Selecting Compliant Users for Opt-in Microtolling
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Micro-tolling
In the U.S., traffic congestion costs were estimated at $305 billion during 2018 [Citylab 2018].

Q: Can selfish drivers be incentivized to act socially?
A: Yes! By imposing tolls [1].

Q: Does the system optimum require that all drivers respond to tolls?
A: No! Influencing a specific subset of the drivers (~50%) is usually sufficient [2].

Our Question: What if the subset of influenced drivers is limited in size?

Determining the Compliant Subset
1. Estimate the benefit of making a particular agent compliant instead of non-compliant.
2. Greedily select the agent’s with the highest predicted benefit if compliant.

Determining “benefit of compliance”
The benefit of agent a being compliant:

\[ h^*(a) = m_l - m_g + (l_l - l_g) v_a \]

Where:
- \( m_l \) is the marginal impact of a if non-compliant.
- \( m_g \) is the marginal impact of a if compliant.
- \( l_l \) is the latency suffered by a if non-compliant.
- \( l_g \) is the latency suffered by a if compliant.
- \( v_a \) is agent a’s value of time.

Marginal impact is unknown in practice.
We approximate \( h^* \) with the difference in marginal cost path heuristic:

\[ DMCP(a) = t_l - t_g + (l_l - l_g) v_a \]

Where:
- \( t_l \) is the approximated marginal cost toll paid by a if non-compliant.
- \( t_g \) is the approximated marginal cost toll paid by a if compliant.

Experimental Results:
1. Use \( \Delta \)-Tolling to approximate marginal-cost toll [4] for DMCP.
2. Evaluate on three traffic scenarios (two shown).
3. Compare to other agent selection mechanisms.
   a. TE: Use negative of agent’s value of time to approximate \( h^* \).
   b. RANDOM: Random assignment.

DMCP and DMCP+TE achieve near optimal performance with less than 50% of agents compliant!

Motivation
Tolling is unpopular! [3]
Our solution: Optional participation in a tolling scheme.

Opt-in Microtolling
Some drivers are charged tolls and others are not.
- Charged tolls = compliant agents
- Not charged tolls = non-compliant agents
All drivers can take any link in the road network.
Rational agents would need to be incentivized up front to join system:
  - Not the focus of this paper.

It matters who is compliant!
- Red car has a single path to destination.
- Blue car has two paths to choose from.
- If the red car is compliant it has no effect.
What limited subset of agents should we incentivize to comply to achieve the largest improvement in social welfare?