Dynamic Traffic Models (EE-2)

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Outline

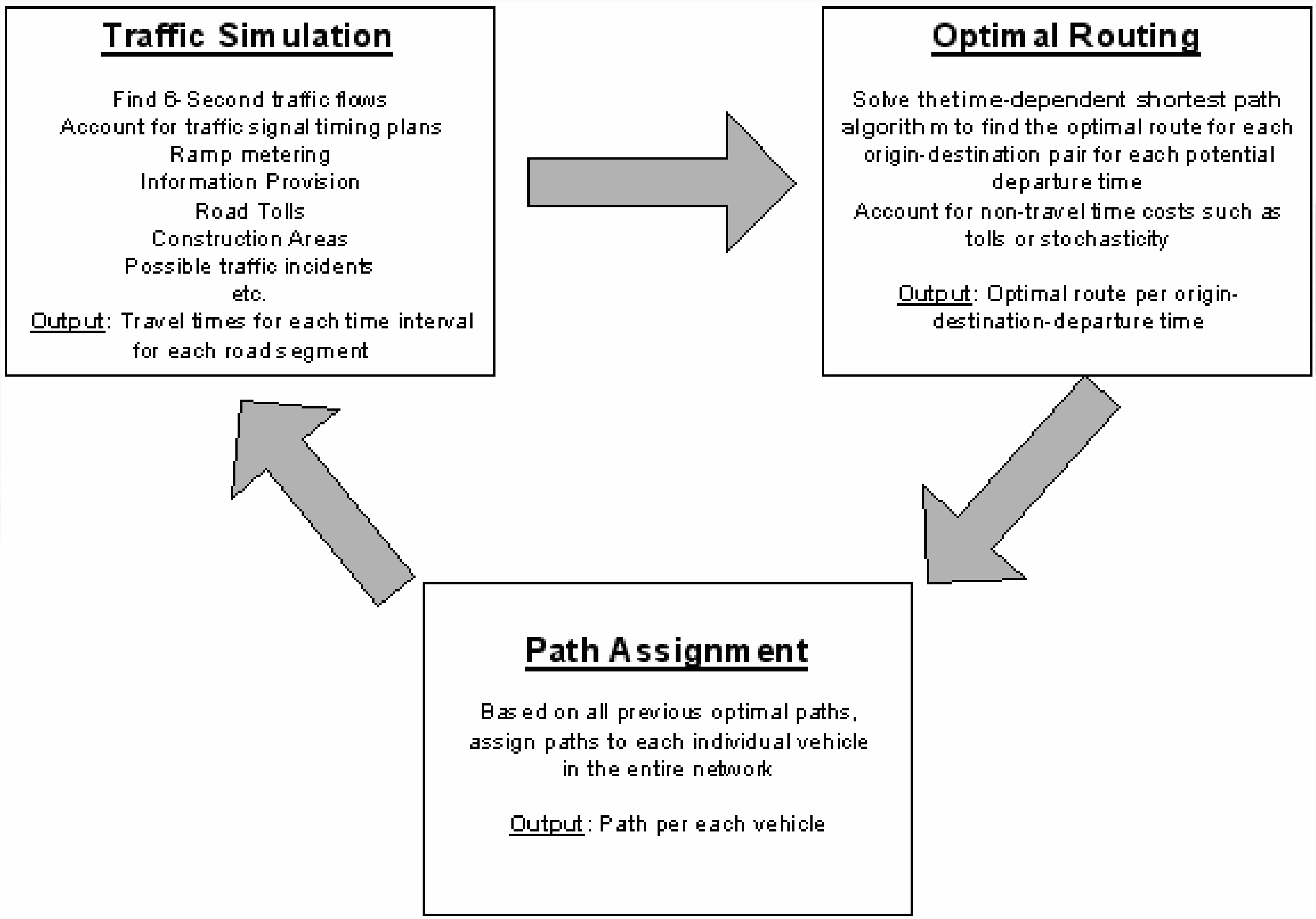
- Why use Dynamic Traffic Models?
- EE-2.2 *Development of Analytical Formulations for Dynamic Traffic Network Conditions with Uncertainty*
- EE-2.3 *Development of Dynamic Traffic Model Considering Uncertain Supply, Traveler Demand*
- EE-2.4 *Development of Specialized Sampling Procedures for Evaluating Demand and Capacity*

Why use Dynamic Traffic Models?

- Allows demand to vary with time
- Captures interaction of adjacent links
- CTM is simple, versatile, linear
- Easier to model uncertain capacity
- Real-time Traffic Operations (VMS signs for evacuation..)

