Autonomous Vehicles Impact on Ride-hailing

a project in mobile data management

Vehicle motion-categories

- Origin->destination
- Stationary (Parked)
- Resource-search

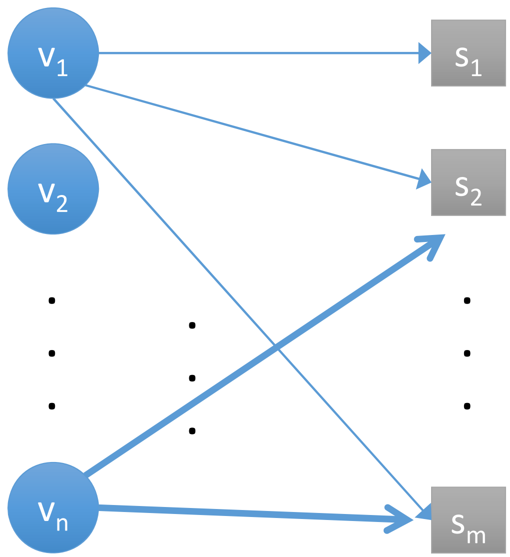
AV impact due to higher initial cost and lower operation cost

Benefits of pooling ride-requests (customers) and ride-offers (vehicles)

t1

Benefits of pooling ride-requests (customers) and ride-offers (vehicles)

Each time period



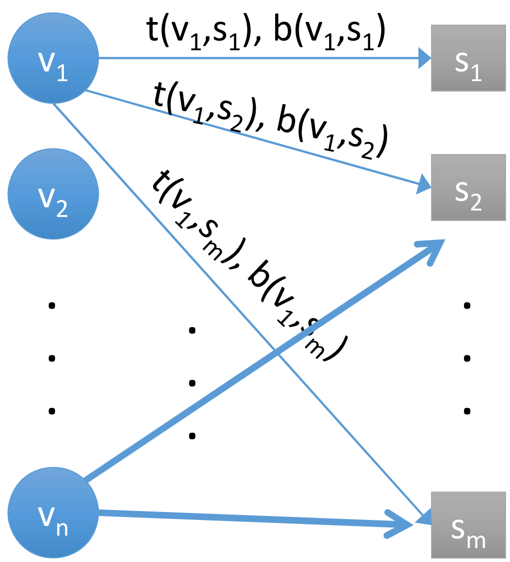
Matching in a bi-partite graph

Utility metrics

- Benefit of resources to vehicles
  - Longer trip preferable to shorter one

- Benefit of vehicles to resources (customers)
  - Travel-time between from AV to resource

Each pair (v_i,s_j) has a travel-time $t(v_i,s_j)$ and a benefit $b(v_i,s_j)$



Matching in a bi-partite graph

Is the benefit an attribute of the customer S_1
or edge (between vehicle and customer)?

Is the benefit an attribute of the customer or edge (between vehicle and customer)?

S_1

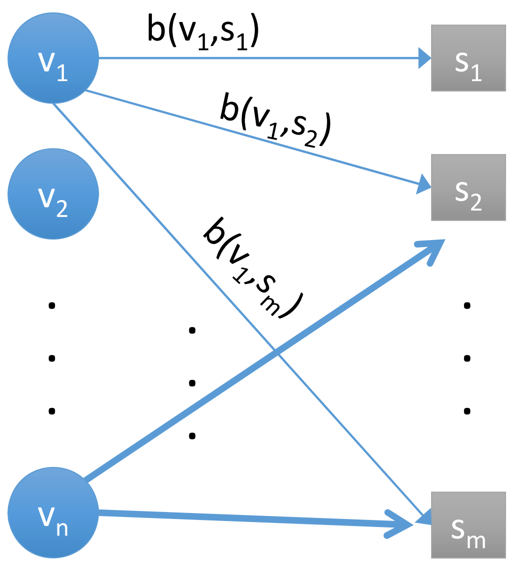
- Benefit of resources to vehicles
  - Benefit of a resource may depend on vehicle
    - Distance between vehicle and customer
      - Benefit = $/TraveledMile
    - Next destination (or depo) of vehicle

