Information-based adaptive routing: Path v.s Policy

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Information in ITS

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The actors

- Travelers
  - Request information: ‘best’ routes ...
  - Form information: as a part of traffic
  - Generate new information: make incidents ...
  - Source of information (V2V)
- Information providers
  - Process (uncertain) information of traffic states
  - Provide consistent information, used and adjusted by travelers
- Network operators

The dual problems (for operators)

- Given network and demand, find the optimal strategies to manage traffic
- Given traffic characteristics and demand, design the optimal network (settings, topology)

Other problem: Capacity design

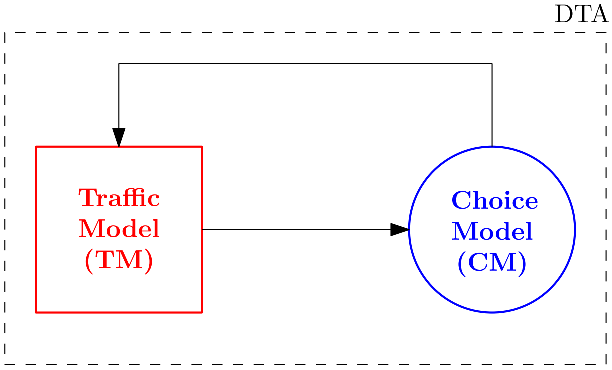
- Maximize demand given traffic characteristics and network infrastructures

Multiple dimensions (time and space): static and dynamic, deterministic and stochastic

Adaptive routing with information to reduce uncertainty

Require an analysis or simulation method to find solutions

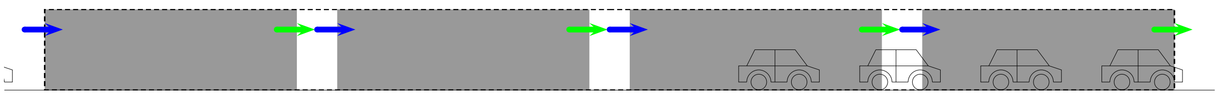
The existing DTA framework

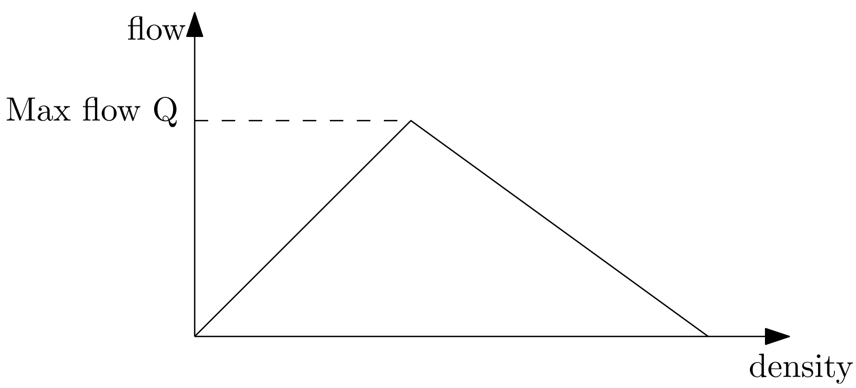


- DTA: Dynamic Traffic Assignment
- In general, DTA models are non-linear
  - Non-holding-back, FIFO
- Solution methods: Heuristics, Fixed-point algorithms, etc.

