Esri International User Conference
San Diego, California

Technical Workshops | July 25, 2012

Network Analyst
Creating Network Datasets

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Agenda

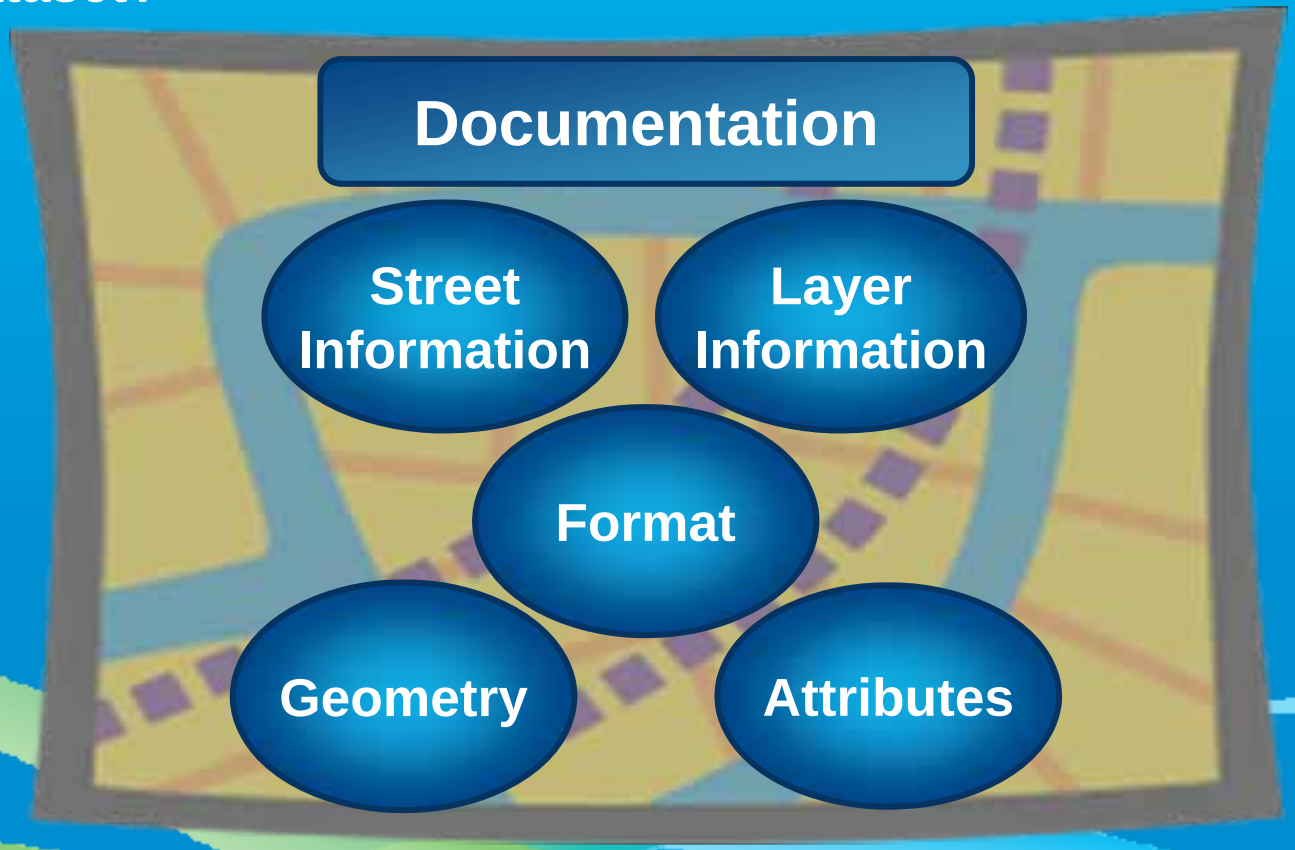
- Preparing street data for use in a network dataset
  - Oneway streets
  - Hierarchy
  - RoadClass attribute
- Using turns, signposts, and historical traffic data
- Creating a multi-modal network dataset
- Parameterized attributes
- Evaluators tips and tricks
- Support & Resources
- Questions

Do I need to create my own network dataset?

- 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

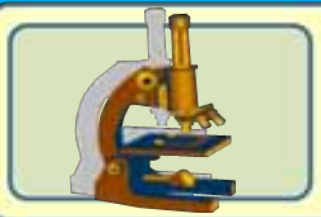
Attributes

- 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

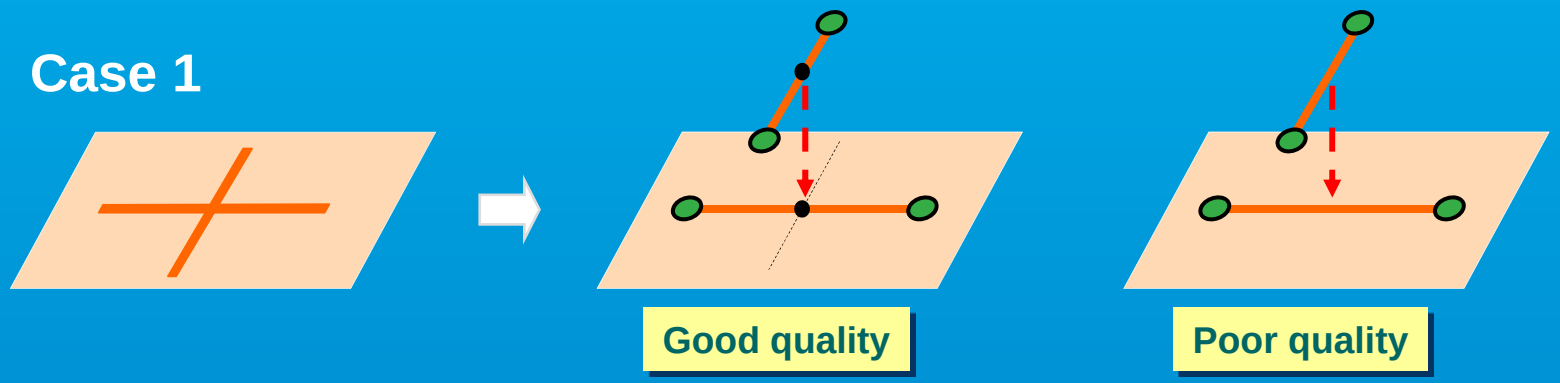
How is street geometry represented?
What street information is provided?
In what layers is this information located?
How is this information formatted?

What information can be used as a setting in the network dataset?