- Disadvantages: time-dependent O-D data not collected

Dynamic Traffic Models



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EE-2.2 Development of Analytical Formulations for Dynamic Traffic Network Conditions with Uncertainty

- **Variables**
- b_i = amount of budget allocated to cell *i*
- x_i^t = number of vehicles in cell *i* at time interval *t*
- y_{ij}^t = number of vehicles moving from cell *i* to cell *j* at time interval *t*
- **Formulations**
- $\min_b Eh(b, \tilde{\xi})$ (1.1)
- subject to
- $\Sigma b_i <= TAB$ (1.2)
- $b_i >= 0$ (1.3)
- where

$$h(b, \tilde{\xi}) = \min_{x,y} \sum_{(i,j)\in E_S} \sum_{t\in T} t y_{ij}^t$$ for SLP2 SO DTA-based NDP (1.4a)

$$h(b, \tilde{\xi}) = \min_{x,y} \sum_{(i,j)\in E_S} \sum_{t\in T} M_t y_{ij}^t$$ for SLP2 UO DTA-based NDP (1.4b)

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EE-2.3 Development of Dynamic Traffic Model Considering Uncertain Supply, Traveler Demand

Uncertainty on right-hand side → Problem still linear!
(not always true with static models)

$$x_i^t - x_i^{t-1} + \sum_{(i,j)\in FS(i)} y_{ij}^{t-1} - \sum_{(j,i)\in RS(i)} y_{ji}^{t-1} = \tilde{d}_i^{\,t} \qquad \forall i \in C \setminus C_s, t \in T$$

$$\sum_{(i,j)\in FS(i)} y_{ij}^t - x_i^t \le 0 \qquad \forall i \in C, t \in T$$

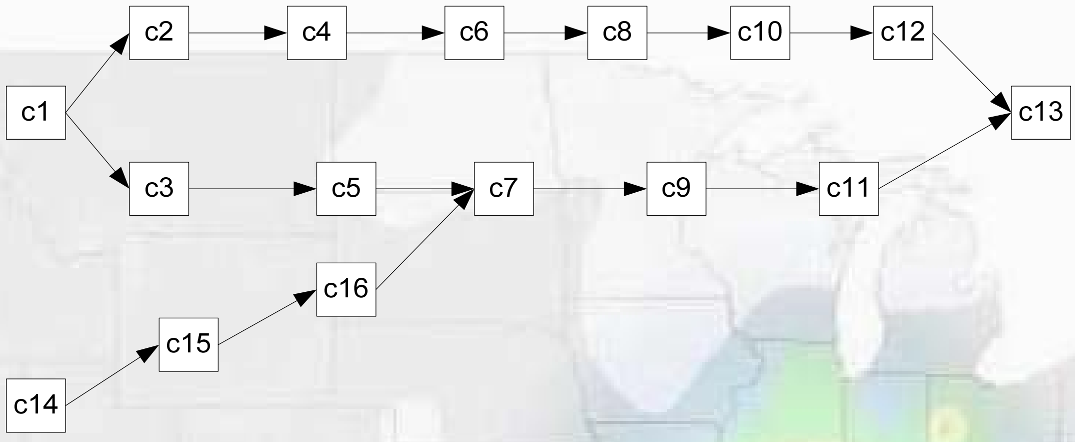
$$\sum_{(j,i)\in RS(i)} y_{ji}^t \le \delta_i^t (\tilde{N}_i^t + \tilde{\chi} b_i - x_i^t) \qquad \forall i \in C \setminus (C_R \cup C_S), t \in T$$

$$\sum_{(j,i)\in RS(i)} y_{ji}^t \le \tilde{Q}_i^t + \tilde{\phi} b_i \qquad \forall i \in C \setminus (C_R \cup C_S), t \in T$$

$$\sum_{(i,j)\in FS(i)} y_{ij}^t \le \tilde{Q}_i^t + \tilde{\phi} b_i \qquad \forall i \in C \setminus C_s, t \in T$$

Solve with Monte Carlo Bounding Procedures using Independent and Common Random Numbers

EE-2.3 Development of Dynamic Traffic Model Considering Uncertain Supply, Traveler Demand



$\tilde{N}_i^t$ **Capacity of cell i at time t**

$\tilde{d}_i^t$ **Demand for leaving cell i at time t**

PMF of $\tilde{d}_i^t$ Types*

Type-1 $\tilde{d}_i^t$ Value	pmf	Type-2 $\tilde{d}_i^t$ Value	pmf
0.5	0.4	1	0.1
1	0.3	1.5	0.2
1.5	0.2	2	0.4
2	0.1	2.5	0.2
		3	0.1

