ArcGIS Tools for Subnetwork Analysis of Dynamic Traffic Assignment

Jack Bringardner
Support from:
Mason Gemar
Dr. Randy Machemehl
ArcGIS Transportation Modeling

• Transportation models aim to predict how people use the transportation system
• Network and traffic models simulate how vehicles use roadways
• Impacts of proposed alterations to the network can be estimated
• New models are more complex and need a method to simplify the problem
Transportation Network Analysis
Modelbuilder

• We built a tool inside ArcGIS using Modelbuilder
• Designed as a sketch planning tool to investigate static traffic assignment results
• Calculates intersection capacity
Geocoding
# Tool Interface

![Intersection Capacity Calculator](image.png)

**Intersection Capacity Calculator**

<table>
<thead>
<tr>
<th>Cycle Length</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Day</td>
<td>PM</td>
</tr>
<tr>
<td>Street 1 Vol</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 1 Lanes</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 2 Vol</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 2 Lanes</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 3 Vol</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 3 Lanes</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 4 Vol</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 4 Lanes</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 5 Vol</td>
<td>0.1</td>
</tr>
<tr>
<td>Street 5 Lanes</td>
<td>0.1</td>
</tr>
</tbody>
</table>

- **Cycle Length (in Seconds)**: Time of Day (AM or PM)
- **Street 1 Volume**: Enter 0.1 to retain current volume (run the model once to generate volume), or new volume to change first selected street's volume in attribute table. Street 2, street 3, and so on are the subsequent rows in the attribute table. Street 1 Lanes: Same as the street volume inputs, but if changed updates the number of lanes field instead of the corresponding selected row in the attribute table.
Network Database
Model Structure

• Submodels built into a main model are called to:
  – Extract the appropriate data from the database
  – Update attributes for the network modification
  – Carry out calculations on the data

• Equations based on the Highway Capacity Manual (traffic engineering guidebook)
Main Model

Inputs
Submodels
Submodel for Data Inputs

Topology
Sub-submodels
Data Extraction using Python

```python
def volume(pointx, pointy, tox, toy, fromx, fromy, tod, amvolab, amvolba, pmvolab, pmvolba):
    if (math.fabs(pointx - tox) + math.fabs(pointy - toy)) < (math.fabs(pointx - fromx) + math.fabs(pointy - fromy)):
        if tod == 'AM':
            return amvolab
        elif tod == 'PM':
            return pmvolab
    else:
        if tod == 'AM':
            return amvolba
        else:
            return pmvolba
```
Submodel for Changing Data Inputs

Iterator Inputs
Report Layout
Sample Report
Dynamic Traffic Assignment

• Traffic planners and engineers have developed dynamic traffic assignment (DTA) models
• Time dependent rerouting provides a much better prediction of traffic operations
• The added detail in DTA models requires much more time to compute results
• Extracting a subarea of the network can drastically reduce model run times
Dynamic Traffic Assignment

Source: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, METI, TomTom, 2013
Initial Subnetwork Testing
Initial Subnetwork Testing

Subnetwork Selection (1/2 Mile) Before VISTA

Subnetwork Selection (1/2 Mile) After VISTA

Basemap Source: BING © 2010 Microsoft and its Data Suppliers
Determine Rerouting

Before (Base Scenario)

Top 10 paths by volume

After (Impact Scenario)

Top 10 paths by volume

Impacted Link (3rd Street EB Closure)
What is a Sufficient Subnetwork?

• After preliminary tests we found that changes to the network are limited to a local area
• We decided to use statistics on the full network run outputs and subnetwork inputs
• This analysis allowed us to identify a size of subnetwork that contained traffic congestion
• We developed a means to standardize testing of subnetwork selection and performance
Connected Order

Subnetwork Selection
with Size Parameter of 1

- Impacted Link
- Selected Link
- Unselected Link
Further Subnetwork Testing
Further Subnetwork Testing
Subnetwork Case Study
Measuring Error of Subnetworks
Accounting for Error

- Once we had a better understanding of what causes the error when extracting a subarea, we attempted methods to correct for it.
- A few methods were tested to predict changes outside the subnetwork.
- Spatial analysis was used to combine entry points to the subnetwork and simplify the assessment of traffic demand at the boundary.
Identifying Trips using Subnetwork

Legend
- External Centroid
- Subnetwork Centroid
- Subnetwork Link
- Traversing Trip
- Bypassing Trip

External-to-External Trips
1. External Entering Component
2. Internal Component
3. External Exiting Component
4. Bypassing External Component

External-to-Internal Trips
1. External Component
2. Internal Component
Spatial Analysis for Entry Points
Visualizing Improved Network Data

• All of these methods were combined to produce the most accurate traffic predictions
• The data provided by the dynamic traffic assignment can be used to replace the less detailed static traffic assignment output
• This improved data can then be used to better evaluate changes to a transportation network efficiently and effectively
Updating Tools with New Networks

NMC DFW vs. DFW 2013

- NMC DFW Roadway Network
- NCTCOG 2013 Roadway Network
Visualizing Results

Travel Time Contour Map for Travel to Downtown CBD
Visualizing Results

Percent Change in AM Peak Hour Travel Time for Major Corridors
Visualizing Results

Rerouting of Trips Entering from NE Corner to SE Exit Points
Reducing the Network Intelligently
Conclusions

• ArcGIS was instrumental in manipulating and visualizing inputs and outputs for the traffic models
• Modelbuilder enabled the automation of multiple procedures used in sequence that needed to be standardized and used repeatedly
• Spatial analysis added a capability that would not have been possible without ArcGIS