ArcCASPER User Manual

A Network Analyst Evacuation Routing Extension

Kaveh Shahabi
Spatial Sciences Institute
Computer Science Department
University of Southern California

Introduction

This how-to document covers what the end user needs to know about “Evacuation Routing Analysis”. It’s recommended that the user gets familiar with other built-in analysis of Network Analyst beforehand. Repetitive instructions that are common among other analysis like ‘Route’ and ‘Closest Facility’ will not be highlighted here. Following is a good online tutorial in this regard.

http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//00470000005r000000.htm

Installation

Download URL: http://www.esri.com/arccasper

In order to install, first unzip the downloaded file. Next, execute the "install.cmd" script. This script needs to be run as an administrator in Windows Visa and later operating systems. Make sure any previous ArcCASPER installation is completely uninstalled. After installation, you should not move the content of the folder specially the DLL files. The script is going to install both 32bit and 64bit edition of the tool. You will need ArcGIS 64bit background geo-processing patch in order to take advantage of the 64bit evacuation routing (http://resources.arcgis.com/en/help/main/10.1/index.html#//002100000040000000).

To uninstall the tool, simply execute the “uninstall.cmd” script and then remove the folder. Don’t forget to backup your data.

Requirements:

- ArcGIS Desktop 10.1
- Network Analyst Extension
- (Optional) Background Geoprocessing (64-bit)

Caution: After upgrading your tool, your analysis layer may become unreadable due to incompatibilities. To avoid this, always export the evacuation data (evacuees, routes, etc.) before uninstall.

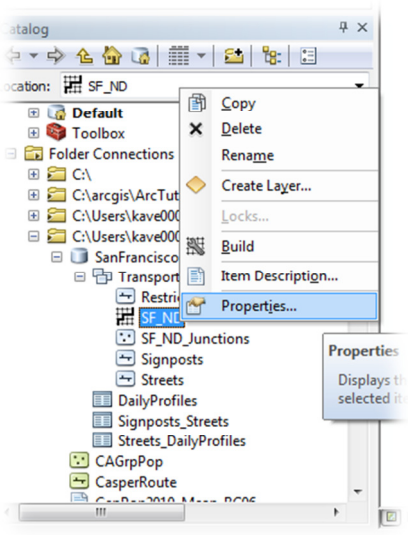

Figure 1: Network Dataset Properties

Section 1: Build a Network Dataset

In order to create and build a network dataset from your street data files please follow the link below:

http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Exercise_1_Creating_a_network_dataset/00470000005t000000/

Once your network dataset is ready, you need to create one additional network attribute called “Capacity”.

Steps:

1. Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.1.

2. Enable the Network Analyst extension if you haven't done so already.
    a. Click Customize > Extensions.
    b. The Extensions dialog box opens.
    c. Check Network Analyst.
    d. Click Close.
3. Open the Catalog window. Click Window > Catalog.
4. Locate your network dataset, then right click on it and select "Properties" (Figure 1)
5. Navigate to the "Attributes" tab. Here you'll see previously identified attributes.
6. Adding "Capacity" attribute:
    a. Click "Add"
    b. Choose the name "Capacity"
    c. Usage type "Descriptor"
    d. Data Type "Double" or "Integer". It depends on the related street shapefile field type.
    e. Click OK when you're done.
7. Click "Apply"
8. Now select "Capacity" from the list and click "Evaluators".

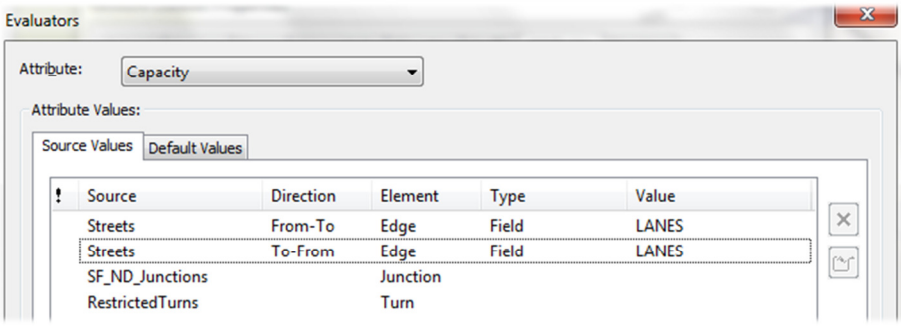

Figure 2: Capacity Network Attribute Evaluator

9. Here you have to specify which field of your street shapefile indicates road width or capacity. For example number of lanes could be one possibility. Set this only for the edges and leave the junction empty (Figure 2). If you do not see your desired field, go back to step 6.d and change the data type. When you're done click "OK".
10. Click OK to exit network properties.
11. Build the network dataset.

