Agenda

• Preparing street data for use in a network dataset
  - Oneway streets
  - Hierarchy
  - RoadClass attribute
• Using turns, signposts, and historical traffic data
• Creating a multi-modal network dataset
• Parameterized attributes
• Evaluators tips and tricks
• Support & Resources
• Questions
Do I need to create my own network dataset?

- Network analysis services on ArcGIS Online
  - Route, Closest Facility, Service Area, VRP
  - Generates Driving Directions
  - Analysis performed on up-to-date street data
  - Much of the world is covered
  - Incorporates historical, live, and predicted traffic where available
  - No network dataset required
Do I need to create my own network dataset? I want to have it on disk

- StreetMap network datasets available
  - SDC format
  - Ready to use
  - Network dataset already created

- StreetMap data on Data & Maps
  - Comes with ArcGIS
  - Data for North America

- StreetMap Premium data
  - Data is more current
  - Data for North America or Europe
Know Your Street Data

- What information can be used as a setting in the network dataset?
Review – What is in a Network Dataset?

Sources
- Line features
- Point features
- Turn features

Connectivity
- End Point / Any Vertex
- Z-Elevation fields
- Connectivity groups

Attributes
- Cost
- Descriptor
- Restriction
- Hierarchy

Directions
- Primary street names
- Alt. street names
- Highway shields
- Boundary field
- Signpost data
Know Your Street Data

- **View data – geometry and attributes**
- **Read the documentation for data**
  - How is street geometry represented?
  - What street information is provided?
  - In what layers is this information located?
  - How is this information formatted?
- **What information can be used as a setting in the network dataset?**
Coincident Geometries

• To enable network connectivity to be modeled
  - Points of coincidence should exist where line features cross or intersect

Case 1

Case 2
Creating Coincident Geometry

- Include sources in a Topology
- Use the Integrate Tool (Geoprocessing)
- Both methods compare features and makes vertices within the cluster tolerance coincident
  - Inserts vertices where features intersect
  - Snaps features that are not coincident
# Common Fields for Street Data

<table>
<thead>
<tr>
<th>Field</th>
<th>Data Type</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>Integer</td>
<td>Ensures proper connectivity</td>
</tr>
<tr>
<td>Oneway</td>
<td>Text</td>
<td>Helps determine one way streets</td>
</tr>
<tr>
<td>Length</td>
<td>Double</td>
<td>Calculate shortest route</td>
</tr>
<tr>
<td>Travel time</td>
<td>Double</td>
<td>Calculate fastest route</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>Integer</td>
<td>Ranking of streets for routing on large network datasets</td>
</tr>
<tr>
<td>Speed</td>
<td>Integer</td>
<td>May be used to calculate travel time</td>
</tr>
<tr>
<td>Road class</td>
<td>Integer</td>
<td>Classification of roads – used for formatting directions text</td>
</tr>
<tr>
<td>Street name or address data</td>
<td>Text</td>
<td>Helps generate network locations and directions</td>
</tr>
</tbody>
</table>
Connectivity using Elevation Fields

- Attribute that enables network dataset to represent multiple “levels” for line features
- Applied to line features with coincident endpoints
- Planar and non-planar features are supported
- Commonly called z-elevation or z-levels

<table>
<thead>
<tr>
<th>NAME</th>
<th>F_ZLEV</th>
<th>T_ZLEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>State St</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

FROM endpoint  
State St  
TO endpoint

Endpoint
Line feature
Elevation Fields – Overpass/Underpass Scenario

- Four lines with coincident endpoints
Oneway field – Most common method

- Text field containing values: FT, TF, < >, N
  - “FT” – one-way in digitized direction
    - FT = traffic only allowed in this direction
  - “TF” – one-way against digitized direction
    - TF = traffic only allowed in this direction
  - <empty> – two-way street
    - “N” – No travel

If other field values, change expression
Hierarchy

- Minimizes impedance while favoring higher order roads
- Basic assumption:
  - Higher order roads are “faster” (time), not necessarily “shorter” (distance)
- Hierarchy classifies network edges into multiple levels when the network dataset is built
  - Levels: lower numeric value = higher order road
Hierarchy Considerations

- Highest level needs to be connected to each other
  - Take restrictions into consideration
- Composition of highest level hierarchy dictates performance vs. accuracy of route returned
  - Larger: more optimal routes, but is slower
  - Smaller: faster performance, but route is less optimal
- Values derived from road classification (e.g., CFCC)
- Edges per hierarchy guide:

