Joint Power Control and Link Scheduling in Wireless Networks for Throughput Optimization

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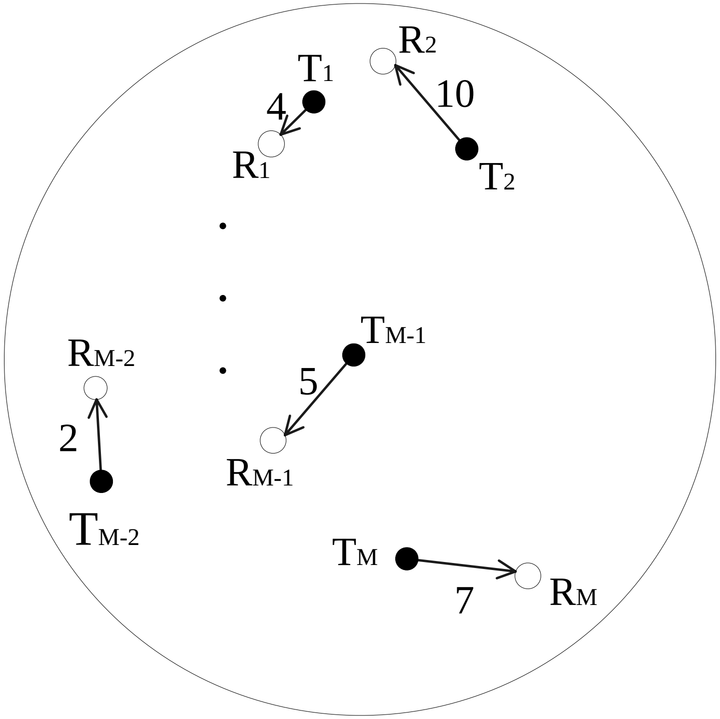
Introduction

- Wireless scheduling
  - Single channel, TDMA network
  - Traffic demands
  - SINR constraints

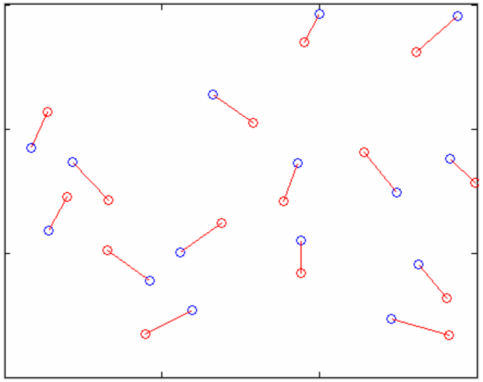


- Objective
  - minimize the total number of time slots
- Power control
  - more links can be active simultaneously
- How to choose the active links in each time slot and the corresponding transmit power ?

Challenge & Solution

- Challenge: too many feasible subset of links
  - Feasible subset of links
    - There exists non-negative power to satisfy SINR threshold

Number of links	15
Possible combinations	$2^{15} = 32,768$
Number of feasible subset of links	11949
Number of feasible subset of links (appear in optimal solution)	23



- Solution: Column Generation method

Column Generation Method

- Decompose the problem into two problems

Master Problem

- Consider only a small number of feasible subset of links

Pricing Problem

- Check whether the solution to the Master Problem is optimal
- Find a feasible subset of links which will further decrease the total number of time slots

- The Pricing Problem is difficult

The Pricing Problem

maximize: $$\sum_{i=1}^{M} \omega_i y_i$$

subject to: $$\frac{p_i \cdot y_i \cdot G\left(T_i, R_i\right)}{N + \sum_{j=1}^{M} p_j \cdot y_i \cdot G\left(T_j, R_j\right)} \geq y_i \cdot \gamma_0$$

variables: $$p_i \geq 0, \quad \text{if} \quad y_i = 1$$
$$p_i = 0, \quad \text{if} \quad y_i = 0$$
$$y_i \in \{0,1\}$$

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The subset of links $\mathbf{y}$ is feasible ⟷ $$\frac{1}{\rho(\mathbf{B_y})} > \gamma_0$$

Power solution $\mathbf{p_y}$: the Perron eigenvector corresponding to $\rho(\mathbf{B_y})$