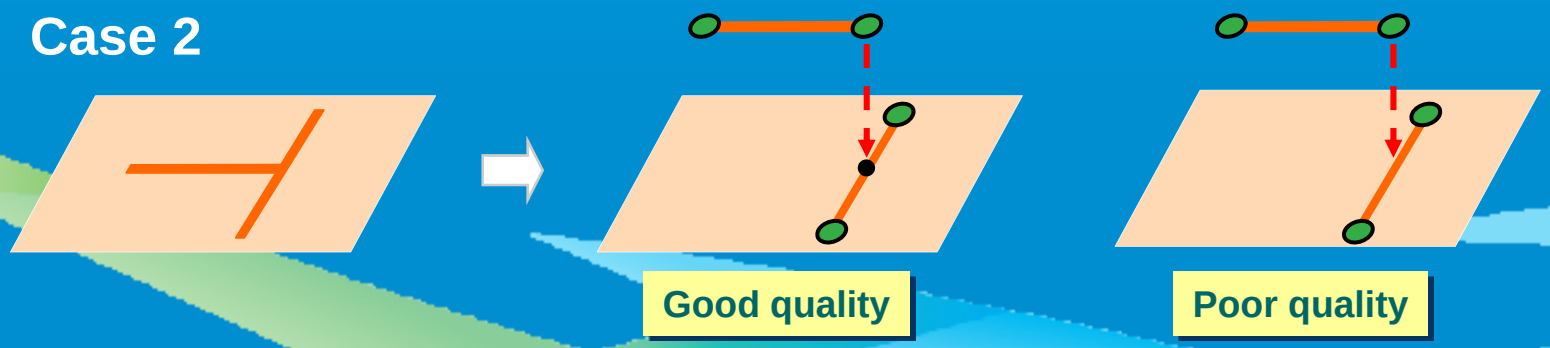
Coincident Geometries

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

Case 1

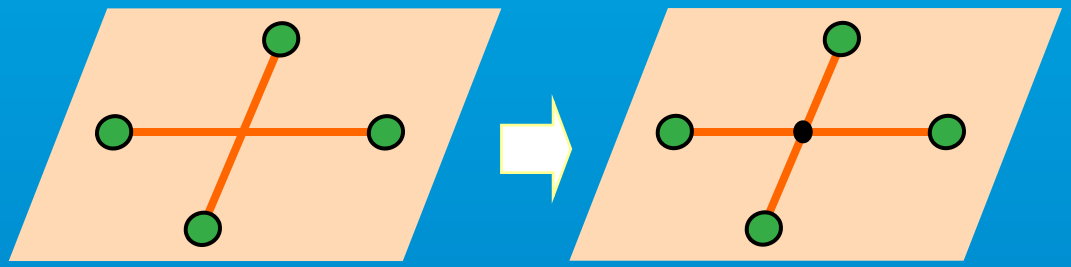


Case 2

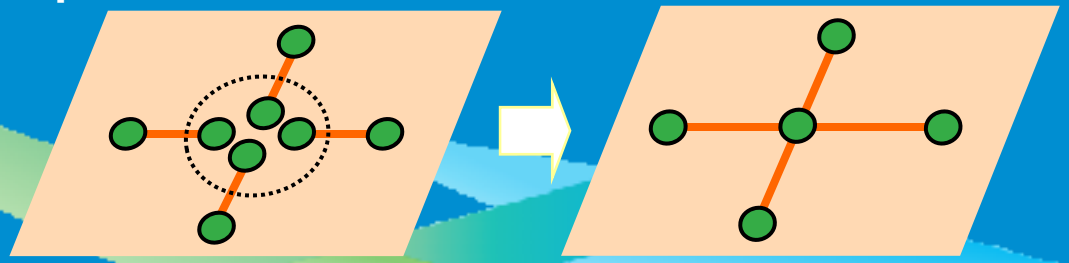


Creating Coincident Geometry

- 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

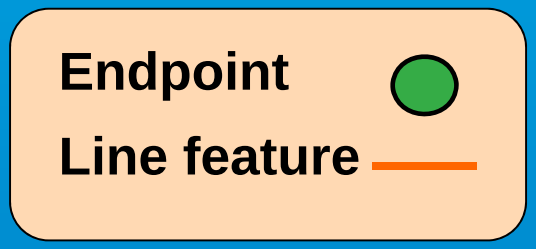


Common Fields for Street Data

Field	Data type	Application
Elevation	Integer	Ensures proper connectivity
Oneway	Text	Helps determine one way streets
Length	Double	Calculate shortest route
Travel time	Double	Calculate fastest route
Hierarchy	Integer	Ranking of streets for routing on large network datasets
Speed	Integer	May be used to calculate travel time
Road class	Integer	Classification of roads – used for formatting directions text
Street name or address data	Text	Helps generate network locations and directions

Connectivity using Elevation Fields

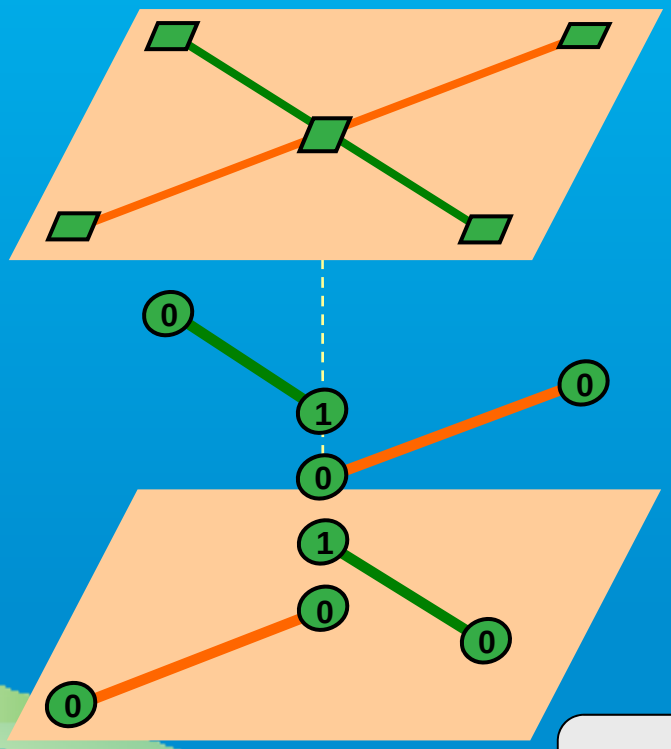
- Attribute that enables network dataset to represent multiple “levels” for line features
- Applied to line features with coincident endpoints
- Planar and non-planar features are supported
- Commonly called z-elevation or z-levels

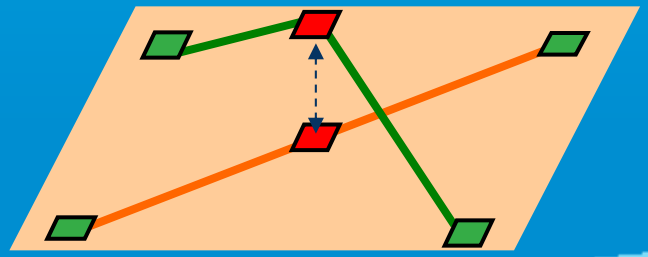


NAME	F_ZLEV	T_ZLEV
State St	0	0

Elevation Fields – Overpass/Underpass Scenario

- Four lines with coincident endpoints





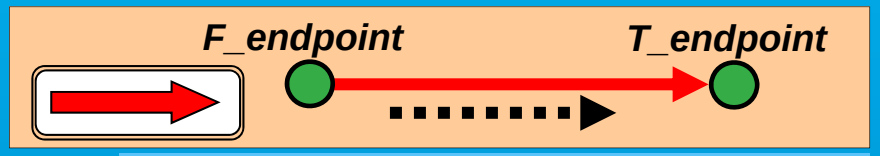
Junction
Endpoint

0-1 lines do not intersect 0-0 lines at the same junction

Oneway field – Most common method

- Text field containing values: FT, TF, < >, N
  - "FT" – one-way in digitized direction

