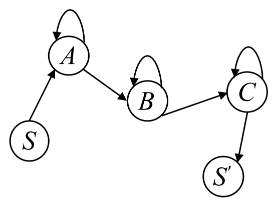
Optimizing Carpool Scheduling Algorithm through Partition Merging

Yubin Duan, Turash Mosharraf, Jie Wu, and Huanyang Zheng

Center for Networked Computing, Temple University, USA

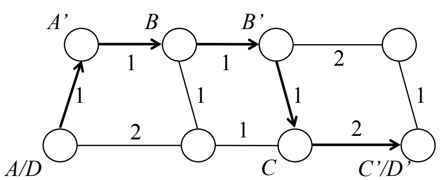
Carpool scheduling problem

- **Target**: minimizing carpools needed, each user has distinct src *s* and dest *d*
- **Detour constraint α**, e.g. no more than $\alpha = 20\%$ of the shortest path
- **Capacity constraint k**, vehicle has capacity limitation, e.g. $k = 2$
- **NP-hard** problem: a special case can be reduced to Hamilton tour



Find a Hamilton tour shorter than $(1+\alpha)$|SS'|

Motivation



- Another user can re-carpool with drivers after previous user got off
- A 4-people carpool D – A –A' –B – B' –C – C' –D' with $k = 2, \alpha = 20\%$
- The minimum number of carpools needed is 1

A Greedy Solution

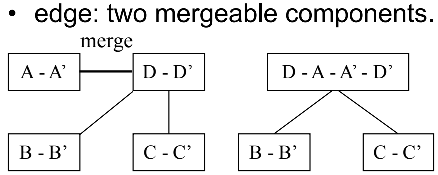
- Based on **component merge**
- **Initialization**, each component contains only one element

  A - A' | B - B' | C - C' | D - D'

- Each component is **a local sequence of *s* and *d***. *d* always appears after corresponding *s*.

  D - A - A' - B - B' - C - C' - D'

- **Merge:** Two components can be merged if all elements can be combined that satisfies capacity constraint k and detour constraint α.
- Construct a **component matching graph**,
  - vertex: component
  - edge: two mergeable components.



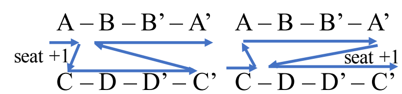
- **Maximum matching** on the component graph to generate new graph
- Repeat maximum matching on the new graph until convergence.

Merge Methods

- E.g. S: A- B- B'- A'; S': C- D- D'- C'
- **Simple merging (SPA)** [1]**:** O($n^{2.5}$)
- **Full permutation (PMA):** O(n!)

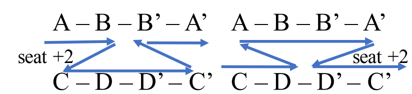
  D - A - B - C - A' -B' - C' - D' not properly nested

- **Driver-alone** insertion **(PMAD):** O($n^{2.5}$)

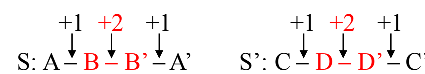


properly nested

- **General** insertion **(PMAG):** O($n^{2.5}$)



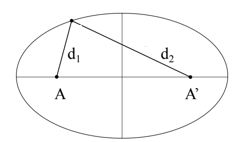
properly nested



(a) S' inserted to S (b) S inserted to S'

Improvement

- In **Euclidean space,** matching eligibility via **geometry properties**

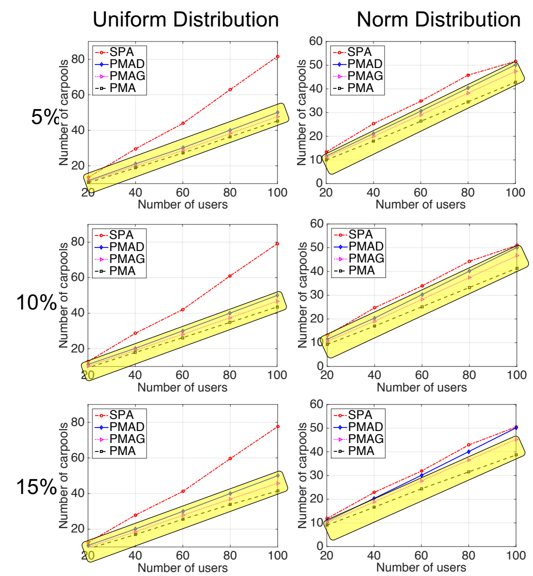


feasible area: $d_1+d_2 = (1+\alpha)$|AA'|

Simulation Results

- **Synthetic dataset**: *s* and *d* locations are individual and range from 0-30 miles in 2-D space.
- **Real-world dataset**: *s* and *d* are extracted from traces of NYC cabs

NYC Yellow Cab Trip Record Data	
Time span	01/01/2017 to 01/31/2017
Avg. requests/min	216.2
Avg. travel time	14.92 mins
Avg. trip distance	2.831 miles
Avg. passenger counts	1.6



- 1. F. Buchholz, "The carpool problem," 1997.