Incentives in Ridesharing with Deficit Control

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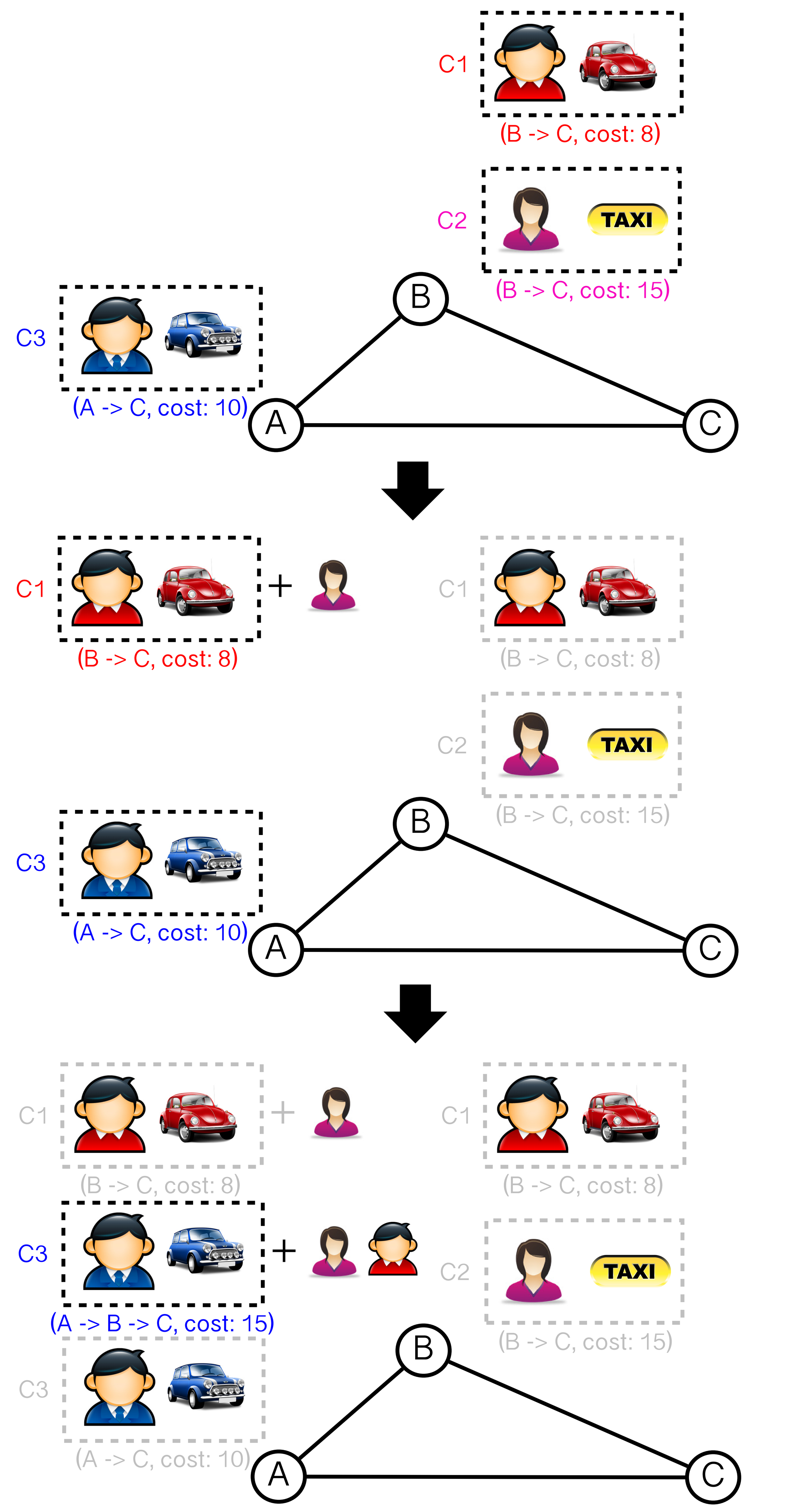
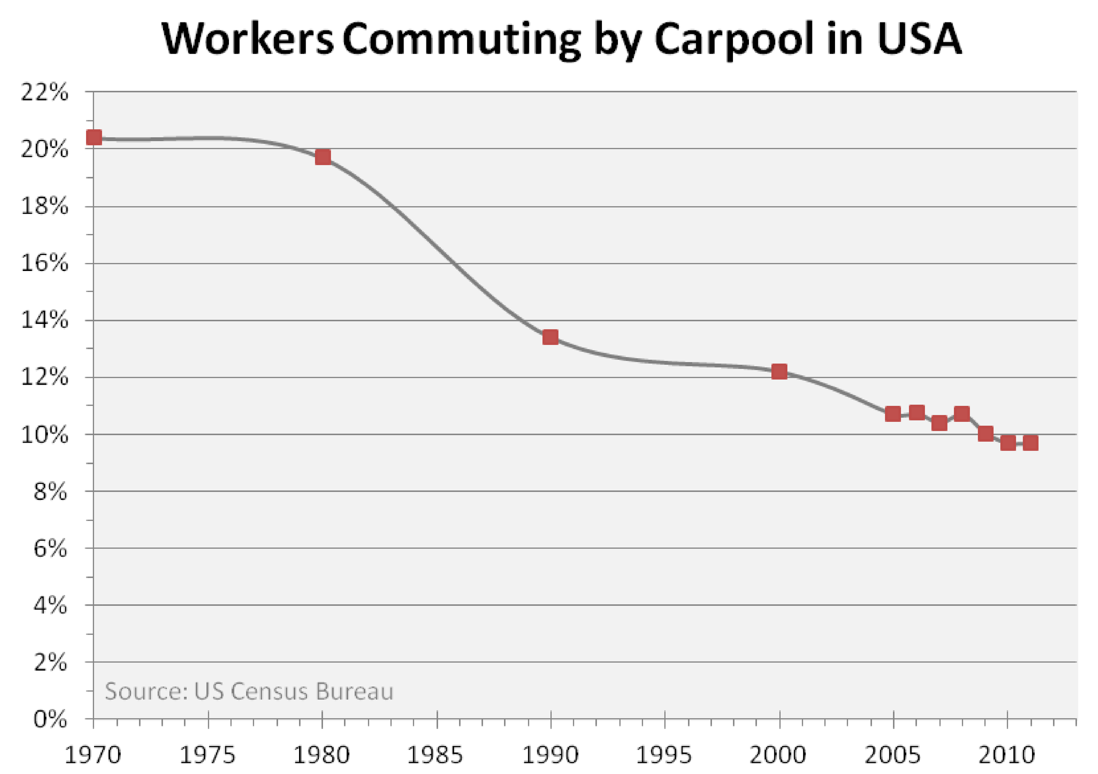
Ridesharing Example