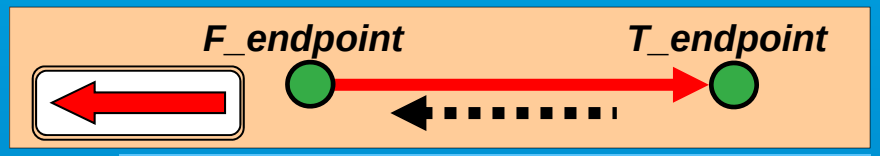
NAME	Oneway
State St	FT



FT = traffic only allowed in this direction

  - "TF" – one-way against digitized direction

NAME	Oneway
State St	TF



TF = traffic only allowed in this direction

  - <empty> – two-way street

NAME	Oneway
State St	< >

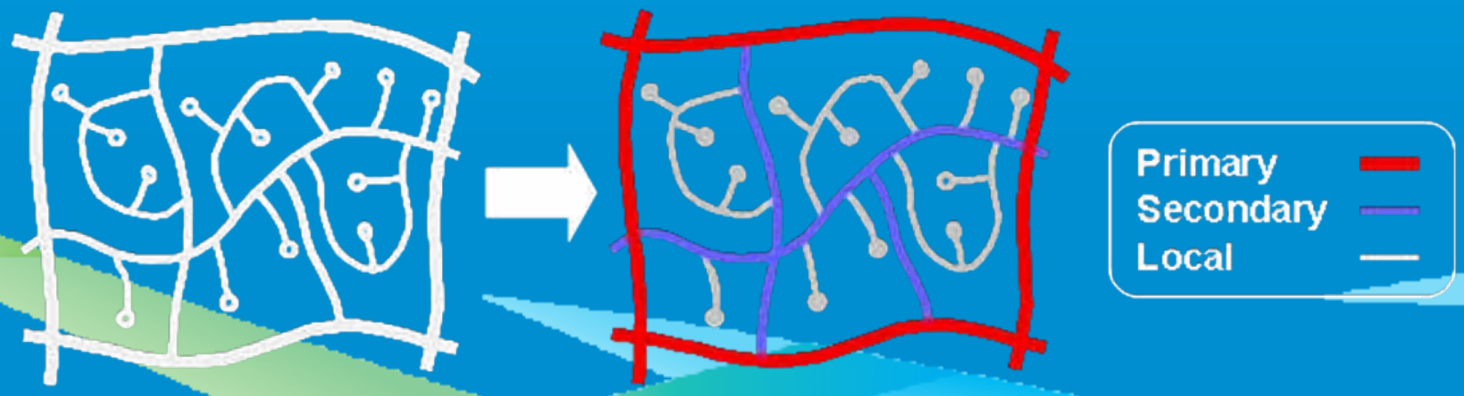
"N" – No travel

NAME	Oneway
State St	N

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 number = 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:

Hierarchy	Regional % of edges 	National % of edges 	Edge count *better guide*
1	5%	3%	~100,000 max
2	15%	17%	Percentage of total
3	80%	80%	Percentage of total

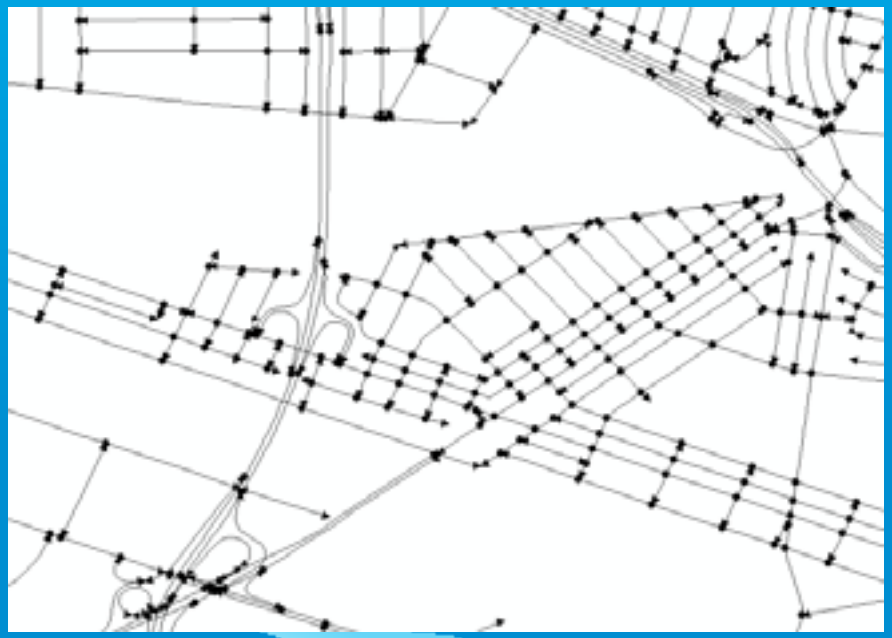
RoadClass attribute

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

RoadClass Value	RoadClass Description	Driving Directions
1	Local road	“Turn left on Main St”
2	Limited access highway	“Go East on I 44”
3	Ramp	“Take ramp and go on US-7 N”
4	Ferry	“Take Lake Expy ferry”
5	Roundabout	“Take roundabout and proceed South on Main St”

Dissolve Network

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

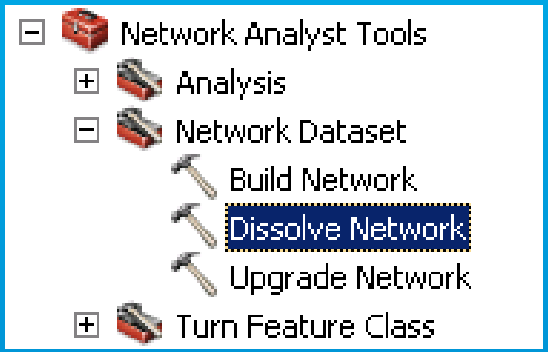


- Fewer line features – Faster network analysis

A

Dissolve Network

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



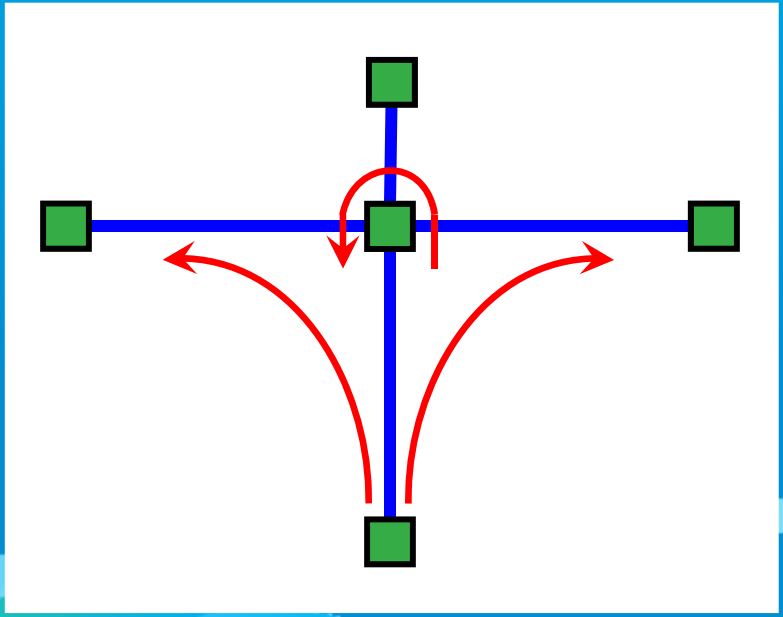
- Creates a new dissolved network dataset
  - Original network dataset is unedited
- Only fields used by network dataset are present in dissolved data
  - Use dissolved dataset for network analysis
  - Keep original data for maintenance and other work