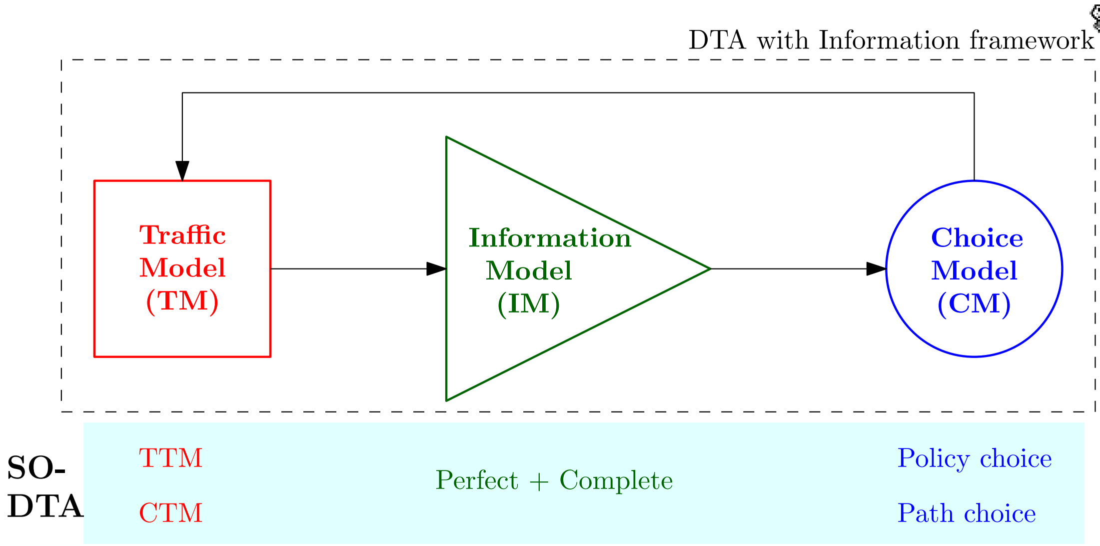
Traffic model: Cell Transmission Model [1]

- A link is divided into segments or cells
- Dynamic description of road segments, caused by incidents
- Spatial distribution of traffic within each cells is averaged





The proposed analysis framework

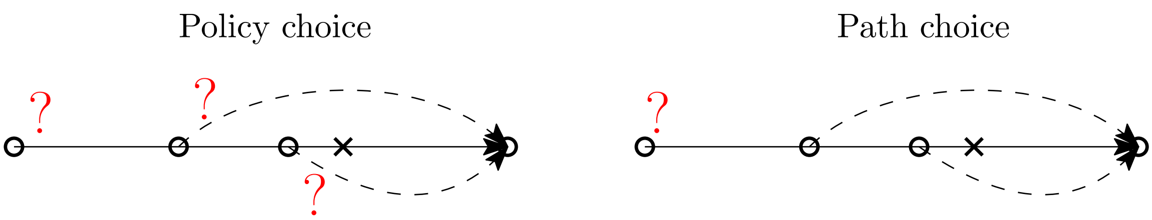


Novel contribution:

- Information model
- **LINEAR** approach to the whole framework

Policy choice v.s path choice

- Policy choice: Choosing a next link or cell to move on
  - Temporal-spatial adaptation
- Path choice: Choosing a path to move on
  - Temporal adaptation



The model settings

- Traffic model: Cell Transmission Model
- Information model: perfect (no error/noise) and complete
- Routing: policy and path choice

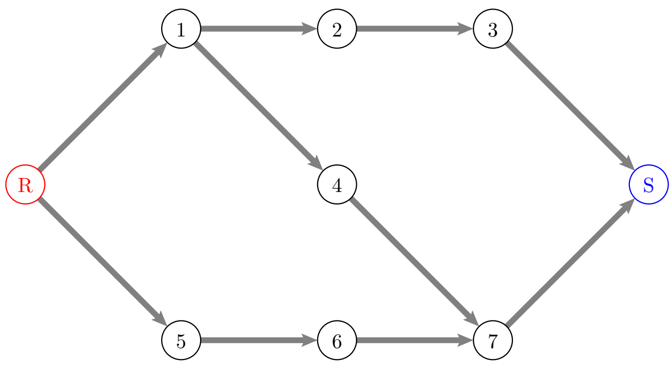
Optimization model:

Objective: Minimize the total travel time

Constraints: CTM constraints
Path/Policy choice constraints

An example

Demand: 480 veh (R to S), all starting at time 1.



