Objective
We propose a system for vehicles to reserve space-time trajectories before departure, with priority in the reservation system determined by an auction. The system provides reduced and known arrival times for high-priority vehicles. Reservations are made through a combinatorial assignment algorithm.

Assumptions
Trajectories are space-time paths with specified arrival times for every spatial point.
- All vehicles reserve trajectories before they depart.
- Vehicles reserve minimum travel time trajectories.
- Cell transmission model for traffic flow.
- First-in-first-out behavior.
- Autonomous intersection management.
- Update connectivity so that later-reserving vehicles cannot interfere with previously reserved trajectories.

Trajectory reservation algorithm
- Order through each vehicle in order of priority, allowing it to reserve an unassigned remaining minimum travel time path.
- Update connectivity so that later-reserving vehicles cannot interfere with the newly reserved trajectory.
  - Initialize-connectivity():
    - Set Y by descending for all \( v \) in Y do
      - \( \pi_v = \text{shortest-path}(v, s, t_v) \)
      - Reserve(\( \pi_v \))
      - end for
- Preventing loitering trajectories
  - Setting (\( \zeta_i(t) = 0 \)) in (b) prevents loitering.

FIFO ordering
- Earlier-departing, lower-priority vehicle \( t' \) could overtake \( v \) in FIFO order.
- Solution: After reserving trajectory for \( v \), remove cell connectivity if FIFO would invalidate v’s trajectory.

Proposition 1
The trajectory reservation algorithm results in vehicle trajectories that satisfy CSM flow constraints and FIFO behavior.

Time complexity
\[
O(|\mathcal{V}| \log |\mathcal{V}| + |\mathcal{E}| + |\mathcal{F}| \log |\mathcal{V}| + |\mathcal{V}|^2 \Gamma + |\mathcal{V}|^3)
\]

Conclusions
- Combinatorial algorithm for trajectory reservations (compatible with congested networks).
- Reduced travel times for high-priority vehicles.
- Lower average travel times for all vehicles (compared with dynamic user equilibrium).
- Acceptable trips with reduced departure or arrival times.

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Auctions held every \( T \) minutes.
- More practical, vehicles only need to reserve their trajectory \( T \) minutes before departure.
- Benefits to high-bidding travelers are reduced and depend on departure time.

Downtown Austin
- Auctions every 15 minutes
- Average over 2 minutes
- Benefits to high-bidding travelers are reduced and depend on departure time.

Travel time and reservation priority
- 0.00 0.01 0.02 0.03 0.04 0.05 0.06
- Average percentage delay
- Reservation priority

Average travel time
- 0 5 10 15 20 25 30 35 40 45
- Average travel time
- Reservation priority
- Free flow travel time

Travel times significantly less than dynamic user equilibrium.
- Queueing and congestion are reduced as a corollary of maintaining the validity of reserved trajectories.
- Lower-priority vehicles experience greater delays on average.
- High variance in delays for low-priority vehicles.
- Earlier-departing, lower-priority vehicle \( t' \) could overtake \( v \) in FIFO order.
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