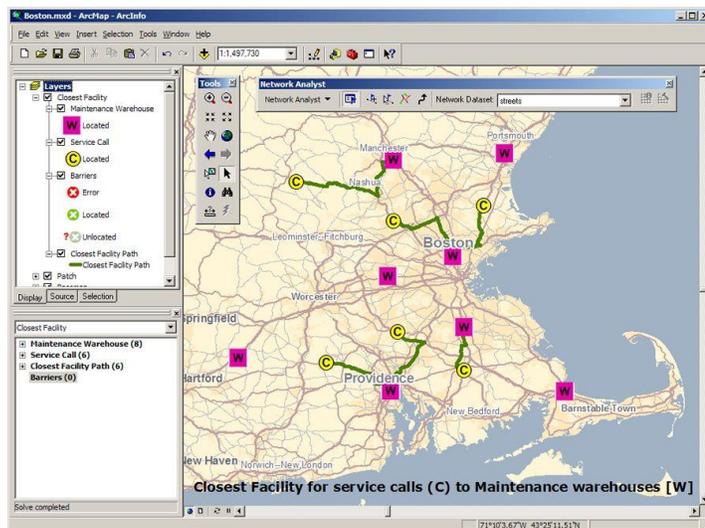# Cookbook 18 November 2013
## *Network Analyst (Part 1)*

## <u>Overview</u>

1. Network Analyst: Overview
2. Network Analyst: Examples
3. The streets/streets4 Network Data Set
4. Community Colleges in MA

ArcGIS Network Analyst provides network-based spatial analysis, such as routing, fleet routing, travel directions, closest facility, service area, and location-allocation. Using ArcGIS Network Analyst, you can dynamically model realistic network conditions, including one-way streets, turn and height restrictions, speed limits, and variable travel speeds based on traffic. You can easily build networks from your GIS data by using a sophisticated network data model.

**With ArcGIS Network Analyst, you can:**

- Find shortest routes.
- Produce the most efficient routes for a fleet of vehicles that must visit many locations.
- Locate closest facilities.
- Determine optimal locations for facilities by performing a location-allocation analysis.
- Define service areas based on travel time or distance.
- Create a network using your existing GIS data.
- Generate a matrix of network travel costs from each origin to all destinations.

http://www.esri.com/software/arcgis/extensions/networkanalyst/index.html

# 1) Network Analyst: Overview

A network is a system of interconnected elements, such as edges (lines) and connecting junctions (points) that represent possible routes from one location to another.

People, resources, and goods tend to travel along networks: cars and trucks travel on roads, airliners fly on flight paths, oil flows in pipelines, and electricity travels through the utility grid.

By modeling potential travel paths with a network, it is possible to perform analyses related to the movement of the oil, trucks, or other agents on the network. The most common network analysis is finding the shortest path between two points.
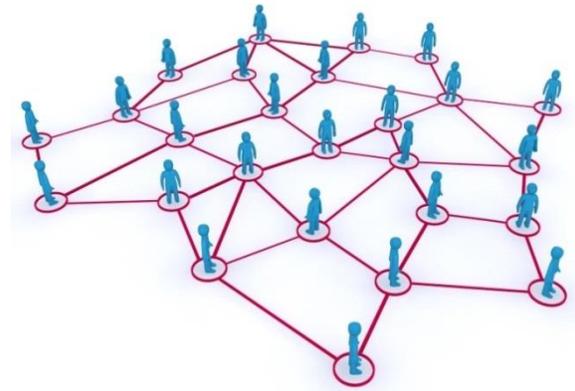
ArcGIS groups networks into two categories: geometric networks and network datasets.

### Geometric Networks (utility and river networks)

River networks and utility networks - like electrical, gas, sewer, and water lines - allow travel on edges in only one direction at a time.

The agent in the network - for instance, the oil flowing in a pipeline - can't choose which direction to travel; rather, the path it takes is determined by external forces: gravity, electromagnetism, water pressure, and so on. An engineer can control the flow of the agent by controlling how external forces act on the agent.
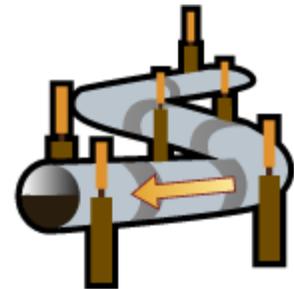
In ArcGIS, utility and river networks are best modeled by geometric networks.

### Network datasets (transportation networks)

Transportation networks - like street, pedestrian, and railroad networks - can allow travel on edges in both directions. The agent on the network - for instance, a truck driver traveling on roads - is generally free to decide the direction of traversal as well as the destination.

In ArcGIS, transportation networks are best modeled by network datasets.

