Operational Problems in Traffic Systems
(Continued)

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Operational Problems

Part 1: Air Traffic Flow Management

• Introduction and conceptual definition of operational problems
• Ground-holding strategies
• Results from case study

Part 2: Road Traffic Flow Management

• Conceptual organization of road traffic management problems
• Integrated dynamic traffic control and assignment
• Results from case study
Information Technology and Transportation Systems Management

Traffic Management Center

User Services
- traffic information
- routing advice

Traffic Surveillance System

Traffic Control
- signal settings
- ramp meeting

Travel Demand

Transportation Network

Network Supply
Desirable Properties of an ATMS/ATIS

- ATMS/ATIS should be responsive to:
  - “future” demand
  - potential adjustments in travel patterns due to information
  - variations in network capacity due to traffic control actions
- ATMS/ATIS should be based on “projected” traffic conditions to:
  - anticipate downstream traffic conditions
  - improve credibility
Traffic Prediction Approaches

• Statistical Methods
  – require no explicit assignment
  – are suitable for short intervals

• Dynamic Traffic Assignment Methods
  – incorporate driver behavior
  – require network performance
  – require time-dependent O-D flows
  – have high computational requirements
A Framework for (Analytical) Dynamic Traffic Assignment

Dynamic O-D Trips → Subset of Paths

Users’ Behavior Models → path flows

Network Loading Model

Link Performance Models

new paths

Path costs

Link-Based Time-Dependent Network Conditions

Time-Dependent Paths Generation
Time-Dependent Shortest Paths Computation

- Realistic networks: 20k road segments, 7k intersections, 700 destinations, 100 time intervals
- Time of known methods:
  - Can be of quadratic as a function of the number of time intervals
  - May take up to 25 minutes for one destination
- Algorithm DOT:
  - 0.8 seconds for one destination
  - Theoretically, this is the best one can do!
- Other avenues:
  - High performance computing implementations (10 to 20 times faster)
  - Exploit hierarchy of transportation networks (5 to 10 times faster)
- Combined effect: 100*10*5=5000
Types of DTA Models

- Microscopic traffic models (MITSIM):
  - Traffic is represented at the vehicle level
  - Vehicles are moved using car-following and lane changing models

- Mesoscopic traffic models (MesoTS/DynaMIT):
  - Traffic is represented at the vehicle level
  - Speed is obtained using models that relate macroscopic traffic flow variables

- Macroscopic (or flow-based) traffic models:
  - Traffic is represented as continuous variables
  - Speed is obtained using models that relate macroscopic traffic flow variables

- Analytical (flow-based) traffic models
Amsterdam Test Network

- 196 nodes, 310 links, 1134 O-D pairs and 1443 paths
- Morning peak: 2 hours and 20 minutes
- Discretization intervals: 2357 (3.50 sec each)
- Various types of users:
  - Fixed routes
  - Minimum perceived cost routes
  - Minimum experienced cost routes
Computer Resources Used

- Link variables: 25 Mbytes
- Path variables: 34 Mbytes
- Average time for one loading: about 3 minutes
- Saving ratio compared to known analytical methods: 1000
- Results are encouraging for real-time deployment

- MITSIM: 1.5 times slower than real time
- MesoTS: 16 times faster than real time
- Analytical approach: 45 times faster than real time
Interdependence of Control and Assignment

- Consequences of the conventional approach:
  - Sub-optimal signal settings;
  - Inconsistent traffic flow predictions.
A Case Study (cont.)

- **Controls**
  - current existing pre-timed control
  - Webster equal-saturation control
  - Smith $P_0$ Control
  - One-level Cournot control
  - Bi-level Stackelberg control
  - System-optimal Monopoly control

- **Route Choices**
  - A set of pre-determined paths (4 paths) for each O-D pair
  - Total of 400 paths
  - Demand is model using C-Logit
## Results from Back Bay Case Study: Total Travel Time

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<tr>
<th>Controls</th>
<th>Total Travel Time (mins)</th>
<th>Gap from System-Optimum (%)</th>
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<td>Existing</td>
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