Demonstration

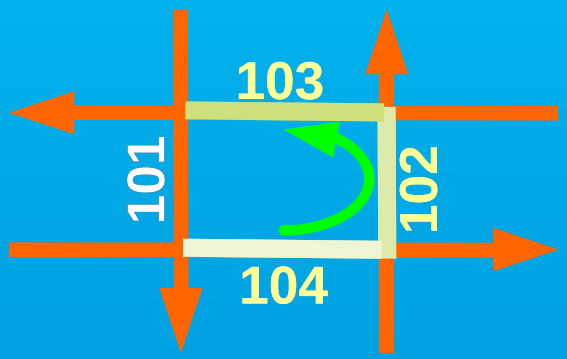
Adding fields for routing to TIGER/Line® street data

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

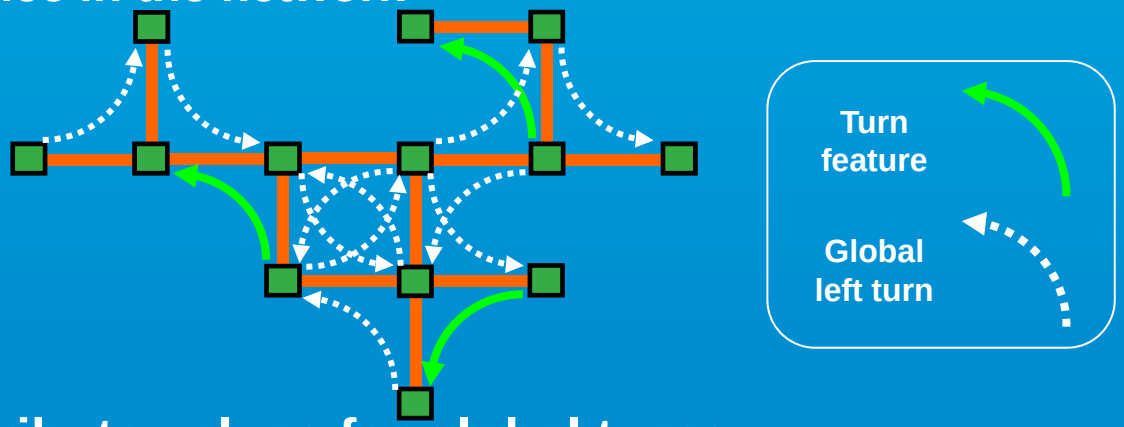
Field	Value
ObjectID	1
Shape	*Polyline*
Edge1End	Y
Edge1FCID	42
Edge1FID	104
Edge1Pos	0.5
Edge2FCID	42
Edge2FID	102
Edge2Pos	0.6
Edge3FCID	42
Edge3FID	103
Edge3Pos	0.4

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

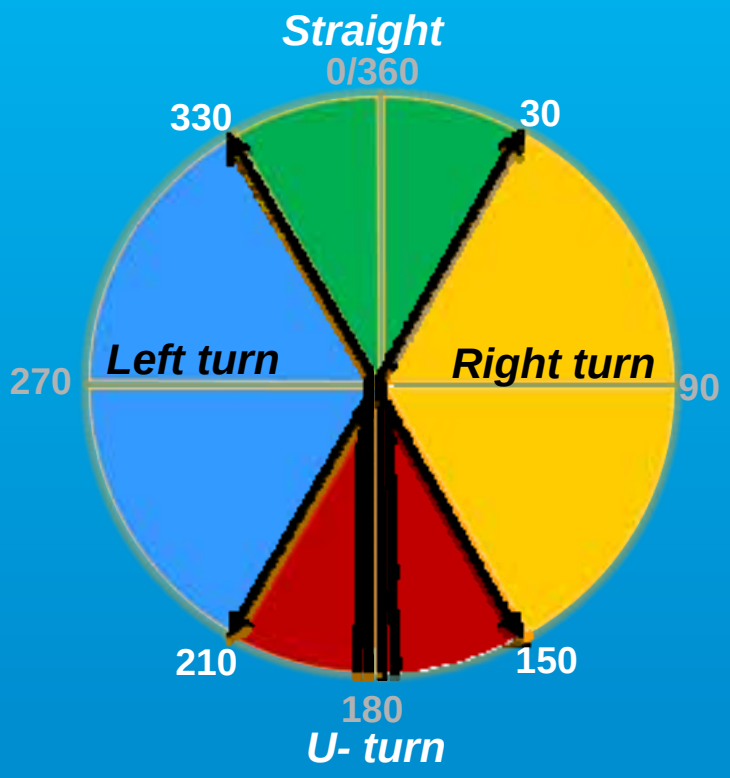
Sample VB Script Code for Global Turn Penalty

Pre-Logic VB Script Code:

