

Toll Modeling in Context of Regional Travel Demand Model

presented to
NC Model Users Group
October 24, 2007

Overview

- Toll Modeling in General
- Toll model application in NC Models
- TransCAD application

Tolls Influence

- Trip Distribution
 - Destination Choice
- Mode Choice
 - SOV, HOV or Toll Path
 - Alternative Competitive Mode
- Trip Assignment
 - Alternative Path Finding

Cost Factor in Path Finding

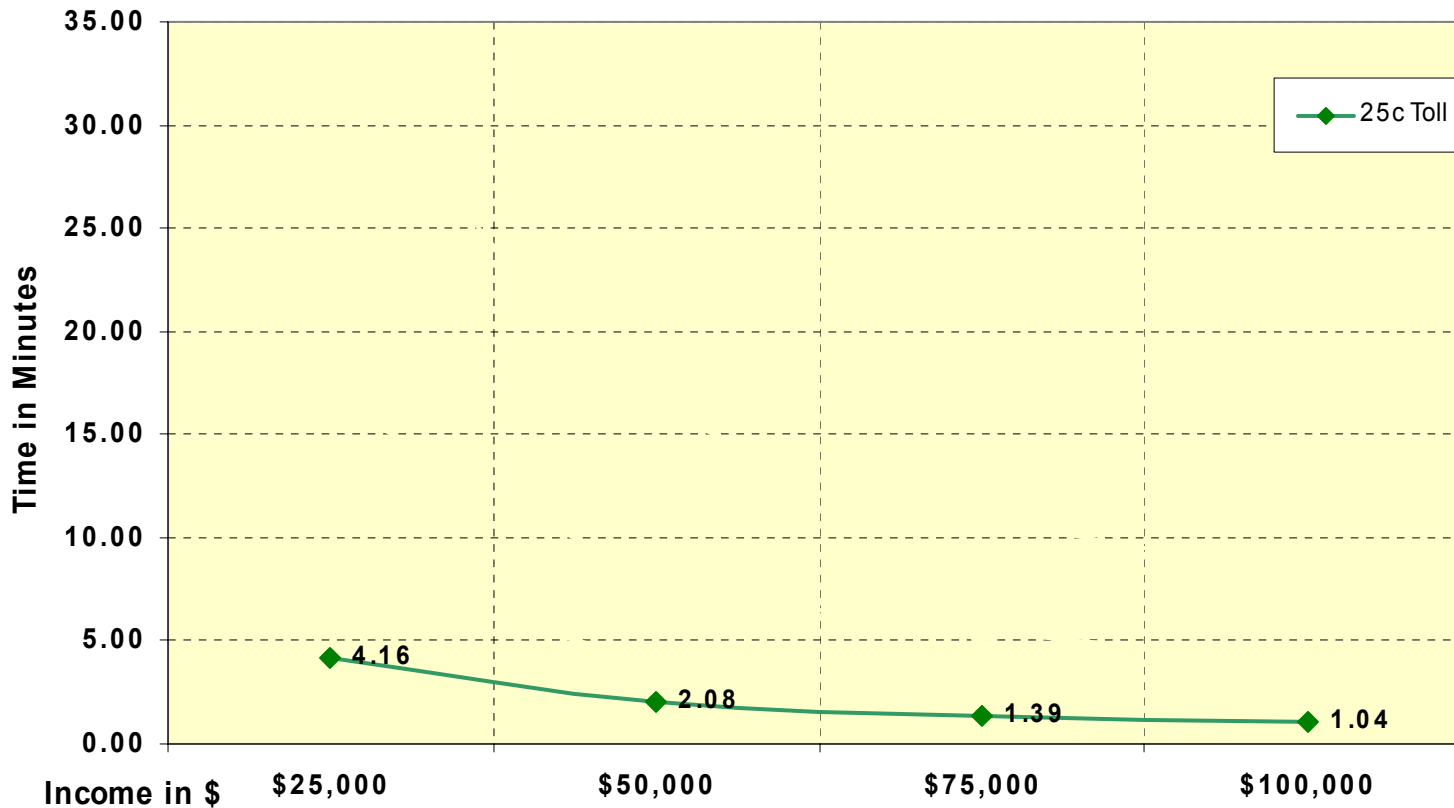
- Highway operating cost
- Transit Fare
- Vehicle Occupancy >1
- Toll Cost

