Optimizing Carpool Scheduling Algorithm through Partition Merging

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Carpool scheduling problem
- **Target:** minimizing carpools needed, each user has distinct src s and dest d
- **Detour constraint α**, e.g. no more than α = 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

Motivation
- Another user can re-carpool with drivers after previous user got off
- A 4-person carpool D – A – A’ – B – B’ – C – C’ – D’ with k = 2, α = 20%
- The minimum number of carpools needed is 1

A Greedy Solution
- Based on component merge
- **Initialization**, each component contains only one element
  - A, B, C, D

- Each component is a local sequence of s and d. d always appears after corresponding s.
  - A, B, 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)**: O(n!)
- **Full permutation (PMA)**: O(n!) not properly nested
- **Driver-alone insertion (PMA)**: O(n^2.5)
  - S: A – B – B’ – A’
  - S’: C – D – D’ – C’

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. request/min: 216.2
- Avg. travel time: 14.92 mins
- Avg. trip distance: 2.831 miles
- Avg. passenger counts: 1.6

Improvement
- In Euclidean space, matching eligibility via geometry properties
  - feasible area: d_1 + d_2 = (1+α)|AA’|