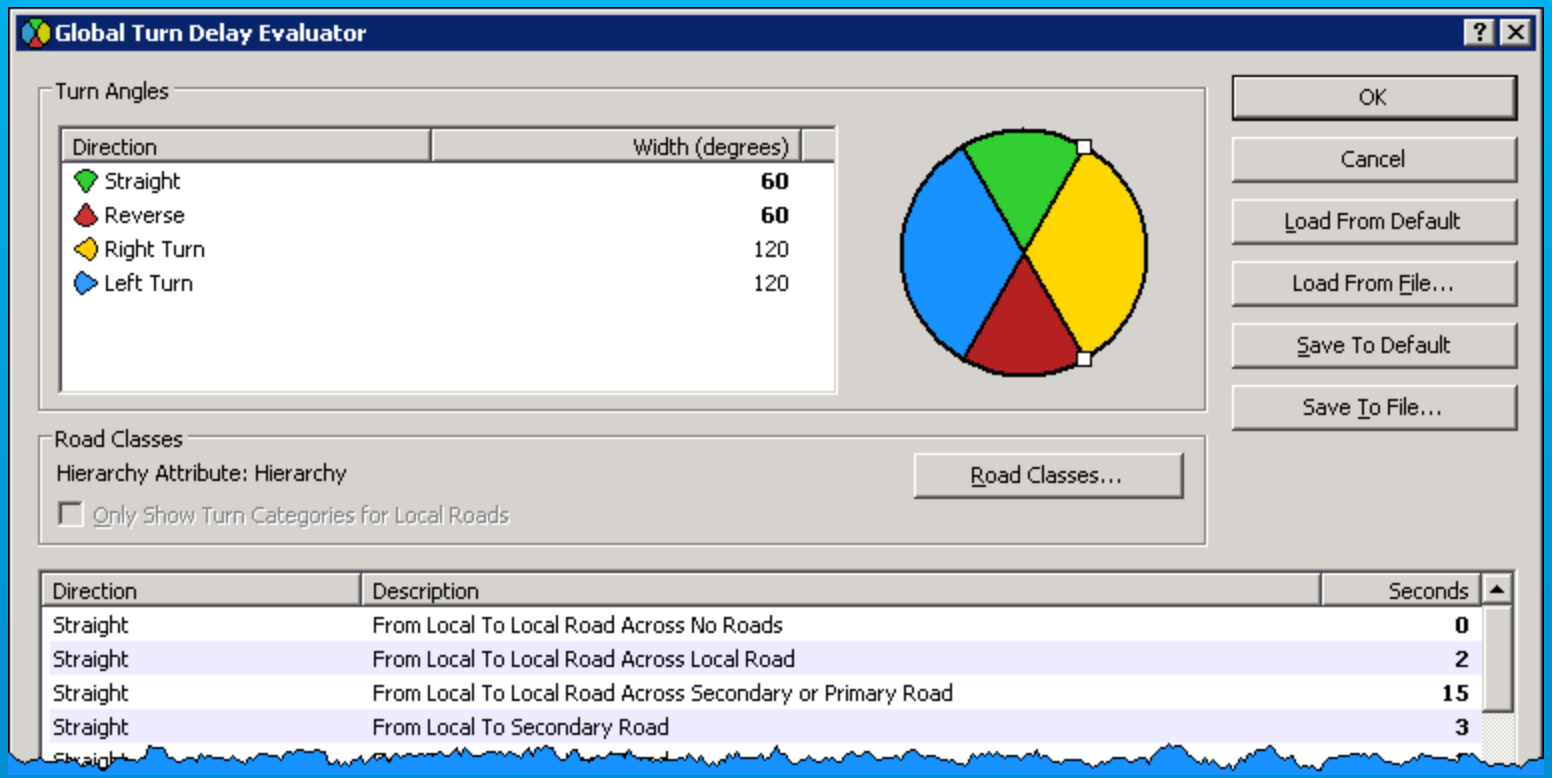
```
a = Turn.Angle
If a > 210 And a < 330 Then
   turnTime = 0.5
Else
   turnTime = 0
End If
```

Expression:

```
turnTime
```



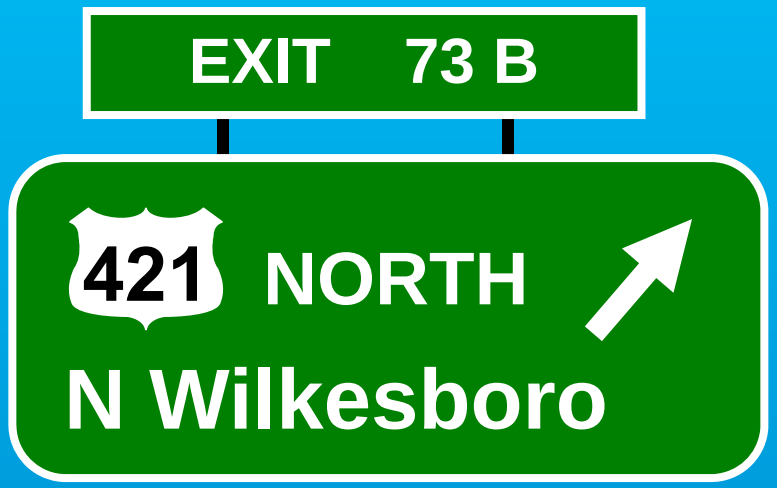
…or use the Global Turn Delay evaluator



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

Exit number	73 B
Street name(s)	US-421
Direction	North
Destination(s)	N Wilkesboro

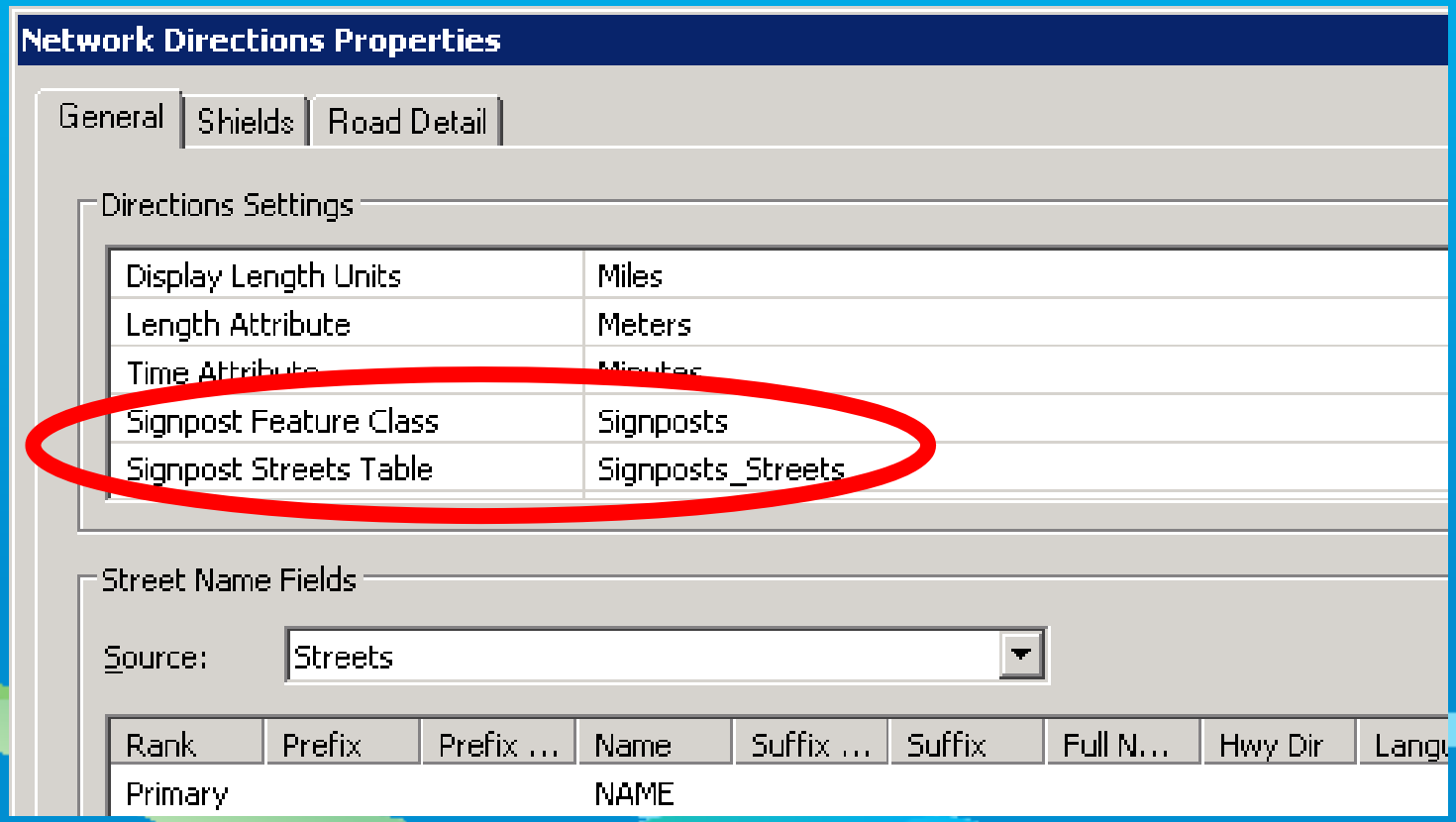
- Signpost streets table
  - Streets traversed when following the sign