* Type-0 $\tilde{d}_i^t$ value = 0 with probability 1

PMF of $\tilde{N}_i^t$ Types*

Type-1 $\tilde{N}_i^t$ Value	pmf	Type-2 $\tilde{N}_i^t$ Value	pmf
1.5	0.25	3.5	0.25
2	0.5	4	0.5
2.5	0.25	4.5	0.25

*Type-3 $\tilde{N}_i^t$ value for source and sink cells = **infinity with probability 1**

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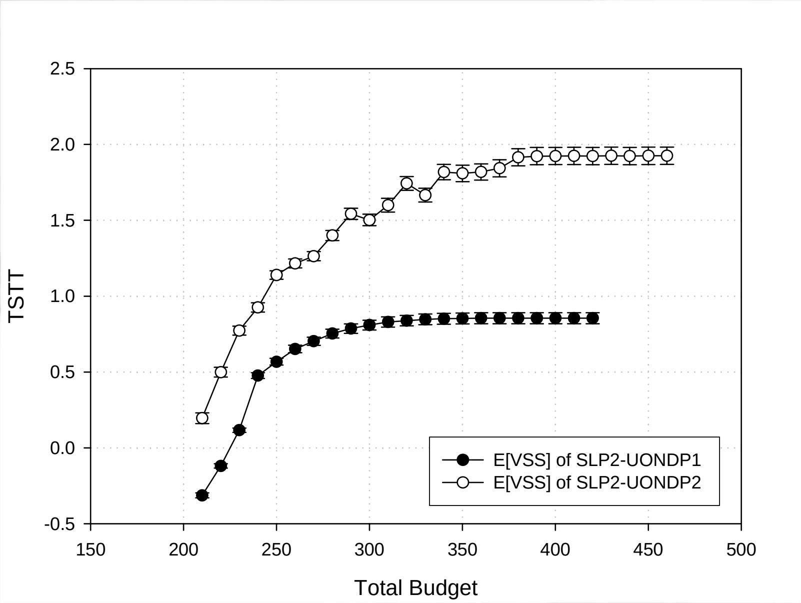
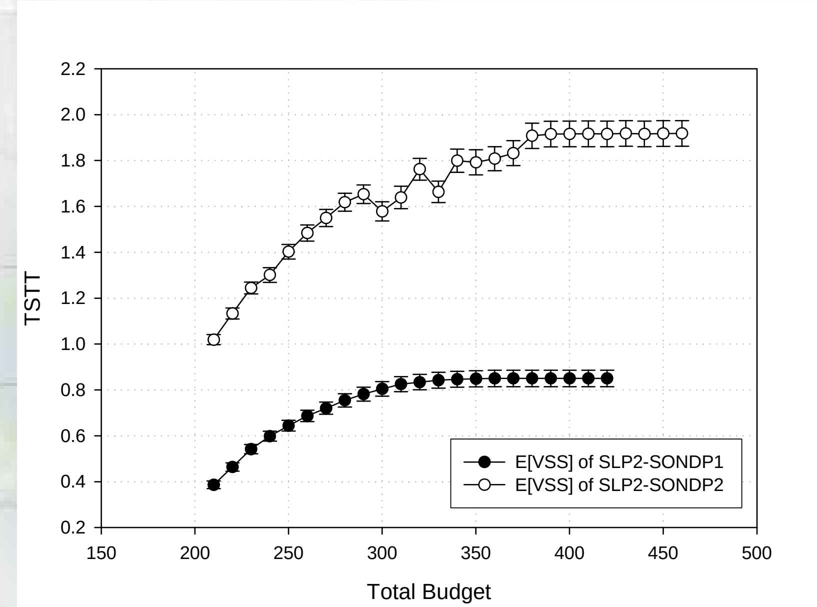
EE-2.3 Development of Dynamic Traffic Model Considering Uncertain Supply, Traveler Demand

Value of the Stochastic Solution Estimates of SO/UO Models and 95% Confidence Intervals





