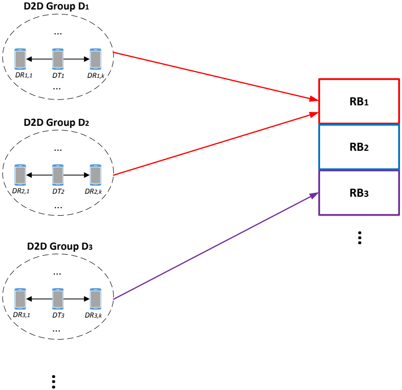
Matching Model

- $\succ$: "Prefer" $\boldsymbol{PL} = \left\{ \boldsymbol{P}(D_1), \ldots, \boldsymbol{P}(D_N), \boldsymbol{P}^{\dagger}(RB_1), \ldots, \boldsymbol{P}^{\dagger}(RB_M) \right\}$
- $RB_m \succ_{D_n} RB_{m'} \Leftrightarrow R_n^m > R_n^{m'}$
- $\mathcal{S} \succ_{RB_m} \mathcal{S}' \Leftrightarrow R_m^{\mathcal{S}} + \sum_{D_n \in \mathcal{S}} R_n^m > R_m^{\mathcal{S}'} + \sum_{D_n \in \mathcal{S}'} R_n^m$



Matching Algorithm

- Step 1: **Initialization**: PL
- Step 2: **Matching Phase**: D2D groups $\xrightarrow{\text{propose to}}$ RBs;
  RBs $\xrightarrow{\text{acceps/reject}}$ D2D groups
- Step 3: **Final matching result**



Numerical Results

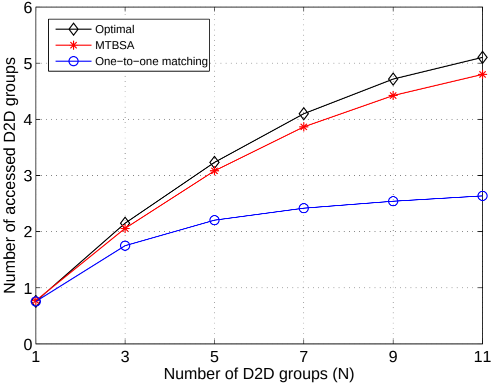


Figure: Number of accessed D2D groups versus different number of D2D groups in the network, with K=3.

Numerical Results (cont')

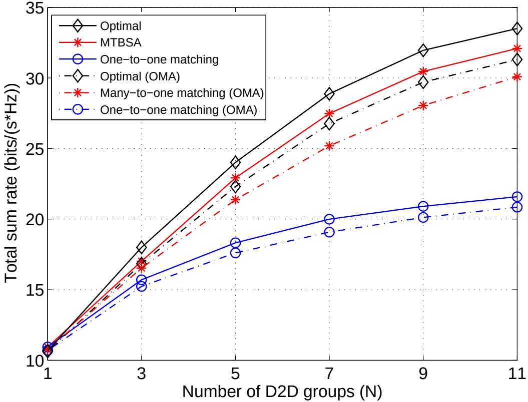


Figure: Total sum rate versus different number of D2D groups in the network, with K=3.

Numerical Results (cont')

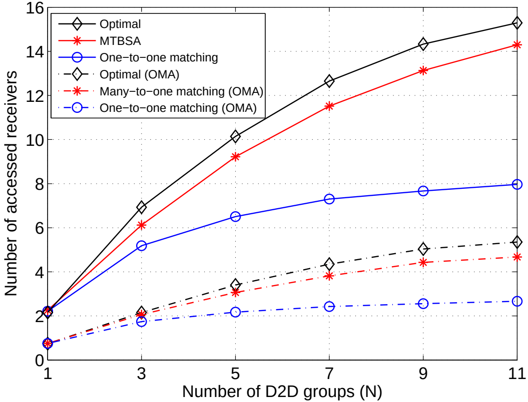


Figure: Number of accessed receivers versus different number of D2D groups in the network, with K=3.

Numerical Results (cont')

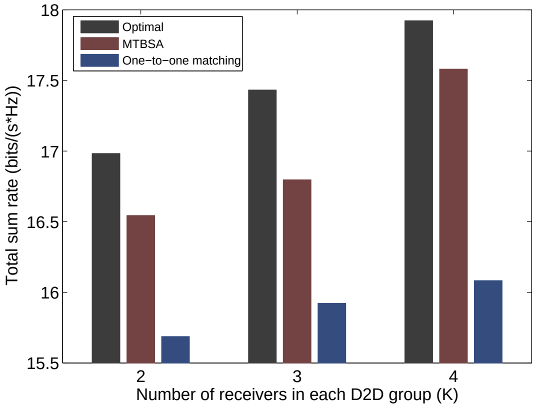


Figure: Total sum rate versus different number of receivers in each D2D group, with N=3.

Conclusions

- NOMA-enhanced D2D framework
- Novel resource allocation algorithm based on **matching theory**
  - Complexity: $\mathcal{O}(NM^2)$
  - Performance: near-optimal performance
- NOMA-enhanced D2D framework **outperforms** OMA-based D2D framework
  - sum rate
  - number of accessed users

Thank you!