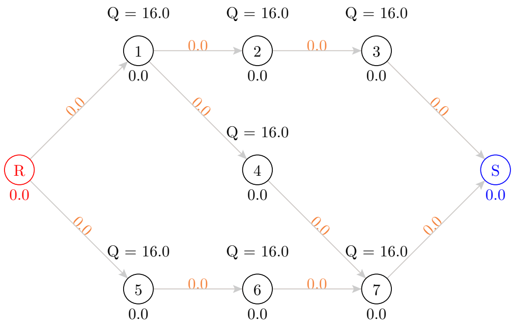
Time unit: 30 seconds

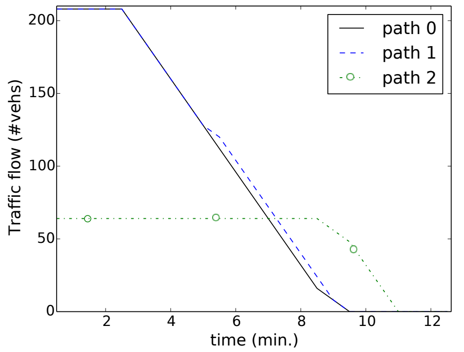
Scenarios for cells 2 and 5	**Max flow**	Time period
s_0	16 veh/time unit	ALL
s_1	8 veh/time unit	$8 \rightarrow 13$
s_2	8 veh/time unit	$8 \rightarrow 17$

Travelers are able to acknowledge s_0 after time 8.
Travelers are able to acknowledge s_1 or s_2 after time 14.

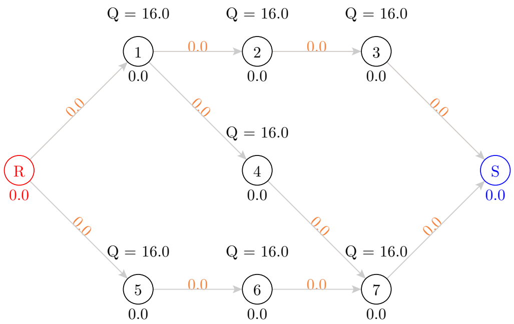
Scenario s_0:

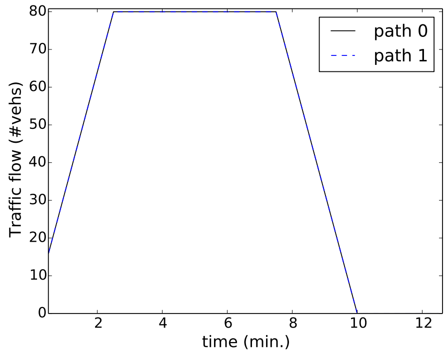
Path:





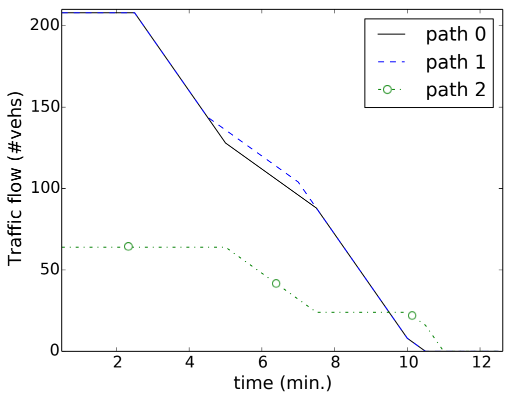
Policy:

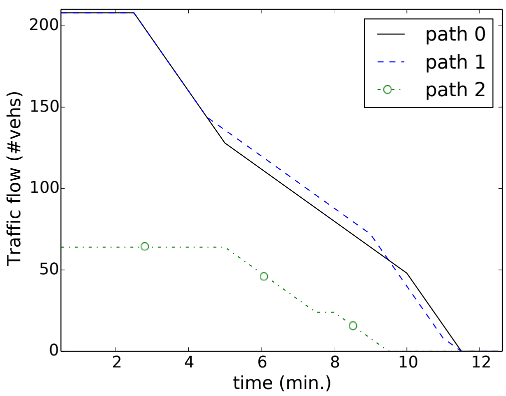




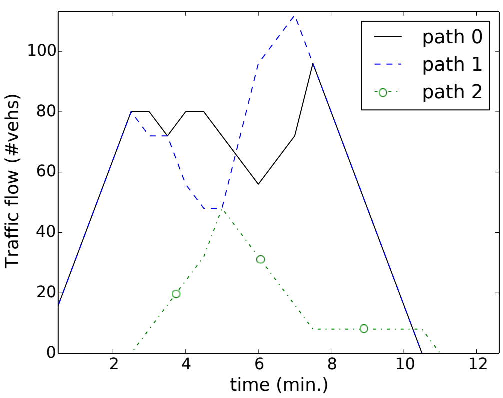
Scenario s_1, s_2:

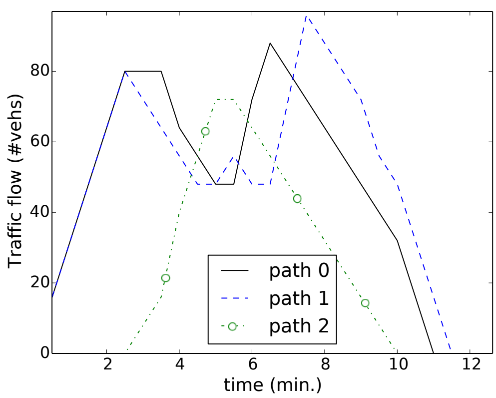
Path:





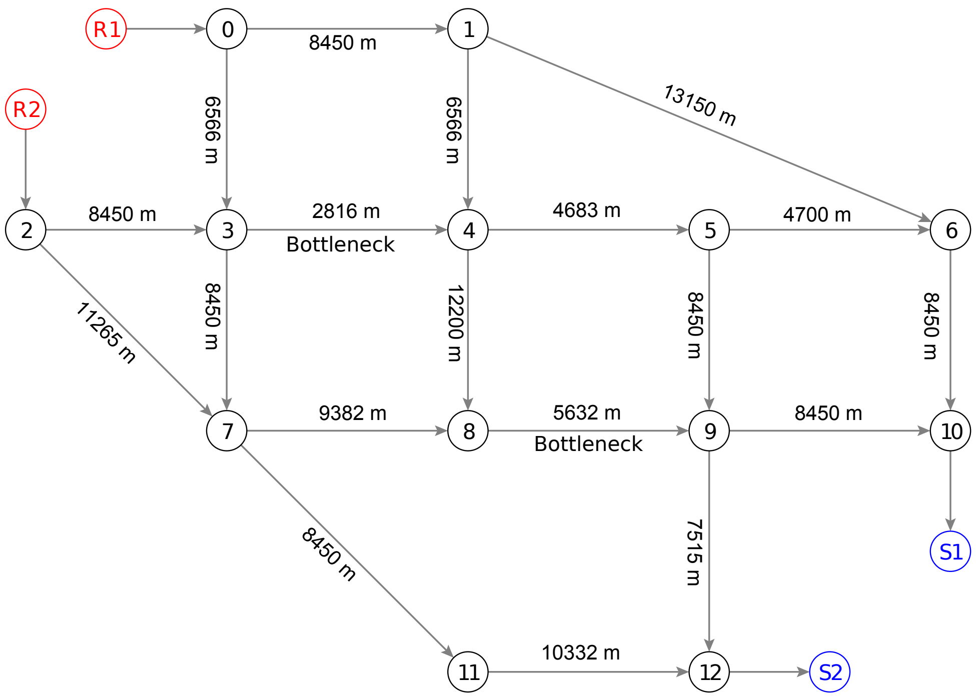
Policy:





Computational performance

Nguyen-Dupuis network [2]