Section 2: Identify Zones

In order to perform an evacuation routing, you need two sets of points: Safe Zone Points, and Evacuee Points. Safe zones are simply locations on the map where evacuees need to be routed to. Evacuee points are locations of people who are in danger. Each evacuee point needs to have a name field and a population field. The population indicates the number of people at that location whom need to be evacuated.

Let us have an example. Imagine a tsunami is coming toward San Francisco and we need to evacuate people who live close to the west side toward inland (Figure 4). We can use the Census block group population data for evacuees. A safe zone is simply a location with a good distance from the beach.

Steps:

1. Locate the Network Analyst toolbar in ArcMap. Click on "Network Analyst Window" so that you can see newly added layers.
2. From the toolbar, open the Network Analyst drop menu and select "New Evacuation Routing". This will create a new empty layer and five sub-layers which you can see in the Network Analyst Window.
3. Right click on "Zones" layer from Network Analyst Window and select "load locations". Select the point shapefile with safe zone points.
4. Right click on "Evacuees" layer from Network Analyst Window and select "load locations". Select the point shapefile with population data. Select the appropriate fields for population and name.

Once you loaded these data, it's ready to perform the evacuation routing.

Section 3: Evacuation Setting

If you right click on the "Evacuation Routing" layer from the table of contents and select "Properties", you will see the evacuation options (Figure 3). Below are short descriptions of the evacuation options:

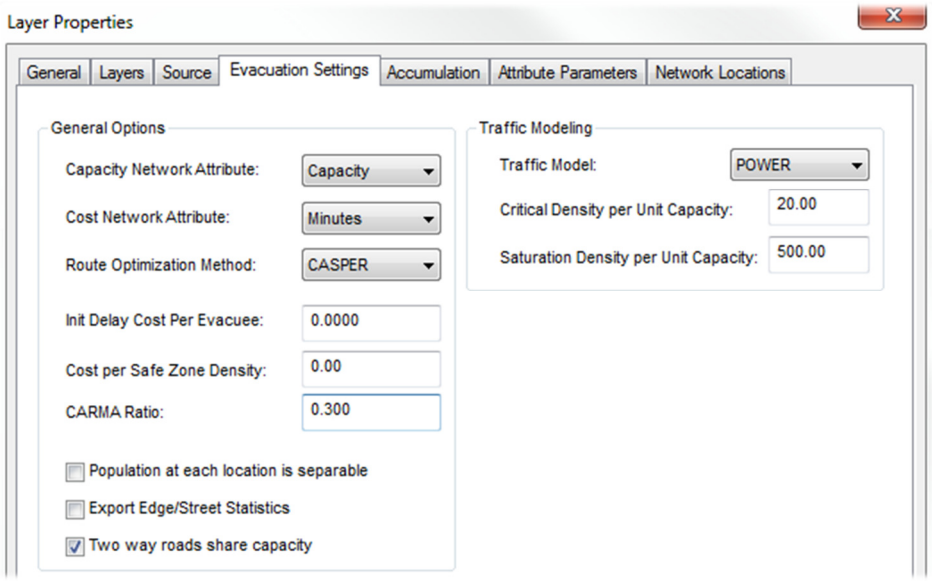

Figure 3: Evacuation Options Window

- **Cost (Impedance) Network Attribute:** Select your impedance or cost attribute.
- **Capacity Network Attribute:** Indicates the "Capacity" network attribute that we added in Section 1. Make sure it's set correctly. The program will read roads widths/lanes/capacities through this attribute.
- **Route Optimization Method:** Indicates the routing algorithm.

