Adaptive Ramp Control

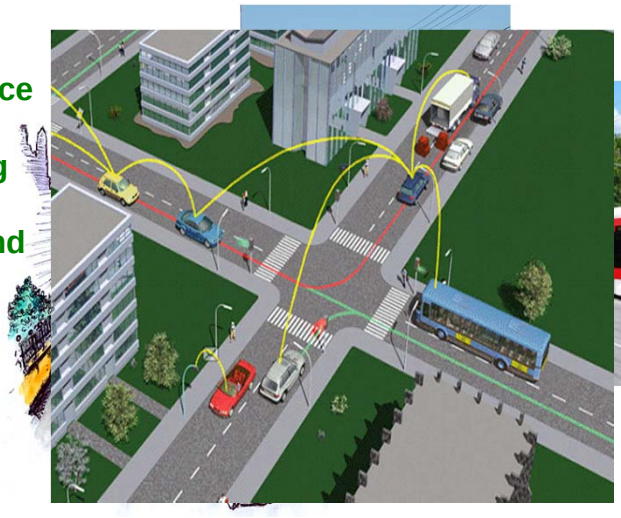
The Gardiner Expressway Case Study

Baher Abdulhai
Kasra Rezaee
Department of Civil Engineering

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute

Congestion Solutions

Intelligence for managing both supply and demand



More Supply

Less Demand

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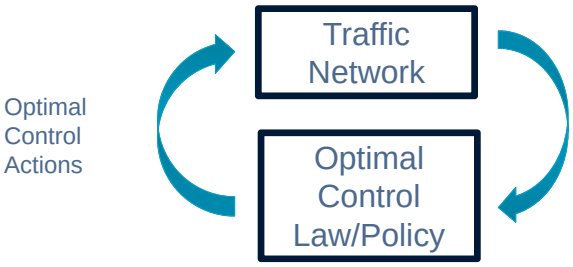
Control Approach Characteristics

1. "Pacing" Beats "Rushing"
2. Real Time: Closed Loop Optimal Control
3. Role for Artificial Intelligence

2. Closed Loop Optimal Control



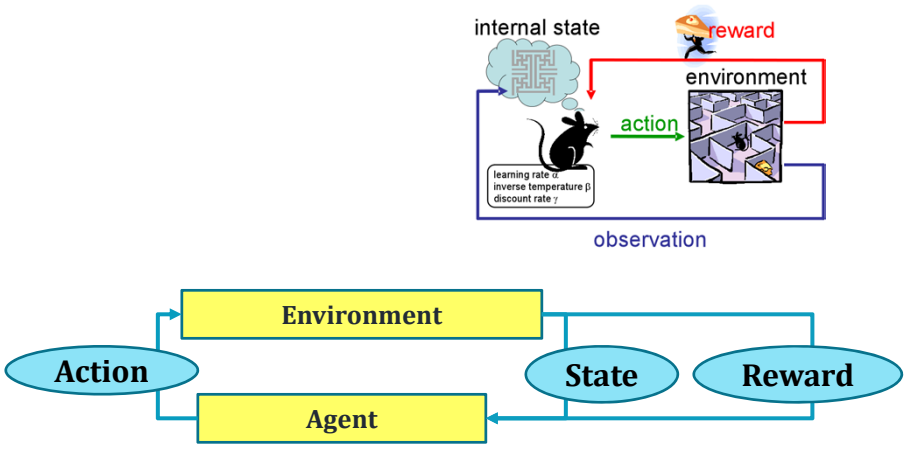
- Always measuring and mapping system state to optimal actions
- Better chance to be on top of changes
- But:
  - How to get the optimal control policy

Possibly let the controller learn it: Machine Learning and AI

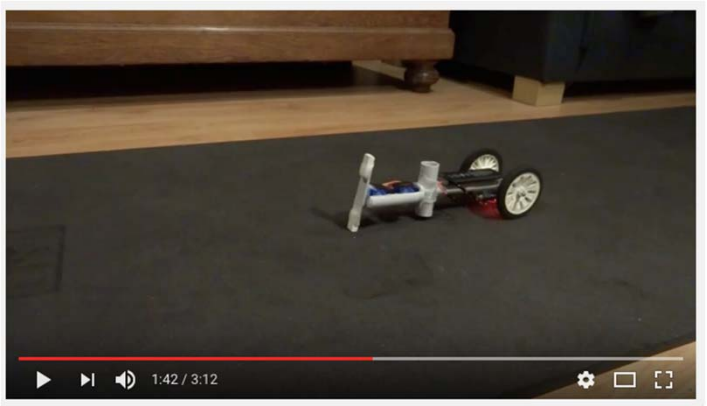
3. Artificial Intelligence:

Self-Learning the Optimal Control Law

AI: Reinforcement Learning



RL: Illustrative Demo



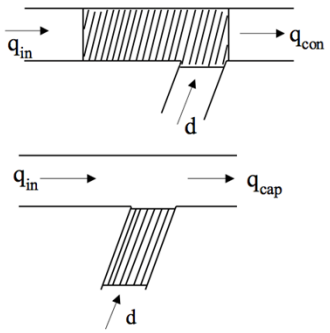
Source: https://www.youtube.com/watch?v=DCjbk4m1G6I

RL: Another Illustrative Demo

Ramp Metering

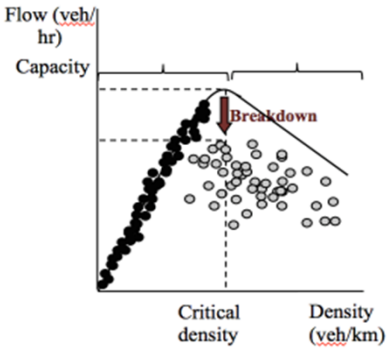
- Why Ramp Metering?
  1. Pacing demand: avoid congestion due to demand exceeding capacity and resulting capacity breakdown
  2. Avoid blockage of exit ramps
  3. Influence route choice behavior
  4. Enhance traffic safety:
     - less congestion
     - safer merging

Congestion Avoidance

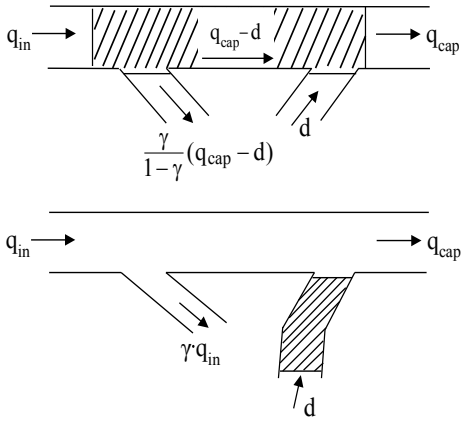


no control

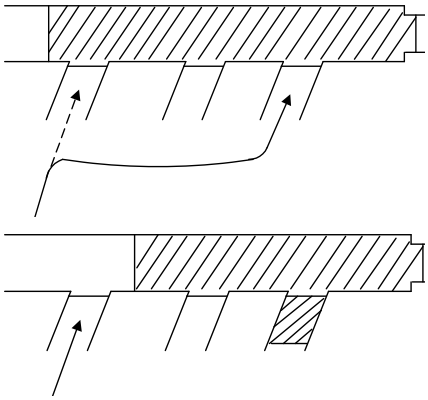
ramp metering



Off Ramp Blockage



Impacting Route Choice



Summary of Today's Status Quo

- Under-utilization of freeway corridors and networks due to recurrent and non-recurrent congestion:
  - high demand creates flow breakdown and congestion causing loss of capacity
  - downstream of congestion (empty stretch ahead)
  - off-ramp blockage (stuck on the freeway)
  - suboptimal utilization parallel arterial
  - reduced safety
  - increased pollution

Ramp Metering Benefits in the Literature

- 30% more vehicles served during rush hours
- Improved service for **all** users
- Reduced urban network load
- > 50% reduction of total time spent
- Efficient response to incidents
- Increased traffic safety
- Decreased fuel consumption and environmental pollution