<table>
<thead>
<tr>
<th>Hierarchy</th>
<th>Regional % of edges</th>
<th>National % of edges</th>
<th>Edge count better guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5%</td>
<td>3%</td>
<td>~100,000 max</td>
</tr>
<tr>
<td>2</td>
<td>15%</td>
<td>17%</td>
<td>Percentage of total</td>
</tr>
<tr>
<td>3</td>
<td>80%</td>
<td>80%</td>
<td>Percentage of total</td>
</tr>
</tbody>
</table>
RoadClass attribute

- Used for formatting the text of driving directions
- Has no effect on network analysis
- Descriptor attribute, five possible integer values:

<table>
<thead>
<tr>
<th>RoadClass Value</th>
<th>RoadClass Description</th>
<th>Driving Directions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Local road</td>
<td>“Turn left on Main St”</td>
</tr>
<tr>
<td>2</td>
<td>Limited access highway</td>
<td>“Go East on I 44”</td>
</tr>
<tr>
<td>3</td>
<td>Ramp</td>
<td>“Take ramp and go on US-7 N”</td>
</tr>
<tr>
<td>4</td>
<td>Ferry</td>
<td>“Take Lake Expy ferry”</td>
</tr>
<tr>
<td>5</td>
<td>Roundabout</td>
<td>“Take roundabout and proceed South on Main St”</td>
</tr>
</tbody>
</table>
Dissolve Network

- Input: Network dataset
- Output: New network dataset with fewer line features
  - North America: 43.8M lines → 15.7M lines

• Fewer line features – Faster network analysis
Dissolve Network

- Speeds up network analysis for large networks
- Geoprocessing tool in Network Dataset toolset

- Creates a **new** dissolved network dataset
  - Original network dataset is unedited
- Only fields used by network dataset are present in dissolved data
  - Use dissolved dataset for network analysis
  - Keep original data for maintenance and other work
Demonstration

Adding fields for routing to TIGER/Line® street data
Turns in the Network Dataset

- Describe transitions between two or more edges
- Used to model cost and/or restrictions in the network
- Incorporating turn elements – more realistic network solver results
- Two options:
  - Turn features
  - Global (default) turns
  - Or Both
Turn Feature

- Polyline geometry
- Turn references edges by:
  - Feature class ID
  - Feature ID
  - Position
- Turn elements built by edge references

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ObjectID</td>
<td>1</td>
</tr>
<tr>
<td>Shape</td>
<td>Polyline</td>
</tr>
<tr>
<td>Edge1End</td>
<td>Y</td>
</tr>
<tr>
<td>Edge1FCID</td>
<td>42</td>
</tr>
<tr>
<td>Edge1FID</td>
<td>104</td>
</tr>
<tr>
<td>Edge1Pos</td>
<td>0.5</td>
</tr>
<tr>
<td>Edge2FCID</td>
<td>42</td>
</tr>
<tr>
<td>Edge2FID</td>
<td>102</td>
</tr>
<tr>
<td>Edge2Pos</td>
<td>0.6</td>
</tr>
<tr>
<td>Edge3FCID</td>
<td>42</td>
</tr>
<tr>
<td>Edge3FID</td>
<td>103</td>
</tr>
<tr>
<td>Edge3Pos</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Editing Turn Features

- Create and edit turn features in the ArcMap Editor
- Edit as you would any other line feature
- Snap geometry to each street in turn
- Network dataset must be built before editing turn features
Global Turns

• For example – adding a penalty for all left turns
• Consist of:
  - All implied two-edge turning sequences in network
  - No need to create a turn feature for every two-edge sequence in the network

• Specify attribute values for global turns
• VB Script evaluator –or– Global Turn Delay evaluator
Sample VB Script code for Global Turn Penalty

Pre-Logic VB Script Code:
  a = Turn.Angle
  If a > 210 And a < 330 Then
    turnTime = 0.5
  Else
    turnTime = 0
  End If

Expression:
  turnTime

Expression Table:

- **Right turn**: 30/360
- **Left turn**: 30/360
- **Straight**: 30/360
- **U-turn**: 0/360
- **Straight**: 0/360

Expression Diagram:
...or use the Global Turn Delay evaluator
Signposts

• Text seen on highway signs
  - Typically includes exit number, street name, and/or destination
• Has no effect on network analysis
• Enhances text of driving directions:
  - “At exit 73B, take ramp to US-421 North toward N Wilkesboro”
Signpost data – Two tables