Ridesharing Market



- Australia (Queensland) will end ridesharing/transit lanes.
- The average car carries just 1.6 people.

Although the market share of ridesharing is not promising, there is a very BIG potential/demand of further development:

- More than 600 ridematching services in US in 2011.
- European ridesharing platform providers *Carpooling.com* and *BlaBlaCar* claimed more than 6 million users in 2012.
- *BlaBlaCar* arranges 400,000 rides a month, equal to 1,000 French high-speed trains.

Problems of Existing Ridesharing

- Flexibility, reliability, safety and privacy,
- **Complicated ride-matching and ride arrangement,**
- **No free market competition.**

Our Contributions

We proposed

1. **the first comprehensive ridesharing model** studied from a pure game-theoretic point of view.
2. **auction-based ridesharing** system incentivizing participation.
3. **flexible deficit control** rather than completely remove deficit.

We showed that although **VCG** mechanism meets most of our goals, it **leads to very high deficit**. Therefore, we designed **two alternatives with flexible deficit control**:

1. Serial dictatorship mechanism with fixed payments.
2. VCG with reserve prices.

The Model

1) Route map: a graph $G = (L, E)$,

- L: stopping points/locations,
- E: routes between stopping points,
- $w(e)$: time required to travel via $e \in E$.

2) Commuter i's **trip:** $\theta_i = (l_i^d, l_i^a, t_i^d, t_i^a, c_i, q_i)$

- $l_i^d, l_i^a \in L$: departure and arrival **locations**,
- t_i^d, t_i^a: earliest departure, latest arrival **time**,
- $c_i \in \mathbb{R}^+$: travel **cost** to finish the trip,
- $q_i \in \mathbb{N}$: extra **seats available** on the trip.

3) Each commuter is allocated as:

- **driver**: drives and takes riders
- **rider**: goes with drivers
- unmatched: goes with his original mode

4) The **valuation** of a

- driver: detour cost
- rider: cost saved

Serial Dictatorship Mechanism with Fixed Payments

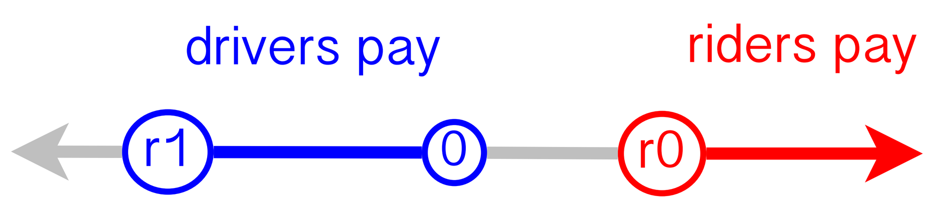
Given predefined fixed payments $p^0 \geq 0$ (for riders) and $p^1 \leq 0$ (for drivers), the allocation is determined as follows:

1. Define the set of (potential) drivers and riders **independently of their trip information**.
2. Order potential drivers and riders independently of their trip information.
3. Maximize drivers utility **according to the order and their trips** (the order of riders is used for tie breaking).
4. Each rider/driver gets the fixed payment p^0/p^1.

VCG with Reserve Prices

Given predefined reserve prices $r^0 \geq 0$ (for riders) and $r^1 \leq 0$ (for drivers), choose the most efficient ride-matching/allocation such that

1. for each rider i, she/he pays **at least** r^0.
2. for each driver j, she/he receives **at most** $-\delta_j r^1$, where δ_j is j's detour time cost over his original shortest travel time.



Properties of Our Mechanisms

Serial Dictatorship Mechanism with Fixed Payments:

- **truthful and individually rational**
- **better deficit control than VCG**
- **very inefficient**

VCG with Reserve Prices:

- **truthful iff** $r^0 \geq -r^1$.
  Otherwise, the manipulation gain is bounded $(\max(-r^1 - r^0, \delta_i^{max}(-r^1 - r^0)))$.
- **weakly budget balanced** without detour. Otherwise, deficit is bounded $(-n_d \delta^{max} r^1 - n_r r^0)$.
- **more efficient** as $r^0 + r^1$ decreases.

Note that, both fixed prices and reserve prices can be defined dependent on the allocation.

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