Interchange: Bidding for Green Lights

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ABSTRACT

In urban environments great effort is directed toward alleviating traffic including the design and implementation of complex software and hardware infrastructure. We introduce the idea of an auction-based mechanism for resolving vehicle intersections using a multi-way group auction mechanism. We propose a supporting infrastructure that has promise for increasing performance and responsiveness to dynamic traffic conditions. In order to evaluate new intersections, we propose new metrics that attempt to capture a more human aspect of vehicular transportation. We demonstrate that Interchange intersections perform well in single and multi-grid configurations, are self-adapting and are responsive to a variety of traffic loads.

THE PREMISE

- Participants have a dashboard User Interface
  - specifying navigation
  - specifying price point
    - [$0.00 - $1.00]
    - pay to turn light green
  - connected to network
- "Interchange" manages intersections
  - using auction mechanics
  - aggregates bids from many drivers
  - selects light patterns that
    - are safe
    - maximize accepted bids

IMPLICATIONS

- Graceful adoption
  - Not all driver's must participate
  - Not all intersections must be supportive
  - Robust to failure
    - Naturally degrades to loop sensors
    - Simple timers
  - Does not require global coordination
- Driver's route must be known
- Solo cars on roads always get green lights for free
- Rushed drivers can pay for green lights
- Cost-sensitive drivers travel in packs
- Ambulances can be given infinite bids
- Instead of money, "credits" could be used that are issued based on environmental impact of vehicle
- Auction losers can receive winners credits
  - Trade off waiting now for priority later
- Sponsors could pay to supplement bids for
  - turns into drive-thru's
  - increased response after public events
- Credits could be traded on a secondary market
- Buses and carpools could multiply their bid by the number of passengers

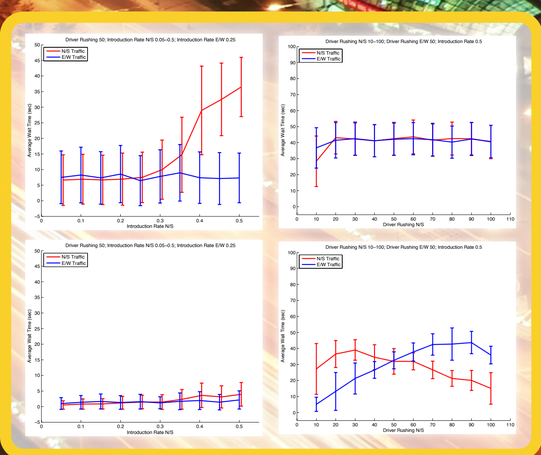
MODELING

When vehicles approach within 10sec (distance varies based on vehicle speed) of an intersection, i, on a route in which they are being confronted with a red light they make a bid via Interchange for a green light and begin decelerating to a stop. A bid is formally a 3-tuple, $b = \{o, d, v\}$, specifying the lane of origin, $o \in O_i$, the destination lane, $d \in D_i$, and a bid value $v \in [\$0.00 - \$1.00]$. A vehicle may only bid once per intersection. Interchange maintains a database of bids and first, aggregates across those that begin and end in the same lanes, $B_{o,d} = \sum_{b \mid b.o=o, b.d=d}(b.v)$. Each intersection, based on the lane and road configuration, has a set of traffic patterns, $\bar{P}$, that when followed, would not result in collisions. Each pattern, $p \in \bar{P}$, allows multiple simultaneous non-colliding transitions of the form $o \rightarrow d$. As time progresses Interchange monitors the aggregation of bids, $\bar{B}$, and then further aggregates for each p, the total bid for a light pattern: $T_p = \sum_{(o,d) \in p}(B_{o,d})$.

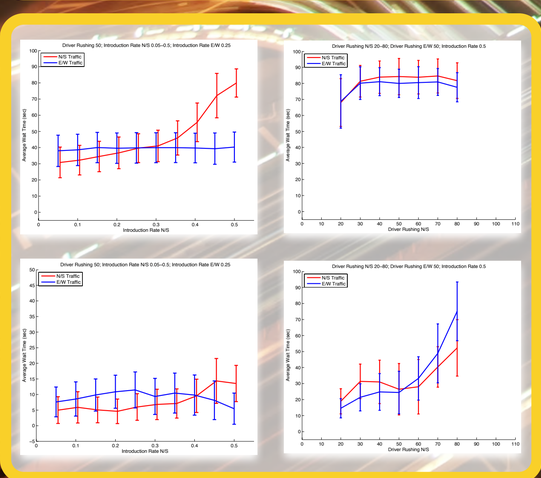
When any pattern bid, T_p, becomes higher than that of the current winning pattern the lights switch to the pattern with the new highest bid, with yellow lights assigned to lanes whose setting is changing from green to red. Bids from slowing and stopped cars are only subtracted from the aggregates as they leave the intersection, not when the lights switch. After a light change, the *second* highest bid *at the time of the last pattern switch* was T'_p. Individuals that benefit from the switch are charged the equivalent proportion of T'_p that they bidded for in T_p. This is consistent with the lowest price that could have been offered to win the auction. Vehicles that pass through the green light after the auction resolution are not charged. Additionally, appropriate minimum switching times are enforced.

RESULTS

SINGLE



MULTI



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