Transportation Network and Temporal Analysis with ArcGIS

ESRI
Sam Berg
sberg@esri.com
Agenda

• GIS for Transportation Systems and Networks

• Network Datasets
  – Data model

• Network Analyst
  – Solvers

• Historic Traffic Speeds

• Time Rendering and Animation
GIS for Transportation

- Manage and edit road and asset data
- Dynamically model realistic network conditions
- Solve vehicle routing problems
Network Datasets
# Network datasets vs. Geometric networks

<table>
<thead>
<tr>
<th></th>
<th>Network datasets</th>
<th>Geometric networks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Usage</strong></td>
<td>Transportation</td>
<td>Electric, Gas, Rivers</td>
</tr>
<tr>
<td><strong>Flow Type</strong></td>
<td>Undirected</td>
<td>Directed</td>
</tr>
<tr>
<td><strong>Network Elements</strong></td>
<td>Network elements: Edges, junctions, and turns</td>
<td>Network features: Edges and junctions</td>
</tr>
<tr>
<td><strong>Source Data</strong></td>
<td>GDB feature classes, shapefiles, or StreetMap data</td>
<td>GDB feature classes only</td>
</tr>
<tr>
<td><strong>Connectivity</strong></td>
<td>User controls when connectivity is built</td>
<td>System manages connectivity</td>
</tr>
<tr>
<td><strong>Attribute model</strong></td>
<td>More robust attribute (weight) model</td>
<td>Weights based on feature attribute fields</td>
</tr>
</tbody>
</table>
# 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 str names
- Alternate str names
- Highway shields
- Boundary field
- Signpost data
Connectivity
Four types of network attributes

• **Cost**
  
  Distance = 1000 m  
  Drivetime = 5 min  
  Walktime = 20 min

• **Restriction**

• **Hierarchy**
  
  1 = Highway  
  2 = Major Road  
  3 = Local Street

• **Descriptor**
  
  SPEED LIMIT  
  65
Common fields on street data

- Used by field evaluator
- Can be specific to the digitized direction of the street

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<td>Double</td>
<td>Calculate shortest route</td>
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<td>FT_Minutes</td>
<td>Double</td>
<td>Travel time in from-to direction</td>
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<td>Speed</td>
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Cost attributes

- Value that is accumulated as you traverse a network element
  - Examples: Distance, driving time, walking time
    
    Distance = 1000 m
    Drivetime = 5 min
    Walktime = 20 min

- Values are apportioned along edges

  Distance = 1000 m
  Distance = 600 m
Restriction attributes

• A Boolean condition that has one of two values:
  – Restricted (true) or Traversable (false)
• Model one-way streets, restricted turns, etc.
Hierarchy attributes

- Integer values representing ranks
- Enables multi-level classification of edge elements
- Used when finding paths in a network dataset

1 = Highway
2 = Major Road
3 = Local Street
Descriptor attributes

- Description that is true for the entire length of the network element
- Used for detailed driving directions or to help derive other attributes
Parameters on restriction attributes

- Add parameters on restriction attributes
- Determine which network elements can be used by a vehicle
Attributes and edge directionality

• For edge elements, attribute values are defined for both directions of travel
  – Relative to the digitized direction of the edge

[Image of a road with traffic and time annotations]
Turn features

• Line features in a specialized feature class
• Two methods to generate
  – Load from turn table
  – Create/edit in ArcMap
• Models additional cost and/or restrictions in the network
• Complex turn movements supported
Elevation fields (Z-levs)

• Attributes that specify the “level” at endpoints
• Applied to line features with coincident endpoints
Elevation fields

Z-Levels are necessary to prevent an overpass from becoming an intersection
Multimodal example
Multimodal connectivity
DEMO

Explore the network dataset
What is Network Analyst?

- Extension for analyzing transportation networks
  - Uses Network Datasets
  - New solver added at 10: Location-Allocation

Route

Closest Facility

Vehicle Routing Problem

Origin-Destination (OD) Cost Matrix

Service Area

Location Allocation
Specialized layers

• **Network layer**
  - References a network dataset
  - Appears in table of contents and Network Analyst toolbar

• **Network analysis layer**
  - Composite layer for network solver
  - Appears in table of contents and Network Analyst Window
Network Analyst Solvers
Route solver

• Finds the best route that minimizes travel cost through a series of stops

• Options
  – Impedance
  – Time windows
  – Find best sequence
  – Directions
  – Start time
  – Multiple routes

• Applications
  – Point to point routing
  – Traveling salesperson
Closest facility solver

- Finds the best route(s) to the closest facility or set of facilities from an incident or set of incidents
- Options
  - Impedance
  - Cutoff value
  - Number of facilities to find
  - Direction of travel
  - Directions
- Applications
  - Emergency vehicle dispatch
  - Customer to stores
Vehicle routing problem (VRP) solver

- Route fleets of heterogeneous vehicles
- Applications
  - Distribution
  - Inspectors
  - Assessors
  - Technicians
  - Para-transit
- Benefits
  - Reduce operation costs
  - Reduce gas consumption
  - Optimize a fleet
Service area solver

• Finds areas you can reach from one or more locations

• Options
  – Impedance
  – Multiple break values
  – Direction of travel
  – Polygon and line options

• Applications
  – Fire response zones
  – Customer service areas
Origin-destination cost matrix solver

- Generates an “OD” matrix of the cost from each origin to each destination
- Multiple origins to multiple destinations
- Application
  - Travel time matrix
- Options
  - Impedance
  - Cutoff value
  - Number of destinations
Location Allocation solver

• A solver that determines the best place to locate or remove one or more facilities from a set of possible facility locations

• Applications
  – Depots
    • Minimize Distance
  – Retail sites
    • Maximize Market Share
  – Fire Stations
    • Locate ten fire stations such that all residences are within four minutes of a fire station
Directions

- Generated from Route, VRP, and Closest Facility solver results
- Options
  - Expandable inset maps
  - Reported units
    - Distance
    - Travel time
  - Running total of time and distance
  - Time windows
  - Print options
Barriers

- Restrict traversability
- Does not require editing the underlying network
Barrier Types

• **Point Barriers**
  – Restriction or Additive cost (new)
  – Temporarily slow down due to traffic accident

• **Line Barriers**
  – New input class for all solvers
  – Restrict traversal through a geo-fence
  – Temporarily slow down roads under construction

• **Polygon Barriers**
  – Used to model inaccessible areas or slower areas
Improvements to Barriers

- Point barriers on an edge can be used to restrict part of a street
  - Previously point barriers would restrict the entire edge

- Line and Polygon barriers are present as inputs for all Solvers

- Barriers can be used as restrictions or to scale attribute costs
DEMO

Routing
Barriers
Location Allocation
Service Areas
Vehicle Routing Problem
Historical Traffic Data

• Historical traffic data (GDB, StreetMap)
  – TeleAtlas 5 minute intervals
  – Navteq 15/60 minute intervals
• Traffic Renderer in Network Layer
• Route solver time-aware
• VRP Solver time-aware after sequencing phase
Time in ArcGIS

- Simple temporal mapping
  - The map is now time aware
  - Time is set by time-slider control
  - Time-enabled layers respond to map time

- Enhances the existing ArcGIS system
  - Time definition from layer properties
  - Simple time properties (existing attributes)
  - Desktop, Server, Engine products

Temporal Visualization is part of ArcGIS
DEMO

Historical traffic data
Time aware crash data
Summary

• GIS plays a large role in transportation network planning and analysis

• Network Datasets aim to model real world transportation infrastructures

• Network Analyst provides the tools to handle the analysis
Questions and comments?