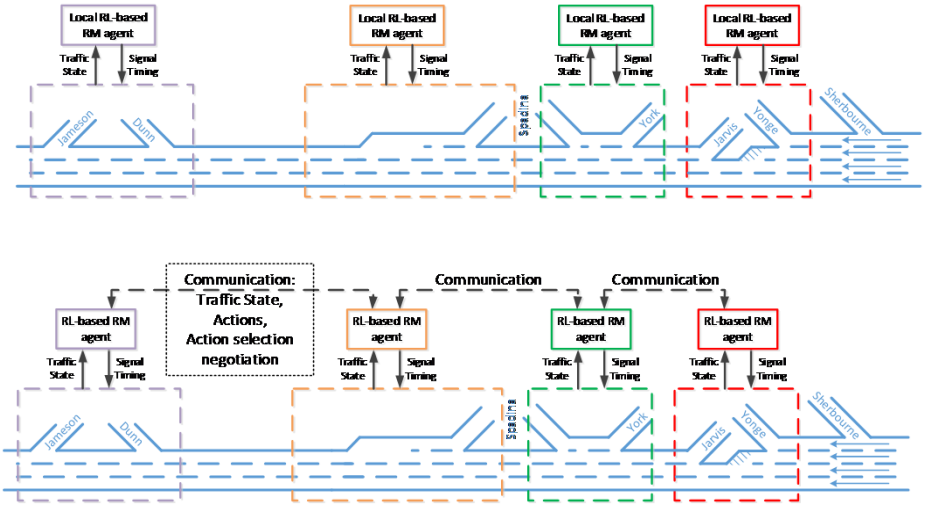
Why NOT RM?

- Fallacy:
  - RM benefits people on the freeway at the expense of those entering from the ramp
  - RM causes traffic to use the surface street, i.e. benefit freeway at the expense of surface streets
- Fact:
  - ramp queues do not mean dis-benefit to surface streets. As the overall throughput of the freeway is improved, more surface street traffic can now use the freeway. i.e. benefit both.
  - Coordinated RM does not penalize later entries (see Gardiner case)

Ramp Metering Categories

- Fixed Time Metering:
  - Mainly off line
  - Based on historical demand
  - Not responsive to real time traffic dynamics
- Traffic Responsive:
  - Realtime
  - Regulator Approach:
    - e.g. ALINEA
  - Optimal Control Metering
    - e.g. RL

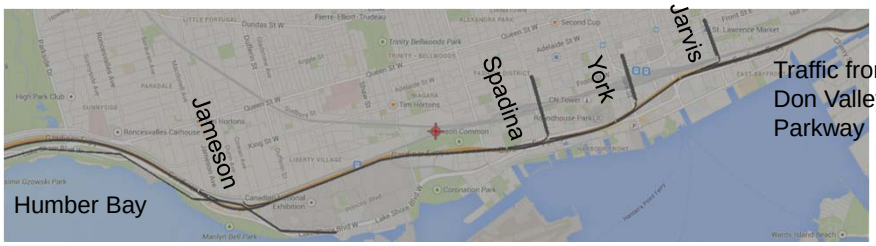
Control of Multiple On-ramps



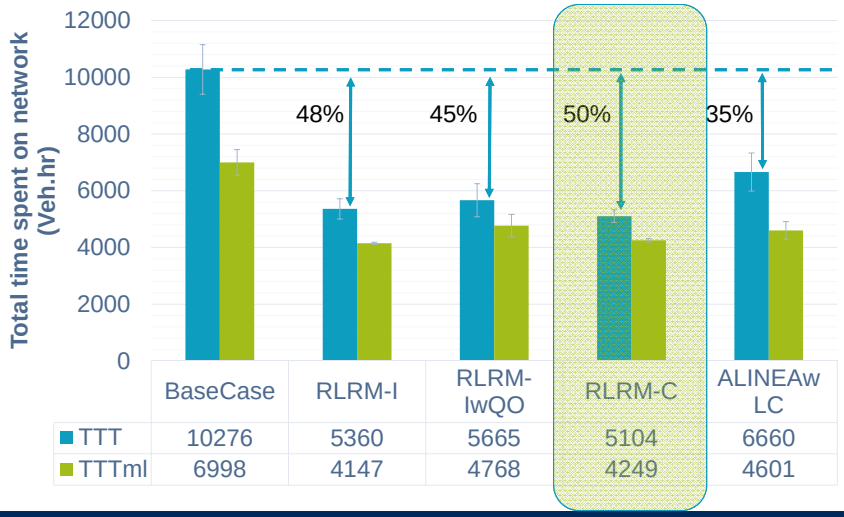
Ramp Metering the Gardiner

Scenarios
- Base Case
- RLRM-I : Isolated
- RLRM-IwQO : Isolated with queue override
- RLRM-C : Coordianted
- ALINEAwLC : ALINEA with linked control