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Algorithms

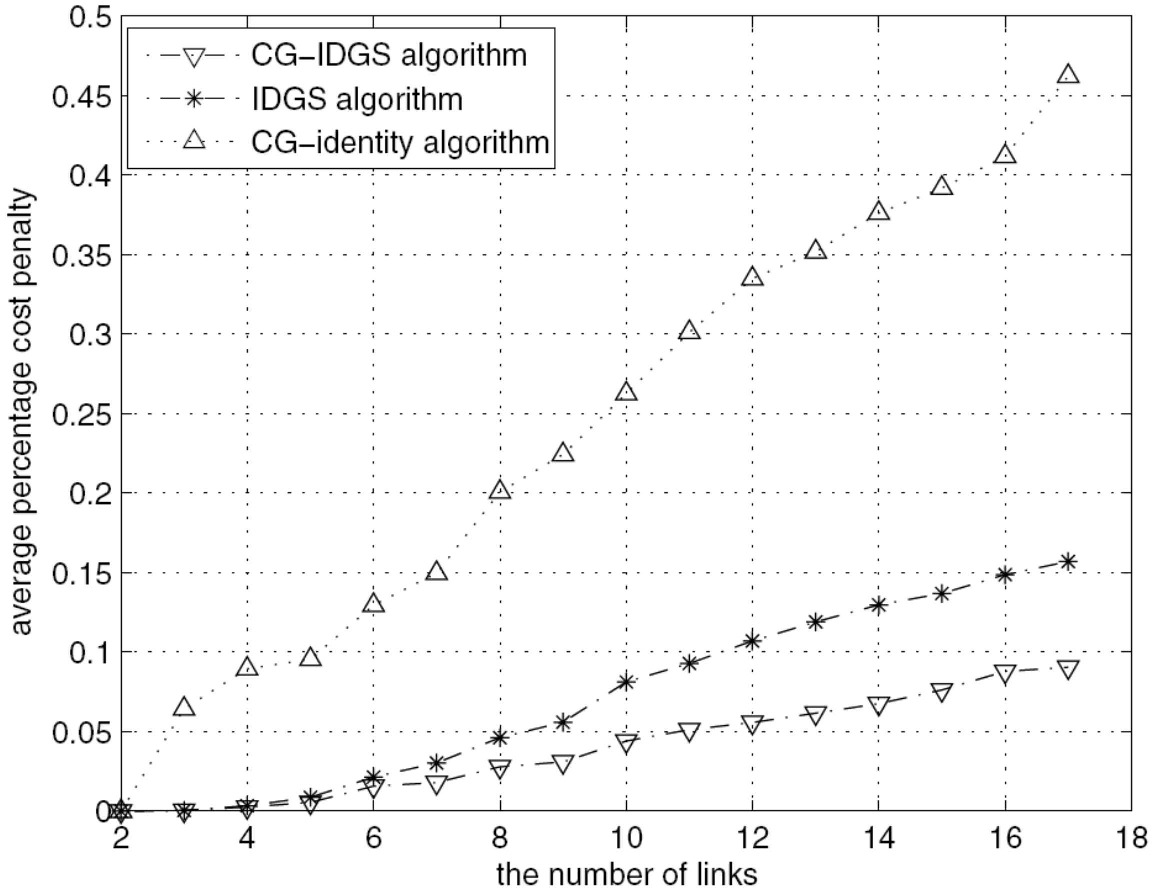
- Solve the Pricing Problem
  - Combined Sum Criterion Selection (CSCS)
- The Initial Feasible Subset
  - A simple Initial Solution
    - Each subset only contains one link: Identity
  - A good Initial Solution
    - Decrease the number of iterations
    - **Increasing Demand Greedy Scheduling (IDGS)**

Simulation Results

- Simulation setting:
  - Location: uniformly distributed in a square $(1km \times 1km)$
  - Path loss model: exponent 4.
  - Traffic requirement: discrete r.v. $[1, 3, 5, \cdots 19]$
  - Averaged over 1000 random networks.