Possible objective functions in matching

- Maximize total benefits of vehicles

- Minimize total wait time of passengers

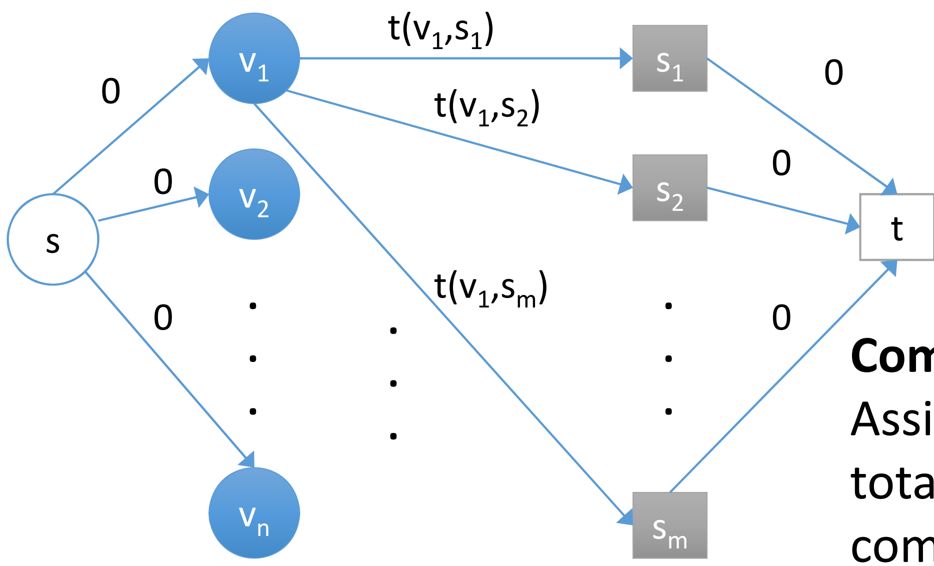
Optimum assignment: max benefit



Assign resources to vehicles such that total benefit is maximized

Max weighted bipartite matching

Minimum Total Wait time

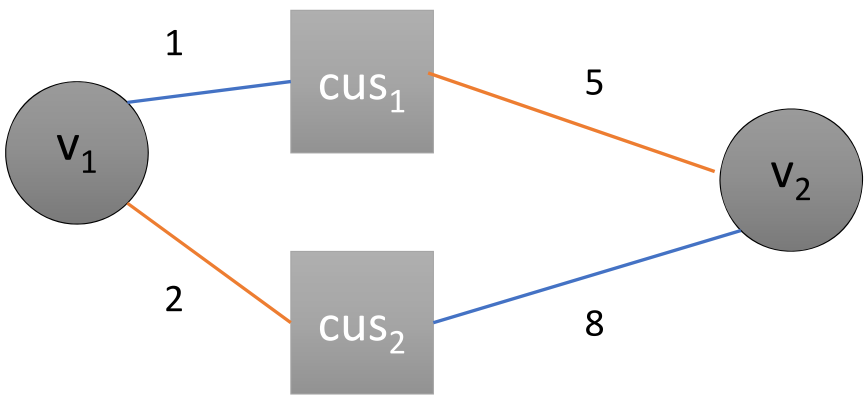


Complexity:
Assignment with minimum total time traveled can be computed efficiently

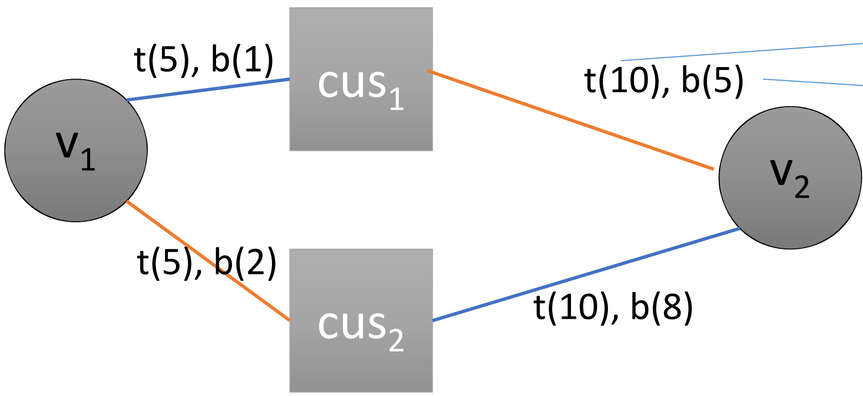
BY: reduction to minimum cost network flow problem.

Customer wait times, 1/benefit

Crowdsourced (fair) vs Autonomous Vehicles(owned)



Resource assignment: Fairness vs. optimality



- Travel time between v_2 and c_1
- Benefit of assigning c_1 to v_2

Optimum V_1->S_1 and V_2->S_2 at total-benefit 9; Total time always 15
but V_1 and S_1 can improve benefit/time

Fair V_1->S_2 and V_2->S_1 at total-benefit 7;
V_1 and V_2 cannot improve
S_1 and S_2 cannot improve

Project objective

- Compare total customer wait times, customer search time, average taxi profit, for autonomous and crowdsourced vehicles