Toll Choice Factors

- Socio-Economic Characteristics of trip makers in combination with travel costs

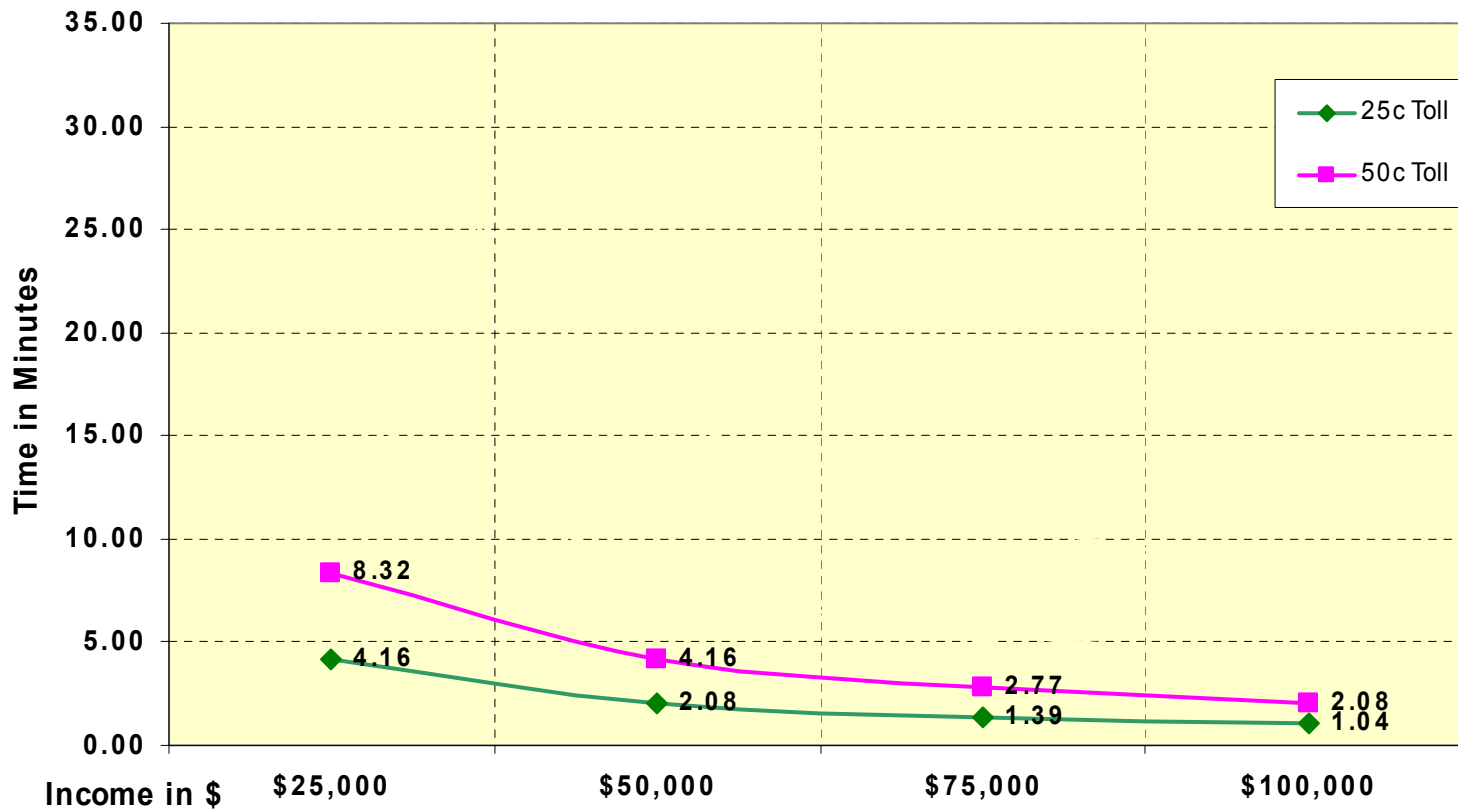
