Network Analyst: Performing Network Analysis

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Goals

- We assume you have some familiarity with ArcGIS Network Analyst

- We describe the capabilities of the solvers and will demonstrate them with several practical examples

- Areas of focus are:
  - Choosing the right solver
  - Configuring solvers for effective results
ArcGIS Network Analyst Extension
Solving transportation problems
Where do you get street data?

- Included with ArcGIS
  - Data and Maps media
  - North America ready-to-route dataset
- Vendor data
  - Vendor street data processing tools
- Government data
  - TIGER
- Community data
  - OpenStreetMap
  - OSM to NDS tools
- Your own data
- No street data at all
  - Network analysis services on ArcGIS online
Network Analyst Workflow

First: Add Street Data

Second: Create a Route Layer
Network Analyst – Creating a Route NA Layer

New Route Layer in the NA Window
Network Analyst – Setting Analysis Properties

Route Layer Properties: Set Impedance Attribute
Network Analyst – Load Locations

Add more fields such as ID’s to NA sub-layers and map them here

Map fields to load additional attributes
Network Analyst – Solving a Route
Network Analyst – Analyze the results

¼ Mile Buffer
Common Workflow – With Load Locations

- Use Calculate Location tool to pre-compute network locations for faster load of locations
  - Can also exclude locating on restricted elements
    - Use SQL Where clause for more control on where to locate locations such as avoid freeway ramps

- Use the 1 key to see where a point is located on a network.

- Use the 2 key for reverse geo-coding
Network Analyst solver settings

- **Barriers** – scaled or restricted
  - Point, line and polygon
- **Restrictions**
  - One-way, height, weight, left-turn, etc
- **Accumulations**
  - Pick a list of attributes to accumulate and report
- **Output Shape type**
  - Measures – enables linear referencing
- **Hierarchy**
  - For fast performance with very long routes (nationwide)
Network Analyst Traversal results

- Route, Closest Facility and Service Area keep the traversal results in memory

- Use the new GP tool Copy Traversed Source Feature to access them and turn them into feature class for later analysis
  - Before 10.1, use an ArcGIS AddIn on our resource web site

- Very detailed and useful for summary applications
ArcGIS Network Analyst Extension

Solving transportation problems
Route – Find Shortest Paths

- For a set of locations
- For many groups of locations or Multi-Route
  - Or between pairs of Origin and Destination locations
Route – Options

- Minimize any network attribute like travel time and distance
- Honor navigation necessities such as
  - Curb approach
  - U-turn rules
  - Turn delays
  - Street restrictions
    - Height
    - Weight
    - One-way
  - Time of day by using historical as well as real-time traffic information
Route – Optimal Shortest Paths

- Also called the Travelling Salesperson Problem
  - Use when you have a single vehicle or person that needs to visit a set of discrete locations in the shortest sequence
Route Demo

Mileage summary by State
ArcGIS Network Analyst Extension

Solving transportation problems

- Route
- Closest Facility
- Service Area
- Location-Allocation
- Vehicle Routing Problem
- Origin-Destination Cost Matrix
Closest Facility – Typical Applications

- Find closest application
  - Closest ATM or Store locator
  - Emergency roadside assistance dispatch

**Closest Hospital From Incident**
Closest Facility

- Use CF when shape, directions or traversal results are needed
  - Else, use OD Cost Matrix solver for computing costs

- Tips on effective use:
  - Use hierarchy only for large distances (~30 miles)
  - Set a reasonable cutoff
  - Pre-process the facilities and load only those that are near the incidents

- For large number of facilities, use 64 bit OS with 4 GB
  - Or use chunking, enabled via registry keys/details in online KB article
Closest Facility Demo
Most traversed streets
ArcGIS Network Analyst Extension
Solving transportation problems
Service Area

- What areas are within 30 minutes of a location
  - Retail/demographic analysis – sum up demand within a 5 minute drive time of a potential store location
Service Area

Detailed Option Has Holes

Generalized Option
Service Area

- To avoid holes:
  - Use Generalized option
  - When using a multi-modal network dataset, use Exclude Sources option
Service Areas