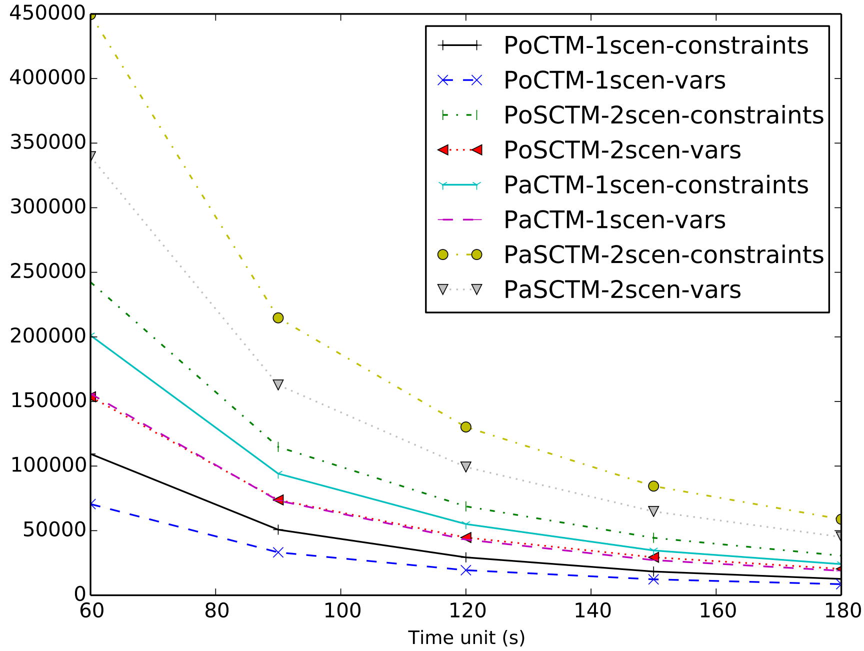
Computational performance

	Number of constraints	Number of variables
PoSCTM	$O((\mathbb{C}+\mathbb{A})\mathcal{X}\mathbb{T}\mathbb{C}_S)$	$O((\mathbb{C}+\mathbb{A})\mathcal{X}\mathbb{T}\mathbb{C}_S)$
PaSCTM	$O((\mathbb{C}+\mathbb{A})\mathcal{X}\mathbb{T}\mathbb{P})$	$O((\mathbb{C}+\mathbb{A})\mathcal{X}\mathbb{T}\mathbb{P})$

$$\frac{Path}{Policy} = \frac{\mathbb{P}}{\mathbb{C}_S} = \frac{\text{Number of paths}}{\text{Number of destinations}}$$

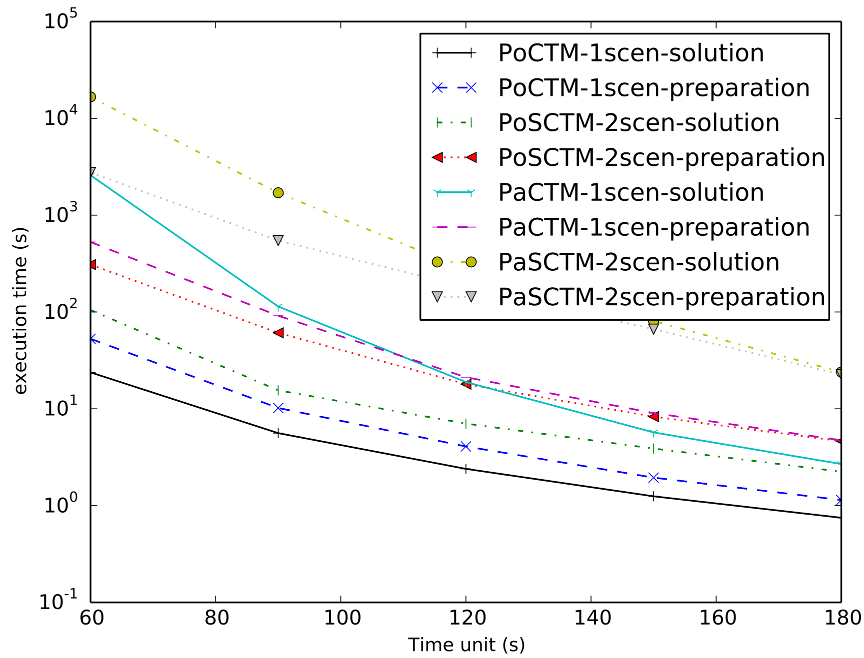
Computational performance

Complexity (constraints, variables)



Computational performance

Execution time



Summary

- Policy-based routing is better than path-based routing
  - Performance
  - Objective value
- BUT, ...
  - Psychological issue: stressful
  - Driver-less car
  - Imperfect and incomplete information
- What is next?

References I

[1] C. F. Daganzo. The cell transmission model: A dynamic representation of highway traffic consistent with the hydrodynamic theory. *Transportation Research Part B: Methodological*, 28(4): 269–287, 1994.

[2] S. Nguyen and C. Dupuis. An efficient method for computing traffic equilibria in networks with asymmetric transportation costs. *Transportation Science*, 18(2):185–202, 1984.