Toll Choice Factors - Income

Effect of Income and Toll Cost on Time



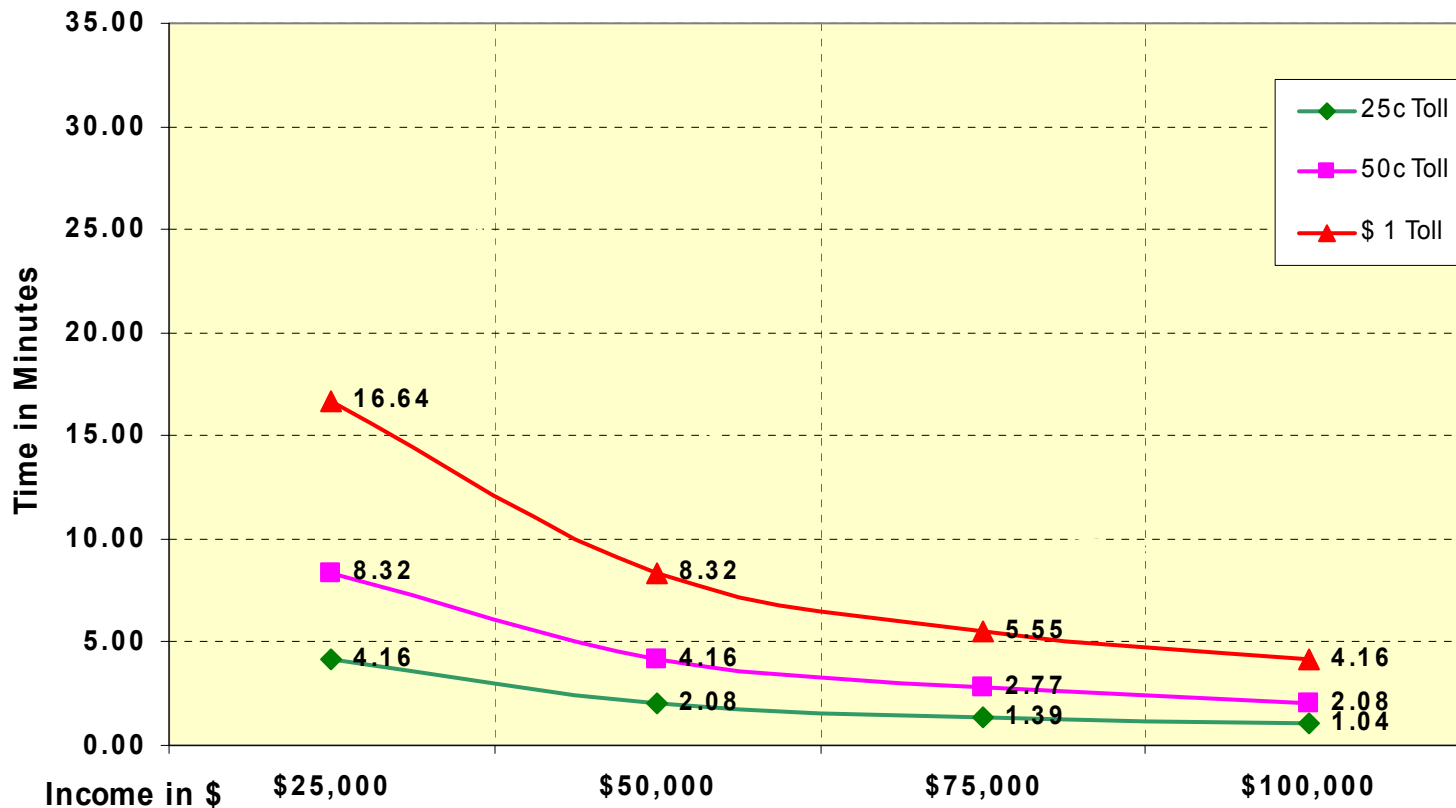
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