In addition, you can create multi-modal network datasets and 3D network datasets.

**Additional Information**

What is the ArcGIS Network Analyst extension?
http://resources.arcgis.com/en/help/main/10.1/index.html#/What_is_the_ArcGIS_Network_Analyst_extension/00470000001000000/

A quick tour of the ArcGIS Network Analyst extension
http://resources.arcgis.com/en/help/main/10.1/index.html#/A_quick_tour_of_the_ArcGIS_Network_Analyst_extension/00470000002000000/

Essential ArcGIS Network Analyst extension vocabulary
http://resources.arcgis.com/en/help/main/10.1/index.html#/Essential_ArcGIS_Network_Analyst_extension_vocabulary/00470000003000000/

What is a network dataset?
http://resources.arcgis.com/en/help/main/10.1/index.html#/What_is_a_network_dataset/00470000007000000/


# 2) Network Analyst: Examples

The three best examples for an application of Network Analyst are: Route Analysis, Service Area Analysis, and Origin-Destination Cost Matrix Analysis.
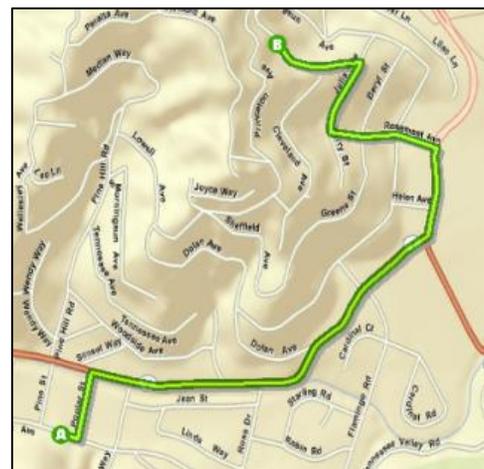
## Route Analysis

Solving a route analysis can mean finding the quickest, shortest, or even the most scenic route, depending on the impedance you choose to solve for. If the impedance (= 'cost') is time, then the best route is the quickest route. Hence, the best route can be defined as the route that has the lowest impedance, or least cost, where the impedance is chosen by you. Any cost attribute can be used as the impedance when determining the best route.

**The Impedance or Network Cost**

Whenever an agent traverses a network element, it is charged some amount, which is the network cost. For example, a path from one city to another might have a network "cost" of 45 miles.

Network cost can be anything you choose but typically is either distance or travel time.



To be used in a network analysis, a network dataset must have at least one cost attribute because network analyses always optimize some cost. For instance, a route analysis finds the least-cost path between two or more points, either in terms of time or distance! In some cases, even more than one cost attribute is required.
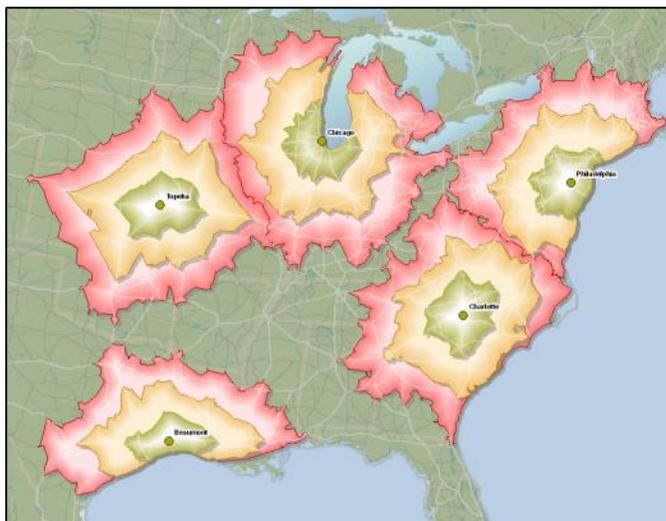
**Additional Information**

Route analysis
http://resources.arcgis.com/en/help/main/10.1/index.html#/Route_analysis/0047000000450000 0/

## Service Area Analysis

With ArcGIS Network Analyst, you can find service areas around any location on a network. A network service area is a region that encompasses all accessible streets (that is, streets that are within a specified impedance). For instance, the 5-minute service area for a point on a network includes all the streets that can be reached within five minutes from that point. Other questions:

- How many houses are within 5 minutes of a fire station?
- How many students drive more than 20 miles to campus?
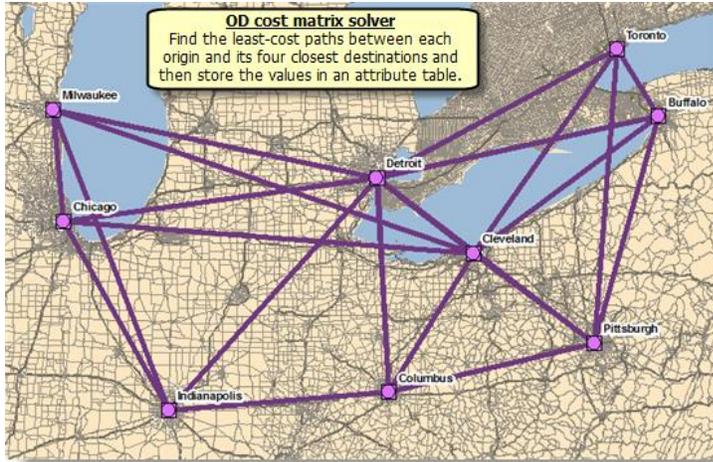


**Additional Information**

Service area analysis
http://resources.arcgis.com/en/help/main/10.1/index.html#/Service_area_analysis/00470000004 8000000/
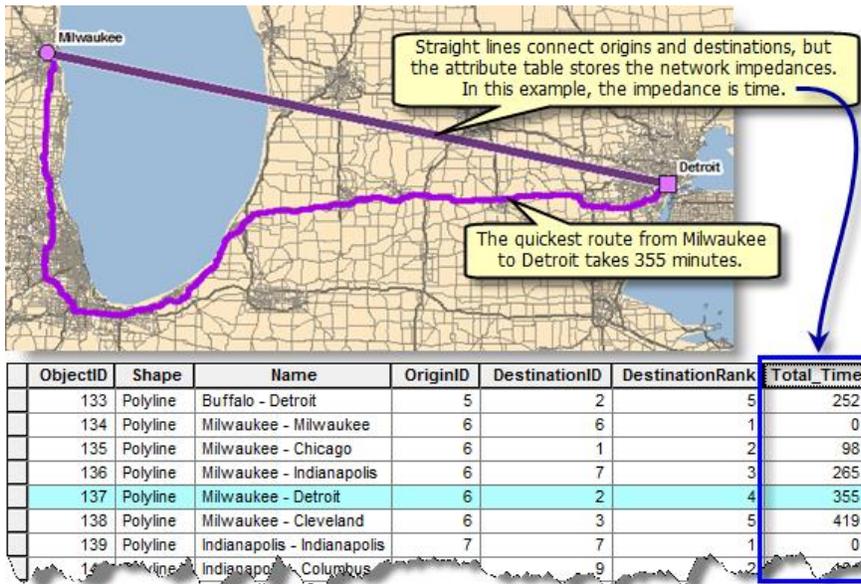
## Origin-Destination (OD) Cost Matrix Analysis

The OD cost matrix finds and measures the least-cost paths along the network from multiple origins to multiple destinations. When configuring an OD cost matrix analysis, you can specify the number of destinations to find and a maximum distance to search.

In the graphic below, the OD cost matrix found the least-cost paths from each origin to the four nearest destinations. The output shape type was set to produce straight lines.

Even though the OD cost matrix solver doesn't output lines that follow the network, the values stored in the Lines attribute table reflect the network distance, not the straight-line distance.



| ObjectID | Shape | Name | OriginID | DestinationID | DestinationRank | Total_Time |
|---|---|---|---|---|---|---|
| 133 | Polyline | Buffalo – Detroit | 5 | 2 | 5 | 252 |
| 134 | Polyline | Milwaukee – Milwaukee | 6 | 6 | 1 | 0 |
| 135 | Polyline | Milwaukee – Chicago | 6 | 1 | 2 | 98 |
| 136 | Polyline | Milwaukee – Indianapolis | 6 | 7 | 3 | 265 |
| 137 | Polyline | Milwaukee – Detroit | 6 | 2 | 4 | 355 |
| 138 | Polyline | Milwaukee – Cleveland | 6 | 3 | 5 | 419 |
| 139 | Polyline | Indianapolis – Indianapolis | 7 | 7 | 1 | 0 |
| 14 | Polyline | Indianapolis – Columbus | | 9 | 2 | |

## Additional Information

OD cost matrix analysis
http://resources.arcgis.com/en/help/main/10.1/index.html#/OD_cost_matrix_analysis/0047000 0004r000000/

# 3) The streets/streets4 Network Data Set

See separate hand-out.
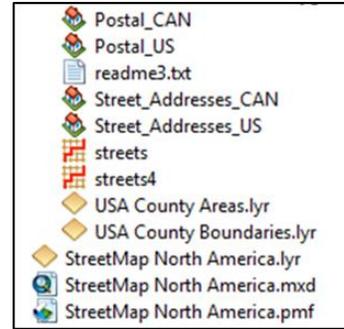


# 4) Community Colleges in MA

See separate hand-out.