Information-based adaptive routing: Path v.s Policy

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Information in ITS

CAIA Seminar
http://www.swin.edu.au  hhoang@swin.edu.au  November 19, 2015  3
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 cell is averaged

\[ \text{Max flow} \ Q \]

\[ \text{density} \]

\[ \text{flow} \]
The proposed analysis framework

**Traffic Model (TM)**

**Choice Model (CM)**

**Information Model (IM)**

**DTA with Information framework**

**Perfect + Complete**

**Policy choice**

**Path choice**

**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.

<table>
<thead>
<tr>
<th>Scenarios for cells 2 and 5</th>
<th>Max flow</th>
<th>Time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S_0 )</td>
<td>16 veh/time unit</td>
<td>ALL</td>
</tr>
<tr>
<td>( S_1 )</td>
<td>8 veh/time unit</td>
<td>8 → 13</td>
</tr>
<tr>
<td>( S_2 )</td>
<td>8 veh/time unit</td>
<td>8 → 17</td>
</tr>
</tbody>
</table>

Travelers are able to acknowledge \( S_0 \) after time 8.
Travelers are able to acknowledge \( S_1 \) or \( S_2 \) after time 14.
**Scenario $s_0$:**

![Graph of Scenario $s_0$ showing traffic flow over time for paths 0, 1, and 2.](image)

**Path:**

![Path diagram for Scenario $s_0$.](image)

**Policy:**

![Policy diagram for Scenario $s_0$.](image)

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**Scenario $s_1, s_2$:**

![Graph showing traffic flow for Scenario $s_1, s_2$.](image)

**Path:**

![Path diagram for Scenario $s_1, s_2$.](image)

**Policy:**

![Policy diagram for Scenario $s_1, s_2$.](image)
Nguyen-Dupuis network [2]

PoSCTM: $O((C + A)^XTC_S)$  
PaSCTM: $O((C + A)^XTP)$

Path Policy = $\frac{P}{C_S} = \frac{\text{Number of paths}}{\text{Number of destinations}}$
Computational performance

Complexity (constraints, variables)

![Graph showing complexity (constraints, variables)](image)

Computational performance

Execution time

![Graph showing execution time](image)
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