- Service Areas now support the Hierarchy option
  - Scalable
  - Fast
Service Area Uses

- Use Lines options to check the connectivity in the network
- Makes very appealing visuals on a map
- For large number of facilities, use one of these options
  - Hierarchy
  - 64 bit OS with 4 GB
  - Enable chunking via registry keys/details on online KB article
Service Area Demo
Demographic summary
Ad Placement
ArcGIS Network Analyst Extension
Solving transportation problems
Origin-Destination Cost Matrix Solver

- Computes network distances between sets of locations
Origin-Destination Cost Matrix Solver

- Internally used by
  - Reorder Stops to Find Optimal Route option
  - Vehicle Routing Problem
  - Location-Allocation
  - Generate Network Spatial Weights tool in the Spatial Statistics toolbox

- Can use with external processes like custom VRP or Linear Programming for advanced analysis
  - Deelesh’s Allocation Tools on Resource Center
Origin-Destination Cost Matrix

• **Tips on effective use:**
  - Use hierarchy only for large distances (~30 miles)
  - Set a reasonable cutoff
  - Do not solve as the active analysis layer (use GP)
  - Use ArcObjects for very large OD with no output lines
  - Use 64 bit OS which allows ArcGIS 10 and 10.1 to use 4 GB of RAM
OD Cost Matrix
Demo
Accumulate Attributes
School Allocation
ArcGIS Network Analyst Extension

Solving transportation problems

- Route
- Closest Facility
- Service Area
- Location-Allocation
- Vehicle Routing Problem
- Origin-Destination Cost Matrix
Vehicle Routing Problem

- This is not the simple Travelling Salesperson Problem!

Multiple Vehicles with different capacities
Vehicle Routing Problem vs. TSP

- Use VRP solver when you have
  - A fleet of vehicles with defined capacities
  - One or more warehouse or dispatch locations
  - Customers have delivery time preferences

- Additional capabilities
  - Drivers can take multiple-breaks
  - Routes can be generated around seed points, e.g. driver home
  - Drivers with technical specialty can be matched to service order
Vehicle Routing Problem Capabilities

Order Properties

Warehouse Properties

Route/Driver Properties
Vehicle Routing Problem Capabilities

- For more information, see the online help!
- VRP Online Help
Vehicle Routing Problem Uses

- **Service problem:**
  - Send technicians to service clients on-site, *i.e.* pest control

- **Delivery problem:**
  - Deliver packages from the warehouse to clients, *i.e.* hardware deliveries

- **Paired-order service problem:**
  - Pick up people from one location and deliver them to another location, *i.e.* bus tour problem

- **Paired-order delivery problem:**
  - Deliver packages from one location to another, *i.e.* package deliveries
VRP Demo
Flag Fundraiser
ArcGIS Network Analyst Extension

Solving transportation problems
Location-Allocation

- Useful for locating
  - Warehouses
  - Retail Stores
  - Fire Stations
- At 10.1, Facilities can have capacity
  - School allocation
Location-Allocation

- Optimize warehouse location for VRP

Re-locating Warehouse Saves five percent fuel
Location-Allocation supports the gravity model (also called the Huff model) for competitive locations.

**Inputs:**
- Your locations
- Your competitor locations
- Demand locations
- Distance decay parameters
- Market share - Locates sites to maximize market share
- Target market share – Computes number of sites needed to achieve a target market share (say 24%)

If all inputs are fixed then you can use Location-Allocation to compute spatial-interactions!
Location-Allocation Gravity Models example

Chain of stores looking to expand market share

Competing chain

Best locations to expand market share by 10%

Location-Allocation target market share model uses Huff gravity model to determine best locations to encroach on competing chains

Potential customers
Tobler’s First Law of Geography:
- Everything is related to everything else, but near things are more related than distant things

Also called distance decay

Start with a survey of distance travelled by customers to come to a typical location