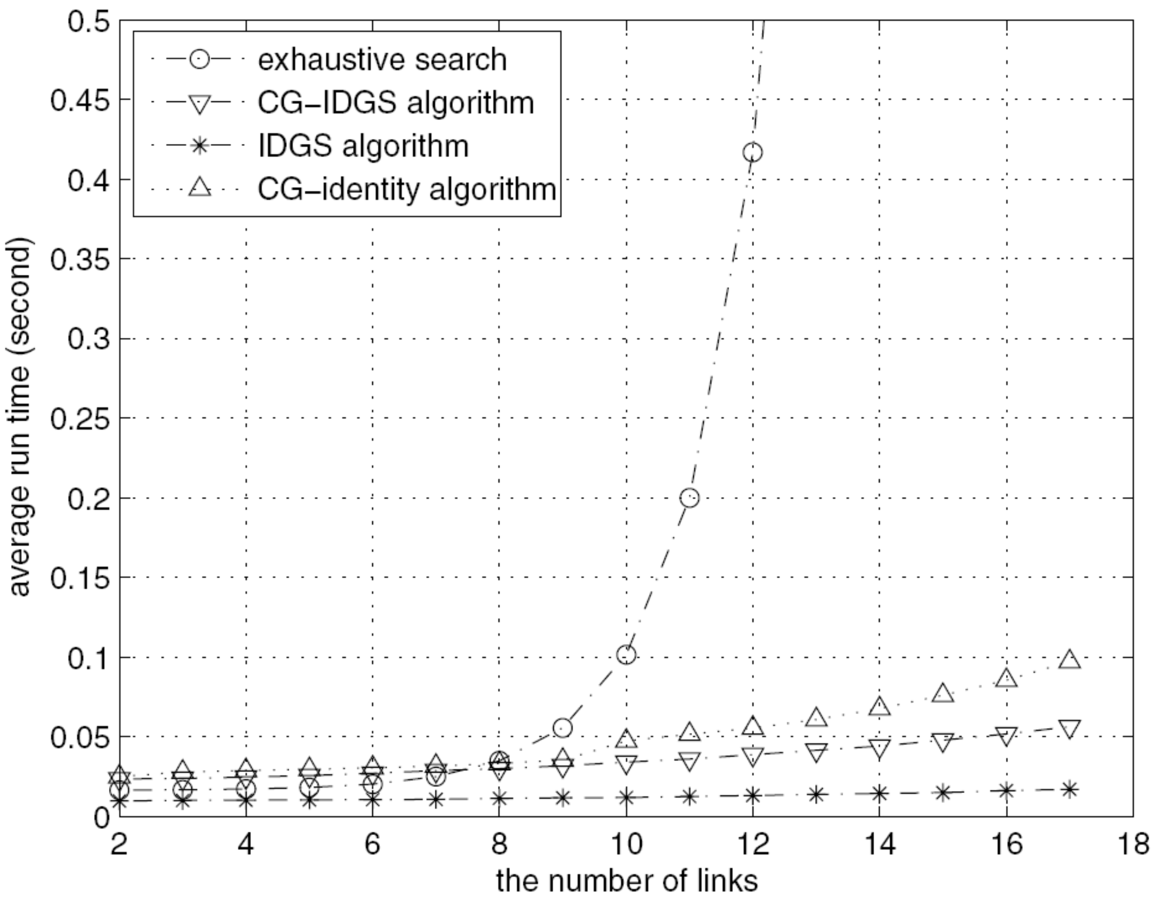
- Performance comparison:
  - IDGS algorithm
  - CG-identity: Column Generation
    - Initial feasible subsets: each subset only consists one link
  - CG-IDGS: Column Generation
    - Initial feasible subsets: generated by IDGS algorithm

Simulation Result (1)



$$\frac{L - L_{opt}}{L_{opt}} \times 100\%$$

Simulation Result (2)



Conclusion & Extension Work

- Conclusion:
  - Propose Column Generation Method
  - Simplify the Pricing Problem without any loss.
  - Column generation + IDGS achieve great performance in short run time.
- Extension Work
  - A general wireless network: half duplex, non-simultaneously reception
  - Different SINR requirements at different receivers
  - The power is limited by a certain value.

Thanks!