***TSTT levels out as total budget increases**

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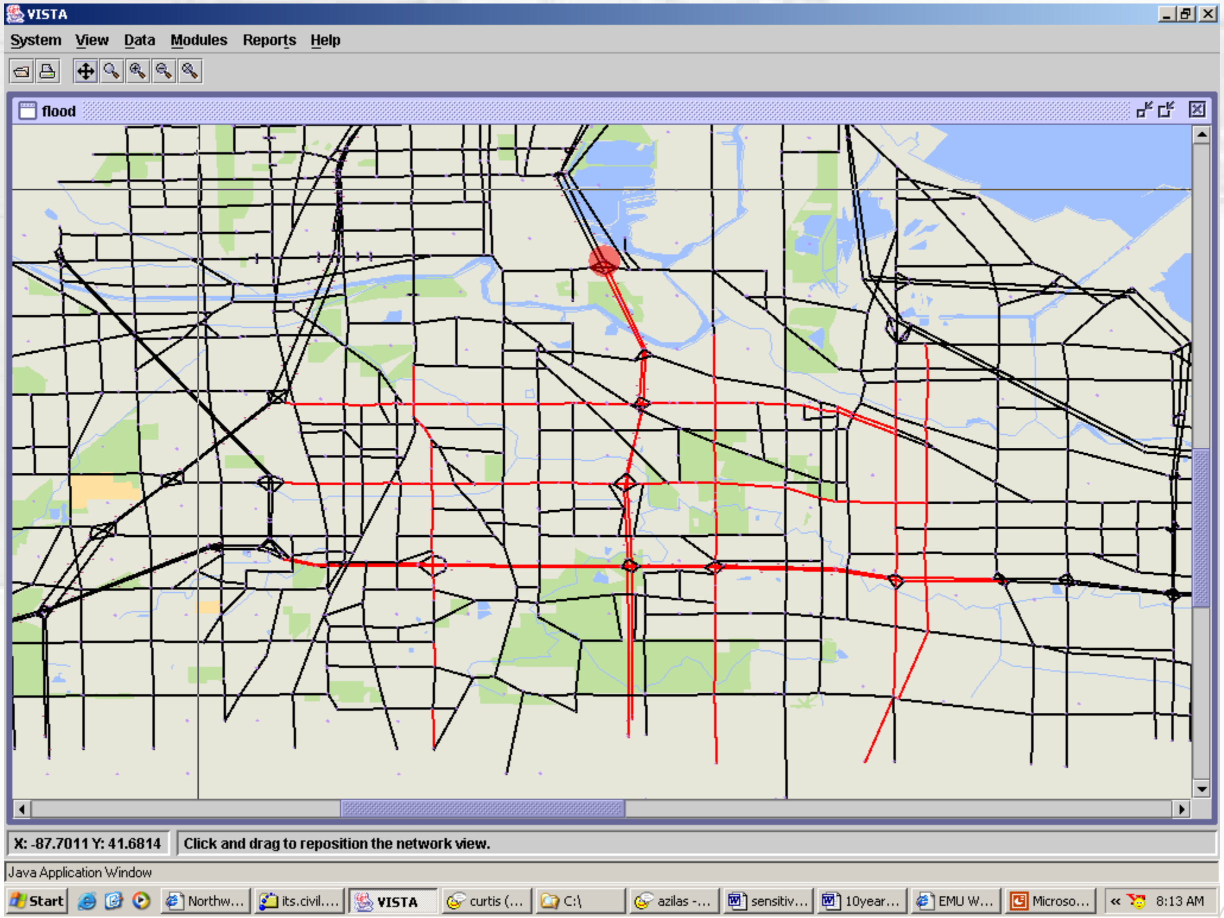
EE-2.3 Development of Dynamic Traffic Model Considering Uncertain Supply, Traveler Demand

Future Directions for EE-2.2…

- Apply methodology to larger networks using VISTA



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EE-2.4 Development of Specialized Sampling Procedures for Evaluating Demand and Capacity

- Specialized sampling procedures evaluated for independent and correlated demands
- Monte Carlo, Latin Hypercube, Anti-thetic, Quasi Monte Carlo, Control Variates
- Performance Measures:
  - $$\text{Bias} = \left| \frac{\overline{c_n} - \overline{c_{100,000}}}{\overline{c_{100,000}}} \right| * 100$$
  - $$\text{Error} = \quad 1.96 * S(\overline{c_n}) = \frac{1.96 * S(c)}{\sqrt{n}}$$
- **Results**
  - **•Latin Hypercube and Anti-thetic consistently performed best for each correlation structure, demand probability distribution, and # of demand realizations**

EE-2.4 Development of Specialized Sampling Procedures for Evaluating Demand and Capacity

Future Directions for EE-2.4…

- Specialized sampling for uncertain capacity
- Examine the impact of correlation
  - Existence of correlation depends on if a scenario-based approach is taken or not

- Include sampling techniques within MAEViz

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Future Opportunities for Collaboration

- Numerous opportunities exist as the network-wide transportation conditions impact directly relates to the traveling public
  - Measure how accessibility impacts diverse groups of the public differently
  - Assess the perceived and actual cost of disruptions to travelers
- IT issues are also common as the transportation data sources have certain unique aspects and the necessary interface development while feasible is non-trivial.
  - Transportation data exists but is often maintained by distinct agencies separated both by regional and functional boundaries
  - The VISTA/MAEViz interface can take many forms. It could be primary database connected or using a distributed protocol.