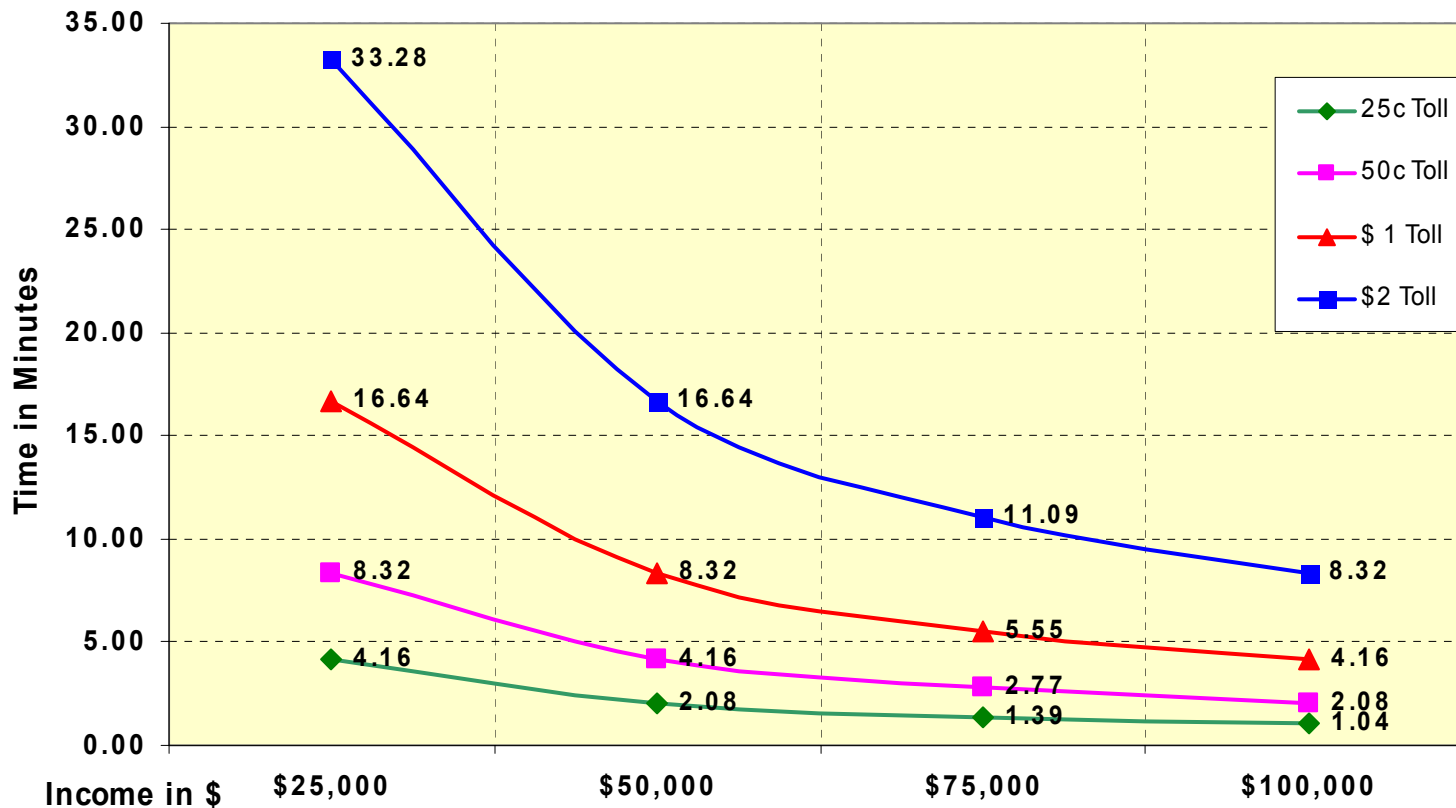
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Toll Choice Factors - Income