Feature class ID	12
Feature ID	41
Positions	0.0 to 1.0

For Vendor data use "Import Signposts" .NET SDK Developer sample

Adding Signposts to the Network Dataset

- **Signpost tables specified in the Directions Settings**



Historical Traffic

- Travel time varies by time of day and/or day of week
  - Travel at 8am:

  - Travel 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

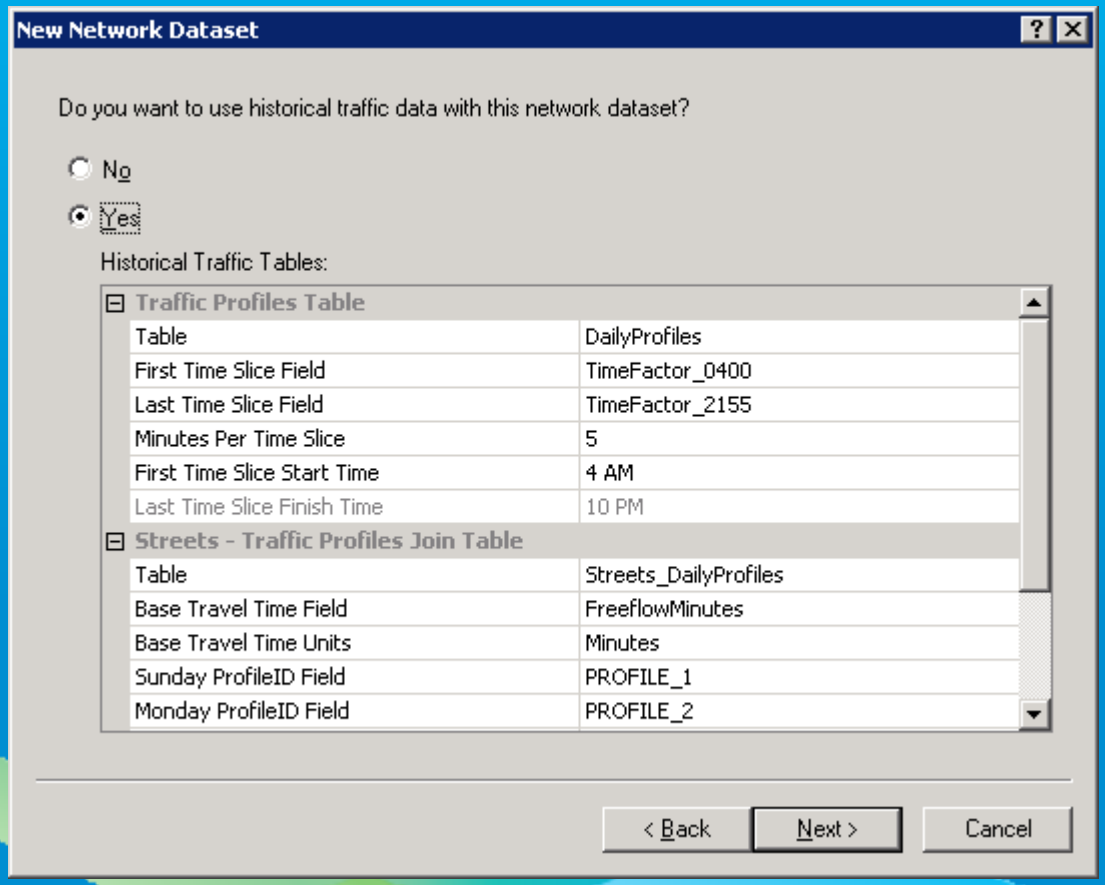
Profile	1 am	5 am	9 am	1 pm	5 pm	9 pm
16	×1.0	×1.1	×2.3	×1.2	×1.4	×1.1

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

Feature class ID	12
Feature ID	41
Positions	0.0 to 1.0
Free-flow travel	10 seconds
Sunday Profile	Profile 10
Monday Profile	Profile 16
…	…

