## Problem

- Traffic congestion is a practical problem resulting in substantial delays and extra fuel costs for drivers, and has negative impacts on environmental conditions.
- For urban road networks, better traffic flow requires better traffic signal control, and real-time, adaptive strategies offer the biggest payoff:
  - Real-time decisions: traffic light cycles through a sequence of phases $I$, each phase $i$ has a variable duration that can range between a minimum and a maximum.
  - Local observation: inflows of vehicles in the prediction horizon ($H$), the current phase index and duration of traffic light, and the current decision time.

## Challenge

Goal: Scalable network-wide optimization
- Intersection level: the number of joint signal control sequences and local observations is huge in the prediction horizon.
- Network level: effective coordination for handling non-local impacts between tightly-coupled intersections in a complex network.

## Contributions

- Real-time traffic signal control based on coordinated look-ahead scheduling:
  - Each intersection is locally controlled by an agent using a schedule-driven intersection control strategy (SchIC) [3]. At each decision point, each agent constructs a schedule that optimizes movement of the observable traffic through its intersection, and uses this schedule to determine the best control action to take.
  - For strengthening its local view, each agent queries the scheduled outflows from its upstream neighbors to obtain an optimistic observation, which is capable of incorporating non-local impacts from indirect neighbors.

### Summary

- Multi-agent coordination = look-ahead scheduling + coordination mechanism(s)

## Reference


## Performance Evaluation

<table>
<thead>
<tr>
<th>Demand (vehicles/hour)</th>
<th>Waiting Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td>200</td>
</tr>
<tr>
<td>B</td>
<td>300</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
</tr>
<tr>
<td>D</td>
<td>500</td>
</tr>
<tr>
<td>E</td>
<td>600</td>
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## Control Strategies

- BPU: Balanced phase utilization [1] (offset calculation)
- SchIC: Schedule-driven intersection control [3]
- CoLo: SchIC + Optimistic non-local observation

## Ongoing Work and Future Directions

- Pilot test: Scalable urban traffic coordinator:
  - Currently testing a 9-intersection 2-way road network in the East Liberty area of Pittsburgh, PA, USA.
  - Real-world challenges: uncertainty, robustness to failures.
  - URL: https://pilot.surtrac.net (available soon)

- Advanced coordination mechanisms:
  - Pricing mechanisms to dampen any disruptive changes on schedules made by upstream agents (intersections).
  - Negotiation mechanisms to reach for an equilibrium in an over-saturated traffic sub-network.
  - Dynamic learning of edge weights for critical flows.