- Plot as a function of assignment period

Air Pollution Personalization

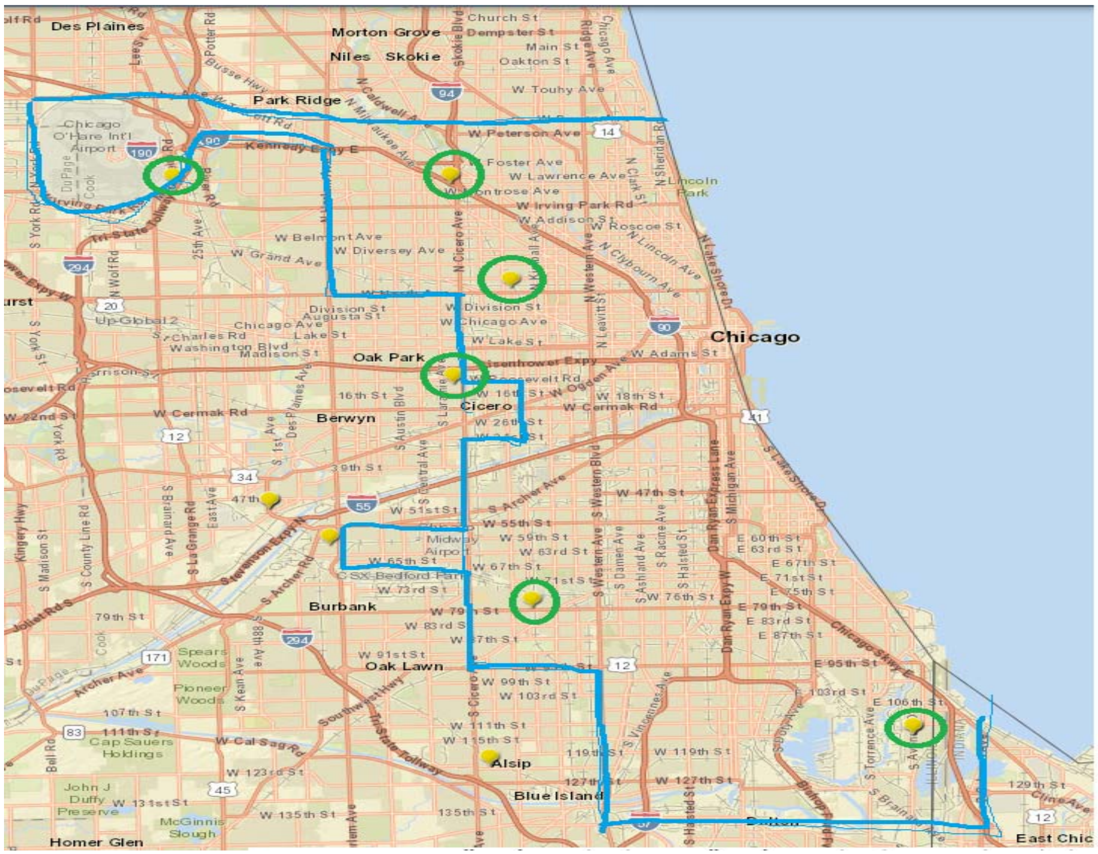
Topics:

Data Fusion and Integration
Mobile Data Management

Background

- World Health Organization (WHO): air pollution the world's largest environmental health risk
- China: over 1 million deaths attributable to air pollution in 2012
- India: pollution levels exceeding 20 times the maximum indicated by the WHO
- U.S.: 166 million people live in areas with unhealthy air
- Health Effects Institute: for each 10 $\mu g \cdot m^{-3}$ increase in PM_{10}
  - an approximate 1% increase in hospital admissions for cardiovascular disease
  - a 2% increase in admissions for lung diseases in vulnerable population
- each 10 $\mu g \cdot m^{-3}$ elevation in $PM_{2.5}$ air pollution, approximately a
  - 4% increased risk of mortality
  - 6% increased risk of mortality due to cardiopulmonary disease,
  - 8% increased risk of mortality due to lung cancer

EPA Airnow stations in Chicago



Color code

$PM_{2.5}$	Air Quality Index	$PM_{2.5}$ Health Effects	Precautionary Actions
0 to 12.0	Good 0 to 50	Little to no risk.	None.
12.1 to 35.4	Moderate 51 to 100	Unusually sensitive individuals may experience respiratory symptoms.	Unusually sensitive people should consider reducing prolonged or heavy exertion.
35.5 to 55.4	Unhealthy for Sensitive Groups 101 to 150	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease, the elderly and children should limit prolonged exertion.
55.5 to 150.4	Unhealthy 151 to 200	Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion.
150.5 to 250.4	Very Unhealthy 201 to 300	Significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; significant increase in respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.
250.5 to 500.4	Hazardous 301 to 500	Serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.

Personalization of EPA data

- physiology (age, gender, health condition)
- activity (still, running, walking, biking etc.),
  - Its Intensity

Project Objective

- Integrate following data sources
  - ios/android activity recognition
  - Smartphone sensors (GPS, accelerometer, compass)
  - meteorological features, e.g. wind speed and direction
  - Physiology
- To <u>automatically, seamlessly</u> determine heart rate (tightly correlated with breathing rate)

Possible approach

- Machine learn the heart rate using examples
- Examples can be generated by people wearing a heart rate monitor.

Project result:

- Accuracy of the heart-rate prediction

- app that answers continuous query:

  - What is my current level of pollution inhalation?

Desired (but not strictly necessary) qualifications of team

- Familiarity with machine learning