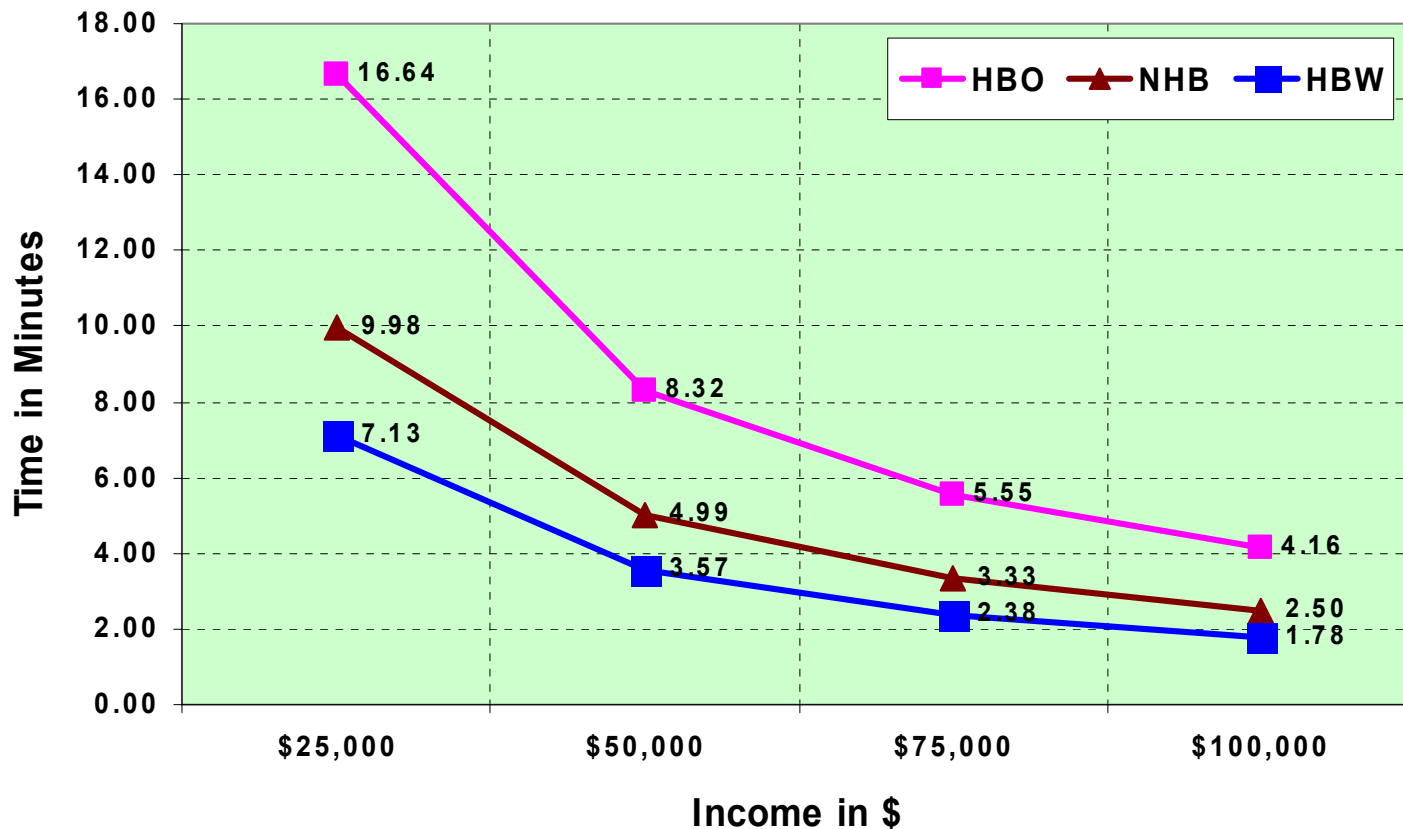
Effect of Income and Toll Cost on Time



Toll Choice Factors

- Trip Purpose

Value of \$1.00 Toll in Minutes by Trip Purpose



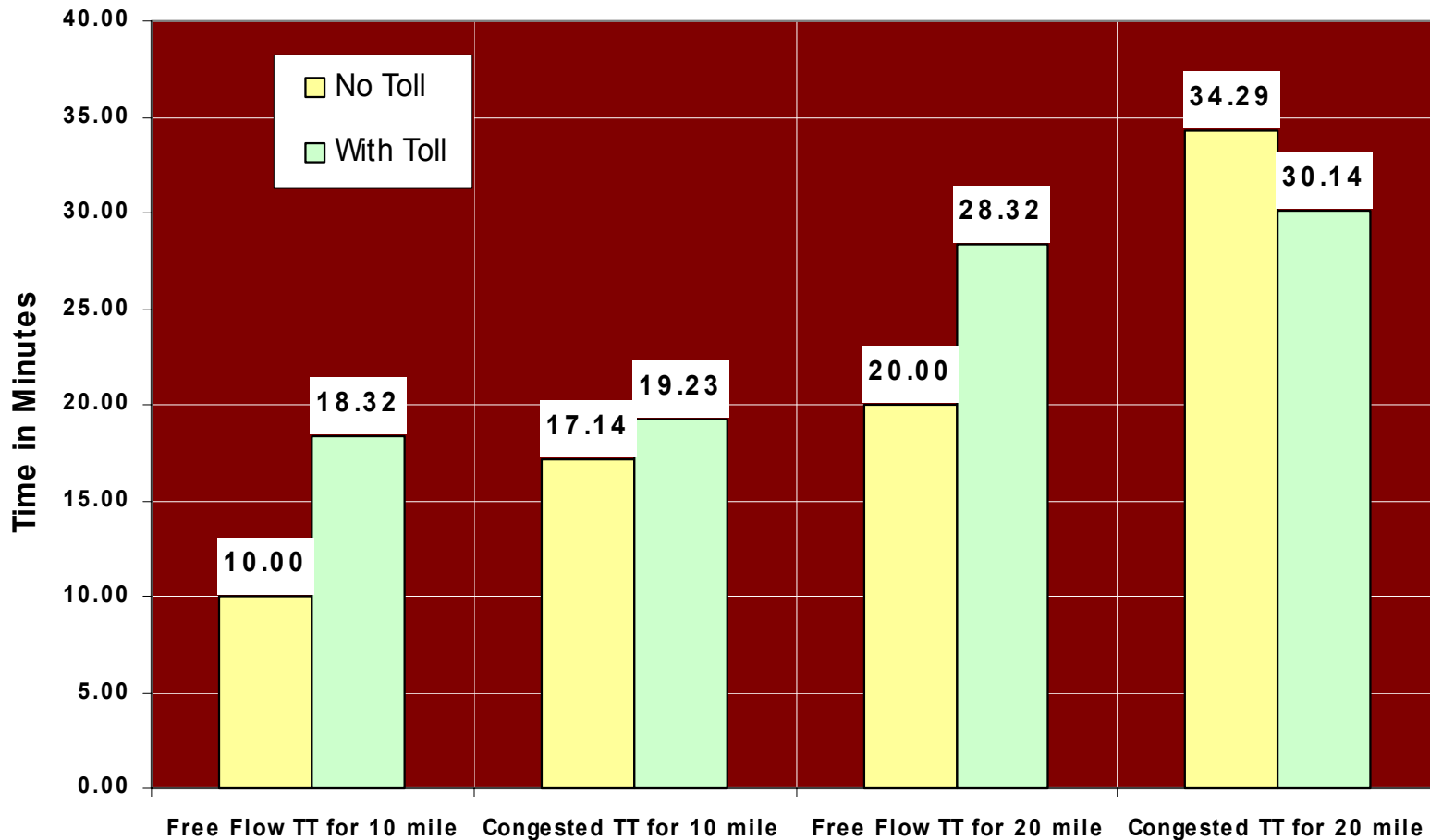
Toll Choice Factors

- Time of Day
 - AM and PM Peak
 - Off Peak
- Method of Toll Collection
 - Cash
 - Electronic Toll Collection
- Vehicle Type
 - Car, Trucks
- Vehicle Occupancy
 - SOV, HOV

Toll Choice Factors

- Trip length for toll users

Travel Time by Trip Length



Toll Models

- Mode Choice
- Highway Assignment
 - Route Choice Sub-Model
- Highway Assignment
 - Equivalent Time Penalties