- **Signpost feature class**
  - Actual text on sign

<table>
<thead>
<tr>
<th>Exit number</th>
<th>73 B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street name(s)</td>
<td>US-421</td>
</tr>
<tr>
<td>Direction</td>
<td>North</td>
</tr>
<tr>
<td>Destination(s)</td>
<td>N Wilkesboro</td>
</tr>
</tbody>
</table>

- **Signpost streets table**
  - Streets traversed when following the sign

<table>
<thead>
<tr>
<th>Feature class ID</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature ID</td>
<td>41</td>
</tr>
<tr>
<td>Positions</td>
<td>0.0 to 1.0</td>
</tr>
</tbody>
</table>

For Vendor data use "Import Signposts" .NET SDK Developer sample
Adding Signposts to the Network Dataset

- Signpost tables specified in the Directions Settings

![Network Directions Properties](image)
**Historical Traffic**

- Travel time varies by time of day and/or day of week
  - Travel at 8am:
  ![Image of traffic at 8am]
  - Travel at 5pm:
  ![Image of traffic at 5pm]

- Used by Network Analyst when a Start Time is specified for the route
Historical Traffic Data – Two tables

### Traffic Profiles table
- Contains free-flow speed multipliers by time of day

<table>
<thead>
<tr>
<th>Profile</th>
<th>1 am</th>
<th>5 am</th>
<th>9 am</th>
<th>1 pm</th>
<th>5 pm</th>
<th>9 pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>×1.0</td>
<td>×1.1</td>
<td>×2.3</td>
<td>×1.2</td>
<td>×1.4</td>
<td>×1.1</td>
</tr>
</tbody>
</table>

### Streets-Traffic Profiles join table
- Specifies free-flow travel times and profiles to use

<table>
<thead>
<tr>
<th>Feature class ID</th>
<th>Feature ID</th>
<th>Positions</th>
<th>Free-flow travel</th>
<th>Sunday Profile</th>
<th>Monday Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>41</td>
<td>0.0 to 1.0</td>
<td>10 seconds</td>
<td>Profile 10</td>
<td>Profile 16</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Historical Traffic in the Network Dataset

- Specify when creating the network dataset
Demonstration

Using Turns, Signposts, and Historical Traffic Data
Connectivity for a Multi-Modal Network Dataset

- Connectivity groups “connect” at transfer points
  - Example: Rail stations
- Non-connecting edge sources in separate connectivity groups
Multi-Modal: Considerations for Road and Rail

- Road and Rail example – two common scenarios:
  - Railroad station not on rail track
  - Railway station entrance along middle of road
- For Railroad stations not along the road
  - Create “transfer edges”
- For station entrances not at the road ends
  - Create junction with Override policy at entrance
  - Insert vertex on street feature at station entrance
Network Attributes for a Multi-Modal Network Dataset

• Create a cost attribute for each scenario you are modeling
  - Automobile
  - Pedestrian (walk only)
  - Pedestrian using light rail
  - etc.

• Create restriction attributes to prevent invalid traversals
  - Example: Restrict driving on the rail lines
Demonstration

• A multi-modal network dataset
Parameterized Attributes

- Network attribute that accepts a parameter
- Used to model dynamic aspect of an attribute’s value

Parameterized attribute

- Input Parameter value(s)
- (Optional) Other Network Attribute(s)
Example – implementing a height limit

- Requires both a Descriptor and a Restriction attribute
  - Descriptor attribute
    - Specifies the height limit for each road
  - Restriction attribute
    - Stores the vehicle height parameter
    - Performs the appropriate restriction
    - May use Function evaluator or VB Script evaluator
      - Function evaluator – faster & easier

Bridge clearance: 12’6”

Restriction evaluates to True (Restricted) if vehicle height exceeds 12 ft, 6 in

Pre-Logic VB Script Code:

```vbnet
restricted = false

height = ParameterValueByName("VehicleHeight")
if height > 0 then
  maxHeight = Edge Attribute ValueByName("MaxHeight")
  if maxHeight > 0 then
    restricted = height > maxHeight
  end if
end if
```
Using Height Restriction During Solve

- When using solver:
  - Set attribute restriction on **Analysis Settings** tab
  - Specify actual vehicle height on **Attribute Parameters** tab