Historical Traffic in the Network Dataset

- **Specify when creating the network dataset**

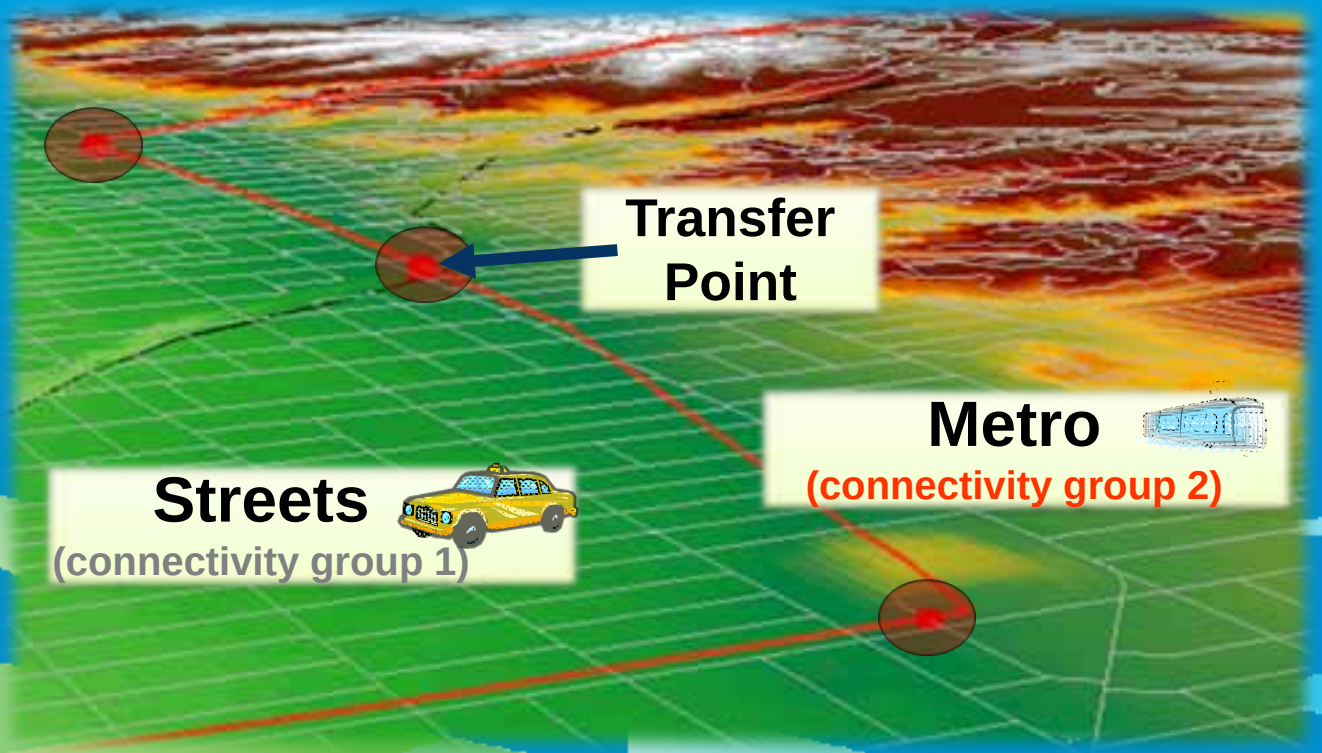


Demonstration

Using Turns, Signposts, and Historical Traffic Data

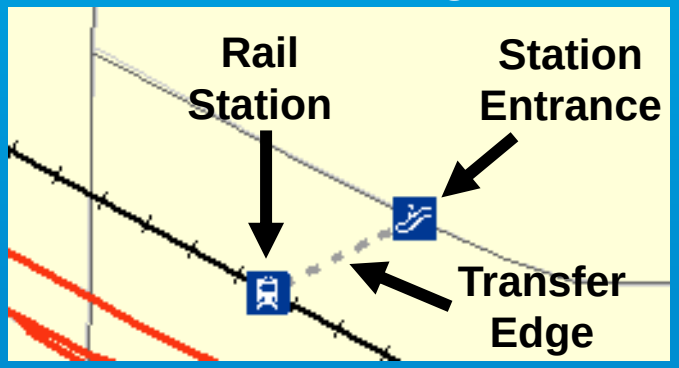
Connectivity for Multi-Modal Network Dataset

- Connectivity groups “connect” at transfer points
  - Example: Rail stations
- Non-connecting edge sources in separate connectivity groups



Multi-Modal – considerations for Road & Rail

- Road & 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”



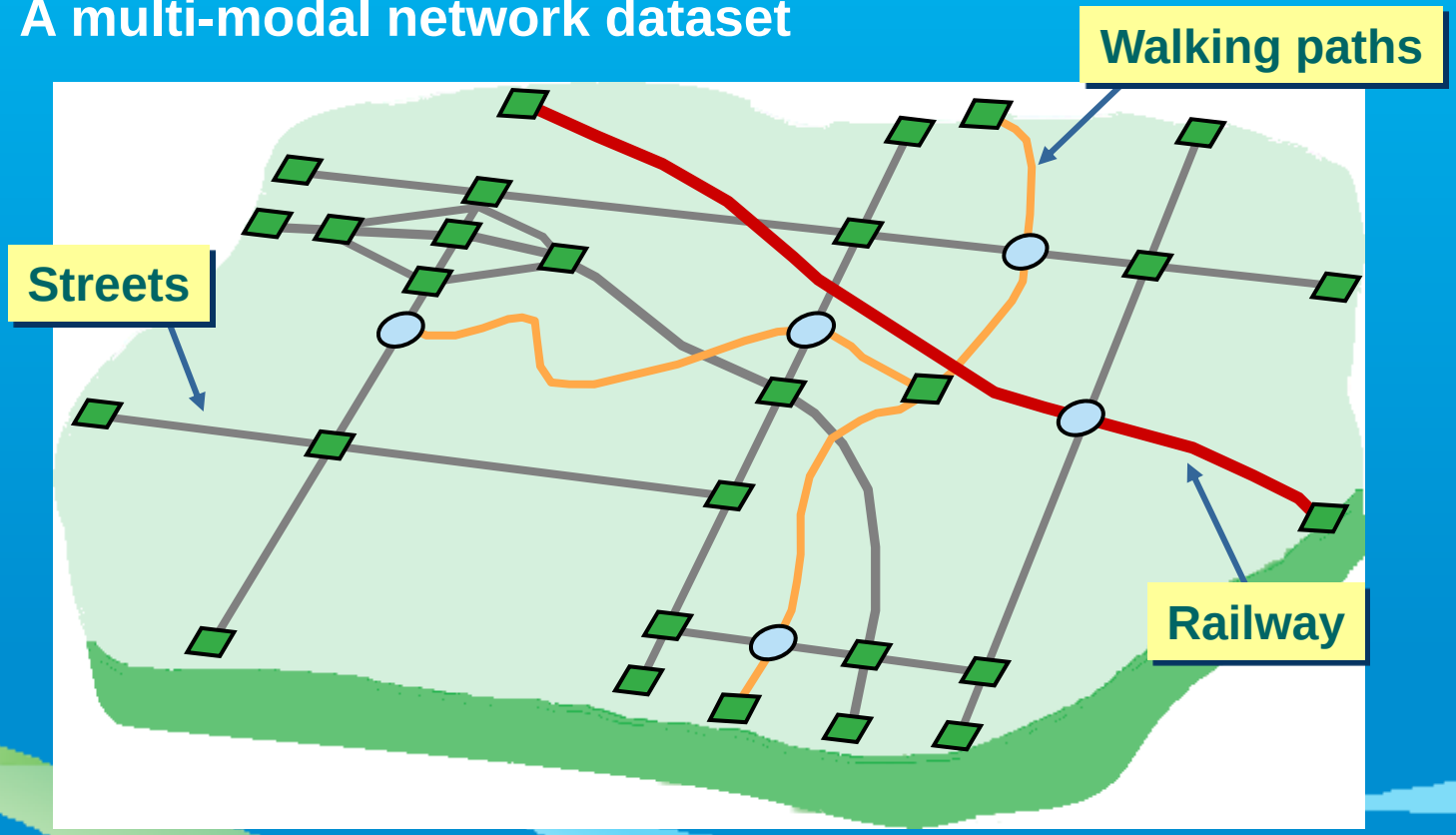
- For station entrances not at the road ends
  - Create junction with Override policy at entrance
  - Insert vertex on street feature at station entrance

Network Attributes – 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

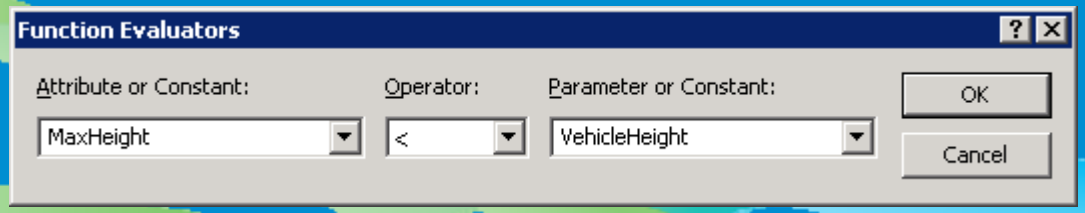
Input Parameter value(s)