Assignment Toll Models

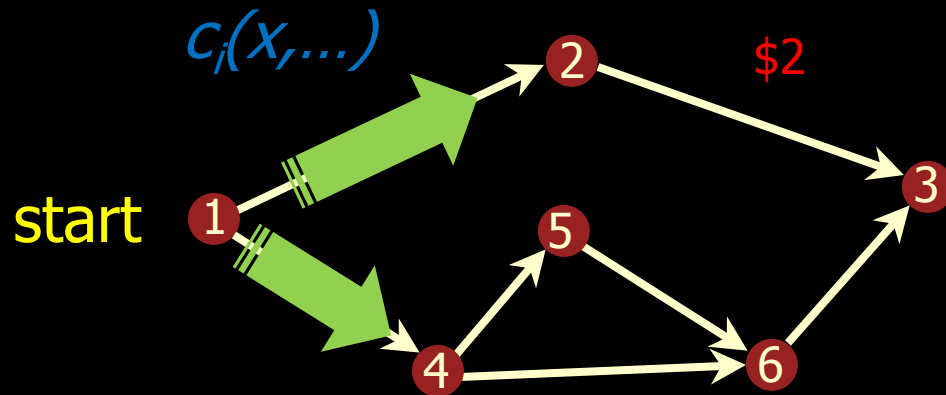
Generalized assignment procedure

- uses travel time and costs by time of day

Feedback loop through mode choice

- uses successive averaging of travel times

Path-Finding



If no toll, then 1, 2, 3 is best path

With toll on 2-3, must convert \$ and time to equivalent units

Best path might now be 1-4-6-3

Example: Wilmington

- 4-step model
 - Survey for Trip Generation, Distribution
 - Borrowed Mode Choice
- Developed, calibrated without tolls

Example: Wilmington

Used BPR as VDF

$$t = t_f \left[1 + \alpha \left(\frac{v}{c} \right)^\beta \right]$$

⇒ How to incorporate toll without recalibration?

Example: Wilmington

- Use generalized cost VDF

$$c_i(x) = k_i + \delta \cdot L_i + \varphi \cdot t_f \left[1 + \alpha \left(\frac{v}{c} \right)^\beta \right]$$

- k : fixed cost \Rightarrow toll
- δ : operating cost (per mi) \Rightarrow 0
- φ : value of time \Rightarrow ??
 - ↳ Use locally determined value

Example: Wilmington

Assignment with User VDF

Inputs

Line Layer: Wilm Model Network

Network File: P:\...WORK\BASE YEAR NETWORK.NET

Delay Function: Generalized Cost Function

Method: Stochastic User Equilibrium

Matrix File: Veh PA Output Matrix

Matrix: Total

Parameters

| Name | Field | Default Value |
|---------------|-------------------------|---------------|
| Time | [AB_Time / BA_Time] | N/A |
| Capacity | [AB_CAP / BA_CAP] | N/A |
| Alpha | Alpha | 0.15 |
| Beta | Beta | 4 |
| K | [[AB Toll] / [BA Toll]] | 0 |
| Op. Cost | None | 0 |
| Value of Time | None | 0.5 |

Field: None Default Value: 0

Settings

Iterations: 250 Convergence: 0.0050

Function: Normal Error: 5.0000

OK Cancel Network Options Settings

MMA

- With MMA (more advanced) toll functionality built-in

BUT

- Must make sure VOT was correctly calibrated at outset
- Be aware of different cost function:

$$gC_{OD}^m = \sum_{i \in A_{OD}^m} \left\{ \text{VOT}^m \cdot \text{VDF} \left(t_a, c_a, \sum_m \text{PCE}_m x_a, \dots \right) + \text{FT}_a^m \right\} + \sum_{m \in M_{OD}^m} \text{MT}_m^i$$

Hypothetical Toll for TRM

Multi-Modal Multi-Class Assignment

Line Layer: Network Roads
Network File: P:\...NOBUILD2\OUTPUT\2002BASE.NET
Method: User Equilibrium
Delay Function: Conical Congestion Function
O-D Matrix: PMTrip
Toll Matrix: [Empty]

Class Information

| Matrices | PCE | VOT | Fixed Toll | Road Toll | Exclusion Set |
|----------|-----|-----|------------------|-----------|---------------|
| SOV | 1.0 | 1.0 | [[AB Toll] / [BA | -- | hovqy |
| HOV | 1.0 | 1.0 | [[AB HOV Toll] / | -- | None |
| CV | 1.0 | 1.0 | [[AB CV Toll] / | -- | hovqy |

Use Class: PCE: 1.0, VOT: 1.0, Fixed Toll: [[AB CV Toll] / [BA, Road Toll: [Empty], Exclusion Set: hovqy

Delay Function Parameters

| Name | Field | Default Value |
|-------------|-------------|---------------|
| Time | *FFTIME | N/A |
| Capacity | *AMCAPACITY | N/A |
| Alpha | *ALPHA | 4 |
| Link Length | Length | N/A |
| Speed | None | N/A |

Field: *ALPHA, Default Value: 4

Globals

Iterations: 99, Convergence: 0.0100, Function: [Empty], Error: 5.0000