Gardiner Expressway westbound in Toronto from DVP to Humber Bay

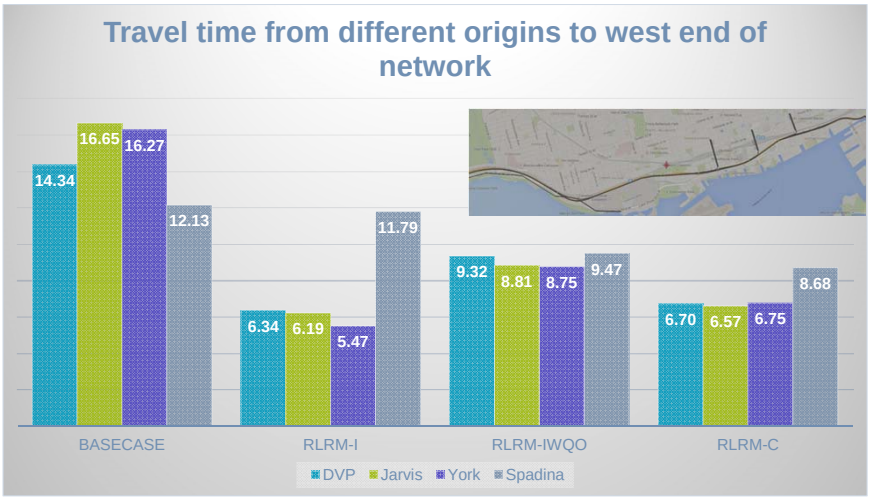


Network Total Travel Time

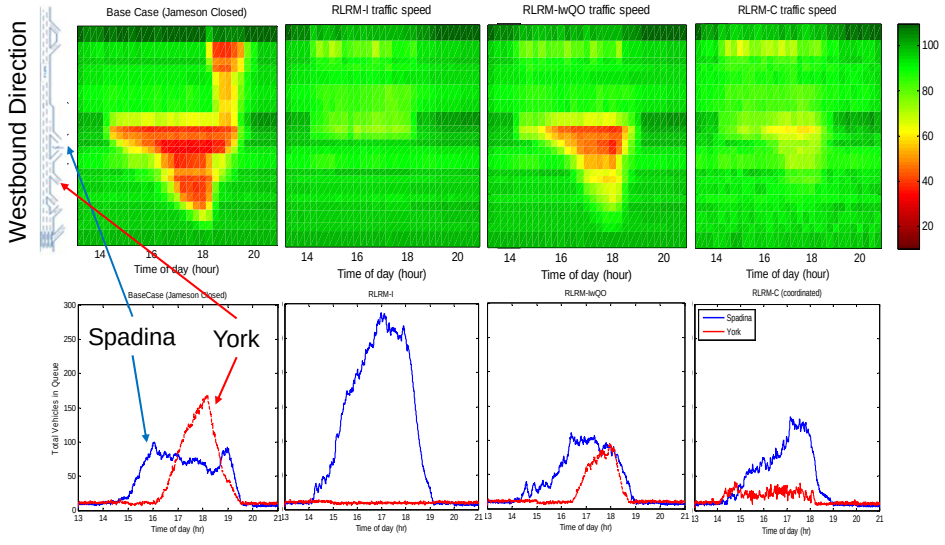


	BaseCase	RLRM-I	RLRM-IwQO	RLRM-C	ALINEAwLC
TTT	10276	5360	5665	5104	6660
TTTml	6998	4147	4768	4249	4601

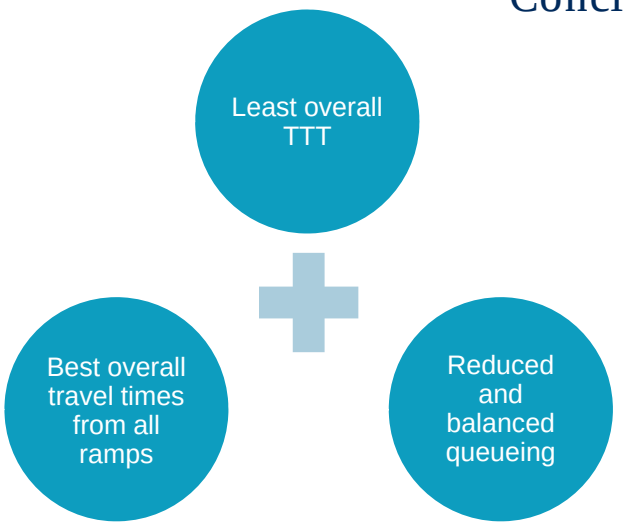
Downtown Origins Travel Times



Local vs. Coordinated



Conclusion



Thank You!