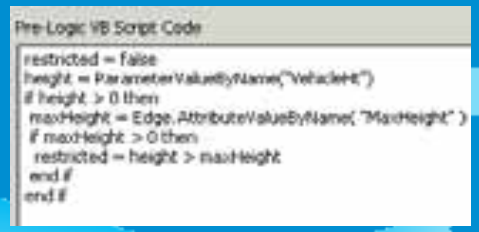
(Optional)
Other Network Attribute(s)

Example – implementing a height limit

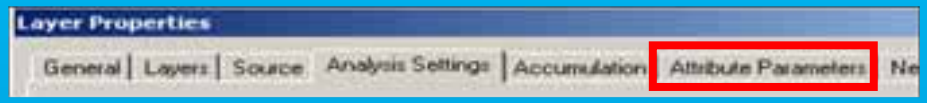
- Requires both a Descriptor and a Restriction attribute
- Descriptor attribute
  - Specifies height limits for each road
- Restriction attribute
  - Stores vehicle height parameter
- Performs the appropriate restriction
- May use Function evaluator or VB Script evaluator
  - Function evaluator – faster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

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

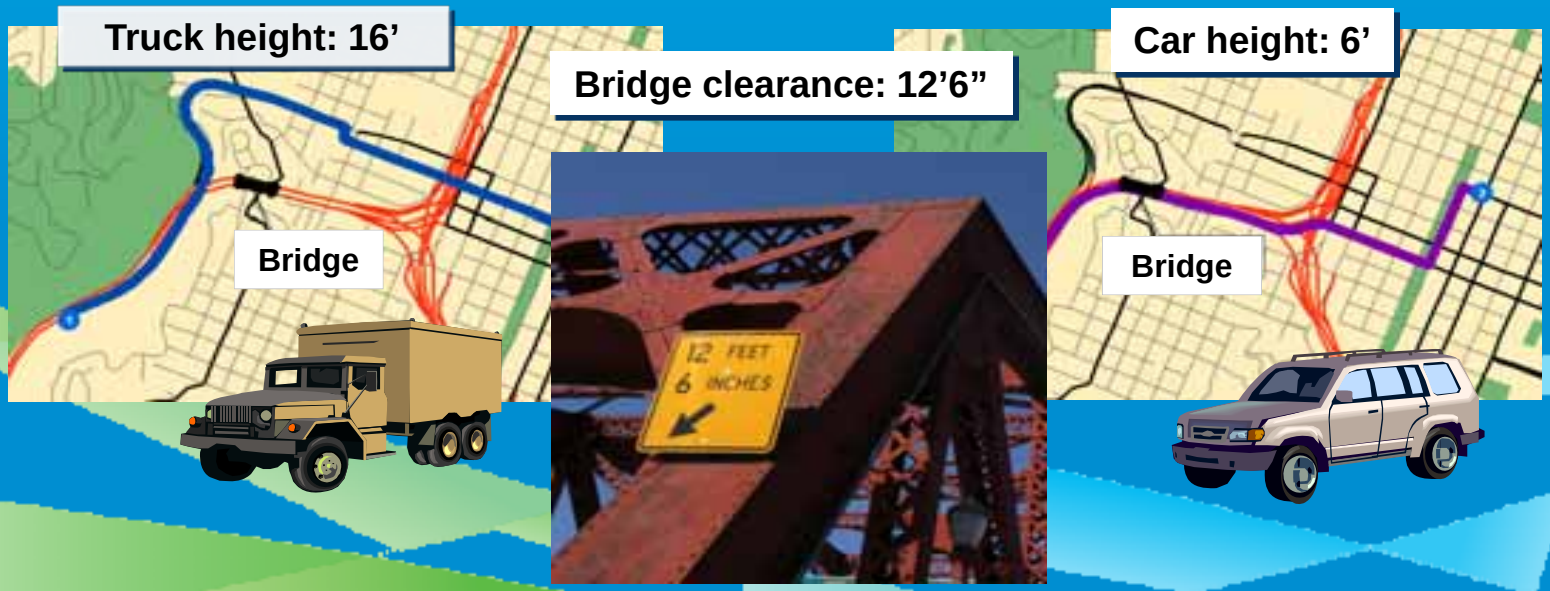




Using Height restriction during solve



- 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:

Attribute	Evaluator(s)
Length	*Field* – assign the [meters] field
TravelTime	*Edge Traffic*, *Global Turn Delay* – use historical traffic, turn delays
TurnRestriction	*Constant* – "true" (implies all turns restricted)
MaxHeight	*Field* – assign the [Height_Limit] field
HeightRestriction	*Function* – specify MaxHeight attribute < VehicleHeight parameter

- 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 & Resources

Esri Support Center

- Online portal to technical information

- Knowledge Base
  - Technical articles
  - White papers
- Community
  - Discussion Forums
  - E-mail lists
- Downloads
  - Patches & service packs
  - ArcScripts and samples
  - Data models

http://support.esri.com

For more information

- Network Analyst product page
  - Links to Demos, Brochures/White Papers, Success Stories
  - http://www.esri.com/software/arcgis/extensions/networkanalyst/
- Free recorded training seminar
  - Using Network Analyst in ArcGIS Desktop 10
  - http://training.esri.com/gateway/index.cfm?fa=catalog.webCourseDetail&CourseID=1955

Network Analyst Technical Workshops

- Network Analyst – An Introduction
  - Tuesday 8:30 AM, Room 3
  - Wednesday 1:30 PM, Room 4
- Network Analyst – Performing Network Analysis
  - Tuesday 10:15 AM, Room 3
  - Thursday 10:15 AM, Room 4
- Network Analysis with ArcGIS for Server
  - Tuesday 1:30 PM, Room 3
- Automating Workflows with Geoprocessing
  - Wednesday 8:30 AM, Room 10

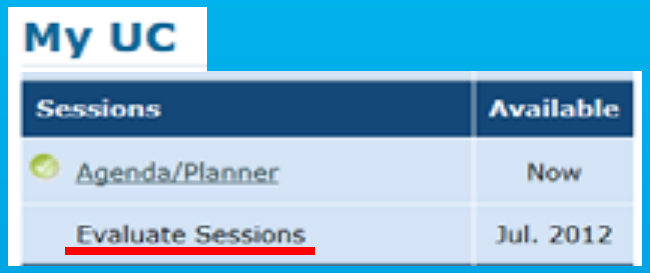
Network Analyst Demo Theater Presentations

- **Modeling Real-World Problems with the VRP Solver**
  - Tuesday 9:00 AM, Analysis & Geoprocessing Island
- **Routing with Open Source Data (OSM)**
  - Tuesday 10:00 AM, Esri Labs Island
  - Wednesday 1:00 PM, Esri Labs Island
- **What's New in Network Analyst 10.1**
  - Tuesday 5:00 PM, Analysis & Geoprocessing Island
- **Routing in Buildings with 3D Networks**

  Thursday 11:00 AM, Analysis & Geoprocessing Island

Steps to evaluate UC sessions

- My UC Homepage >
  "Evaluate Sessions"



- Choose session from "My Planner"

OR

- Search for session by Offering ID:

748

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- Thank you for attending
- Have fun at UC2012
- Open for Questions

- Please fill out the evaluation:

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