- Solver Result:
  - Street is restricted when the actual Vehicle Height is greater than street’s MaxHeight attribute value
Evaluators – review

• A function that determines attribute values for network elements in a network dataset

• Six different types available with ArcGIS:
  - Field  - Constant  - Global Turn Delay
  - Function  - Edge Traffic - VB Script

• Example usages:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Evaluator(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Field – assign the [meters] field</td>
</tr>
<tr>
<td>TravelTime</td>
<td>Edge Traffic, Global Turn Delay – use historical traffic, turn delays</td>
</tr>
<tr>
<td>TurnRestriction</td>
<td>Constant – “true” (implies all turns restricted)</td>
</tr>
<tr>
<td>MaxHeight</td>
<td>Field – assign the [Height_Limit] field</td>
</tr>
<tr>
<td>HeightRestriction</td>
<td>Function – specify MaxHeight attribute &lt; VehicleHeight parameter</td>
</tr>
</tbody>
</table>

• Custom evaluators can be developed
Efficiency of calling evaluators

- **Field evaluator (including Field Expressions)**
  Fast: Attribute values stored when network is built; Retrieved at solve time

- **Constant, Function, & Global Turn Delay evaluators**
  Fast: Attribute values generated at solve time using precompiled logic

- **Edge Traffic evaluator**
  Fast: Multipliers & free-flow values stored when network is built; Travel time determined during solve

- **VB Script evaluator**
  Can be slow: Invokes scripting at solve time

- **Custom evaluator**: Depends on implementation
Evaluators – Tips and Tricks

• Field evaluator
  - Read in values from a field; and/or
  - Perform calculations using multiple field values
    - Example attributes: Length, DriveTime, Oneway

• Constant evaluator
  - Same attribute value across all network elements
    - Example attribute: TurnRestriction

• Custom logic
  - Initial prototyping with VB Script evaluator
  - Final implementation using Custom evaluator
    - Better performance
Support and Resources
Esri Support Center

- Online portal to technical information
- Knowledge Base
  - Technical articles
  - White papers
- Community
  - Discussion Forums
  - Blogs
  - E-mail lists
- Downloads
  - Patches & service packs
  - ArcScripts and samples

http://support.esri.com
For more information

- **Network Analyst product page**
  - Links to Demos, Brochures/White Papers, Success Stories

- **Free recorded training seminar**
  - Using Network Analyst in ArcGIS Desktop 10
Network Analyst Technical Workshops

- **Network Analyst – An Introduction**
  - Tuesday 8:30 AM, Room 32B
  - Wednesday 1:30 PM, Room 32B

- **Network Analyst: Performing Network Analysis**
  - Tuesday 10:15 AM, Room 32B
  - Thursday 1:30 PM, Room 32B

- **Designing your Network Analyst workflow (30 min)**
  - Wednesday 4:30 PM, Hall G: 2
  - Thursday 8:30 AM, Hall F: 1
Network Analyst Technical Workshops

• Network Analyst – Network Analysis with ArcGIS Online and On-premise Services
  - Tuesday 1:30 PM, Room 32B
  - Wednesday 8:30 AM, Room 32A

• Network Analyst – Automating Workflows with Geoprocessing
  - Wednesday 10:15 AM, Room 32A
  - Thursday 1:30 PM, Room 32A
Network Analyst Showcase Area
Demonstrations

• How to Route Inside and Between Buildings Using 3D Network Capabilities
  - Tuesday 1:00 PM ~ 2:00 PM

• Routing and Directions using Data and Services in ArcGIS Online
  - Wednesday 12:00 PM ~ 12:30 PM

• Yay, transit! Using GTFS Public Transit Data for Pedestrian Analysis and Transit Accessibility
  - Wednesday 3:00 PM ~ 3:30 PM
Network Analyst Showcase Area Demonstrations

- Real-time Traffic and Other New Capabilities of Network Analysis
  - Wednesday 3:30 PM ~ 4:30 PM
- Locating Facilities with Resource Constraints Using the Capacitated Location-Allocation Solver
  - Thursday 10:30 AM ~ 11:00 AM
- How to Build Efficient Vehicle Routes that Improve Cost and Consumer Satisfaction using Network Analyst
  - Thursday 12:30 PM ~ 1:30 PM
Thank you…

Please fill out the session evaluation

*First Offering ID: 1274*
*Second Offering ID: 1375*

**Online** – www.esri.com/ucsessionssurveys
**Paper** – pick up and put in drop box