Make a table of cumulative trips

Make an inverse and create an XY scatter plot

Fit an appropriate trend line
## Location-Allocation Beta trend line in Excel

<table>
<thead>
<tr>
<th>Drive Time</th>
<th>Number Customers at Store</th>
<th>Accumulated Trips</th>
<th>Relative Trips</th>
<th>Inverse Relative Trips</th>
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<td>0.02688172</td>
<td>37.2</td>
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<td>12</td>
<td>17</td>
<td>0.091397849</td>
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<td>186</td>
<td>1</td>
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The trend line is given by the equation:

\[ y = 39.341x^{-1.984} \]
Location-Allocation

- **Tips on effective usage:**
  - Use an appropriate distance cutoff
    - Each demand point can have its own cutoff
      - Urban vs. Rural populations
  - Pick suitable candidates
  - If large number of demand/candidate points then aggregate

- Use LA to generate many alternatives and feeding into a Decision Support System
Location-Allocation Demo
Maximize Coverage
Things to watch out for

• Do not include your start/end locations as junctions in the network dataset
  - This causes your locations to “snap” on to these junctions which are usually not connected to any edges and no paths are found.

• Travel times are computed at posted speed limits and are too optimistic
  - Use new historic traffic information
  - Use global turn delays

• De-compose problems regionally if performance is an issue
Summary

- Pick the right solver for the task
- Choose appropriate analysis settings

To learn more
- Go through the NA Tutorials
- Lot of help available on-line
- Visit the ArcGIS resource centers for useful utilities and data
What’s new at 10.1

- Faster service area
- Capacitated location-allocation
- Enhanced restrictions
  - avoid or prefer certain roads
- All solvers are time aware
- Real-time traffic
- Geoprocessing improvements
  - arcpy.na site package
  - Copy traversal result tool
  - Simpler publishing story (SA and VRP)
- Public services
Network Analyst at the User’s Conference
Tech Workshops

- Network Analyst – An Introduction
- Network Analyst – Performing Network Analysis
- Network Analyst – Automating Workflows with Geoprocessing
- Network Analyst – Creating Network Datasets
- Network Analysis with ArcGIS for Server
Demo Theaters

- What’s new in Network Analyst at 10.1?
- Routing with Open Source Data (OSM)
- Modeling Real-World Problems with the VRP Solver
- Routing Inside Buildings with 3D Networks
- Using Streetmap Premium
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<th>Wednesday</th>
<th>Thursday</th>
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<td>Network Analyst: An Introduction Room 3</td>
<td>Network Analyst: Automating workflows with Geoprocessing Room 10</td>
<td>Routing in buildings with 3D Networks **</td>
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<td>Network Analyst: Creating Network Datasets Room 9</td>
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<td>What’s New in Network Analyst 10.1 **</td>
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<td>9 am</td>
<td><strong>Geocoding: Advanced Techniques</strong> Room 14A</td>
<td>* Demo Theater – Online GIS – Exhibit Hall C</td>
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<td><strong>What’s new at 10.1 in Geocoding</strong></td>
<td>** Demo Theater – Analysis and Geoprocessing - Exhibit Hall B</td>
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<tr>
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<tr>
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<td></td>
<td></td>
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<tr>
<td>2 pm</td>
<td>From a table of addresses to locations on the map – the Geocoding workflow</td>
<td>* Geocoding: An Introduction Room 14A</td>
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<tr>
<td>3 pm</td>
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<td>**Geocoding: Advanced Techniques Room 14A</td>
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<td>4 pm</td>
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Moderated Paper Sessions

• **Use of Network Analyst for Web-Based Bicycle Trip-Planning Applications**
  - Wednesday 1:30 – 2:45 – Room 27B (Second presentation)

• **ArcGIS Network Analyst Identifies Emergency and Evacuation Safe Routes**
  - Wednesday 3:15 – 4:30 – Room 17B (First presentation)
Steps to evaluate UC sessions

- My UC Homepage > “Evaluate Sessions”
- Choose session from planner
  OR
- Search for session by offering ID:
  587

www.esri.com/ucsurveyessions
• Thank you for attending
• Have fun at UC2012
• Open for Questions

• Please fill out the evaluation:

  www.esri.com/ucsessionssurveys

  First Offering ID:  587 (Tuesday)

  Second Offering ID:  1168 (Wednesday)