    - SP: ShortestPath search for each evacuee. All the capacities will be ignored here.
    - CCRP: A known capacity constrained technique which will fill up each path with evacuees from source to sink.
    - CASPER: Capacity-Aware ShortestPath Evacuation Routing which will use a logarithmic function to determine realistic traversal speeds for each road segment based on road capacity and number of evacuees (population).
- **Init Delay Cost Per Evacuee:** This number indicates the initial space between evacuees whom are sharing their start locations. This is going to be translated to evacuee density on each road segment.
- **Cost per Safe Zone Density:** If safe zones have a limited capacity, you can implement that into the program using this parameter. This parameter is not yet functional.
- **CARMA Ratio:** CARMA (Capacity Aware Reverse Map Analyzer) is a helper algorithm within CASPER which updates graph vertices based on some heuristics. These heuristics can guide the path finding during CASPER run. By keeping these vertices up-to-date, CASPER will run faster and might be able to find better routes as well. CARMA ratio should be a number from 0.0 to 1.0. Setting the ratio to 0.0 means vertices will be always up-to-date. setting it to 1.0 means vertices will be updated only once at the beginning. It's recommended to leave this value at its default.
- **Population at each location is separable:** This checkbox indicates if the program is allowed to separate the population at each location in order to optimize the routes. This will possibly take more time to compute but might lower the total evacuation time.
- **Export Edge/Street Statistics:** If you select this, the tool will also output the edge reservations, which will be helpful in understanding the network bottlenecks.
- **Two-way roads share capacity:** Will tell the program that the capacity of two-way road segments is shared between both directions as oppose to each having that much capacity. This is usually the case with road segments without a divider.
- **Traffic Model:** User can select different traffic modeling methods. These models help the program predict traffic delays on saturated road segments. Only CASPER optimization method can benefit from these models.
- **Critical Density per Unit Capacity:** This constant indicates the critical density of a road with one unit of capacity (e.g. one lane). It means the road can route up to this many evacuees without affecting the traversal speed. Here density refers to the number of evacuees (cars) per a unit of cost (impedance).
- **Saturation Density per Unit Capacity:** This constant indicates the saturation density of a road with one unit of capacity (e.g. one lane). It means if the road is routing this many evacuees, its traversal speed will reduce to half of the original traversal speed.

Section 4: Output

In order to get the evacuation routes, from the toolbar, click on "Solve". Once the solve is finished, two output tables will be populated with results which we briefly explain in this section.

Routes

Routes are polylines from each evacuee to the selected safe zone. If the 'Separable Evacuee' was ON, there would be many routes for each evacuee location. Each route has an 'EvcCost' which indicates total traversal cost on the route considering the congestions. The 'OrgCost' field indicates the traversal cost without congestion considerations. The 'Pop' field shows how many evacuees will be on this route. The 'Name' field is the name of the evacuee from the 'Evacuees' table. It can be used to join results with the origin points. If you want to know in which order the algorithm assigned routes to evacuees, you can sort the 'Routes' table by 'ObjectID'. In another word, the 'ObjectID's are being generated as the routes being reserved on the network.

EdgeStats

This table lists all touched street segments with useful information about them. By visualizing this table the user can learn more about the shortcomings of the network dataset in terms of capacity bottlenecks and safe zone availability. Below you may find information about each 'EdgeStats' attribute. This table will be populates if the 'Export Edge Statistics' option is ON.

- **EdgeID, Direction, SourceID, SourceOID:** The four of them uniquely identify one edge in the network dataset. The polyline shape however comes from the original 'streets' shapefile.
- **ReservPop:** Number of evacuees that are set to pass this edge during evacuation not necessary at the same time.
- **TravCost:** the traversal cost for this edge with congestion consideration
- **OrgCost:** The original traversal cost of this edge according to the network dataset.
- **Congestion:** A number from 1 to 10,000 which indicates the congestion ratio on this edge. Equals 'TravCost' divided by 'OrgCost'.

Known Issues

- Multi-part turn restriction: The routing algorithm does not take into account any complex (multi-part) turn restriction that your network dataset may have. There are no proper workarounds at the moment.
- Sort by name in route table: Sorting the 'Routes' table by name (which is same as evacuee name) does not work. Also joining this table may result in unexpected behavior. The work around is to export the routes as a separate shapefile and continue from there.
- Safe zone capacity: The safe zone capacity feature is not yet implemented.

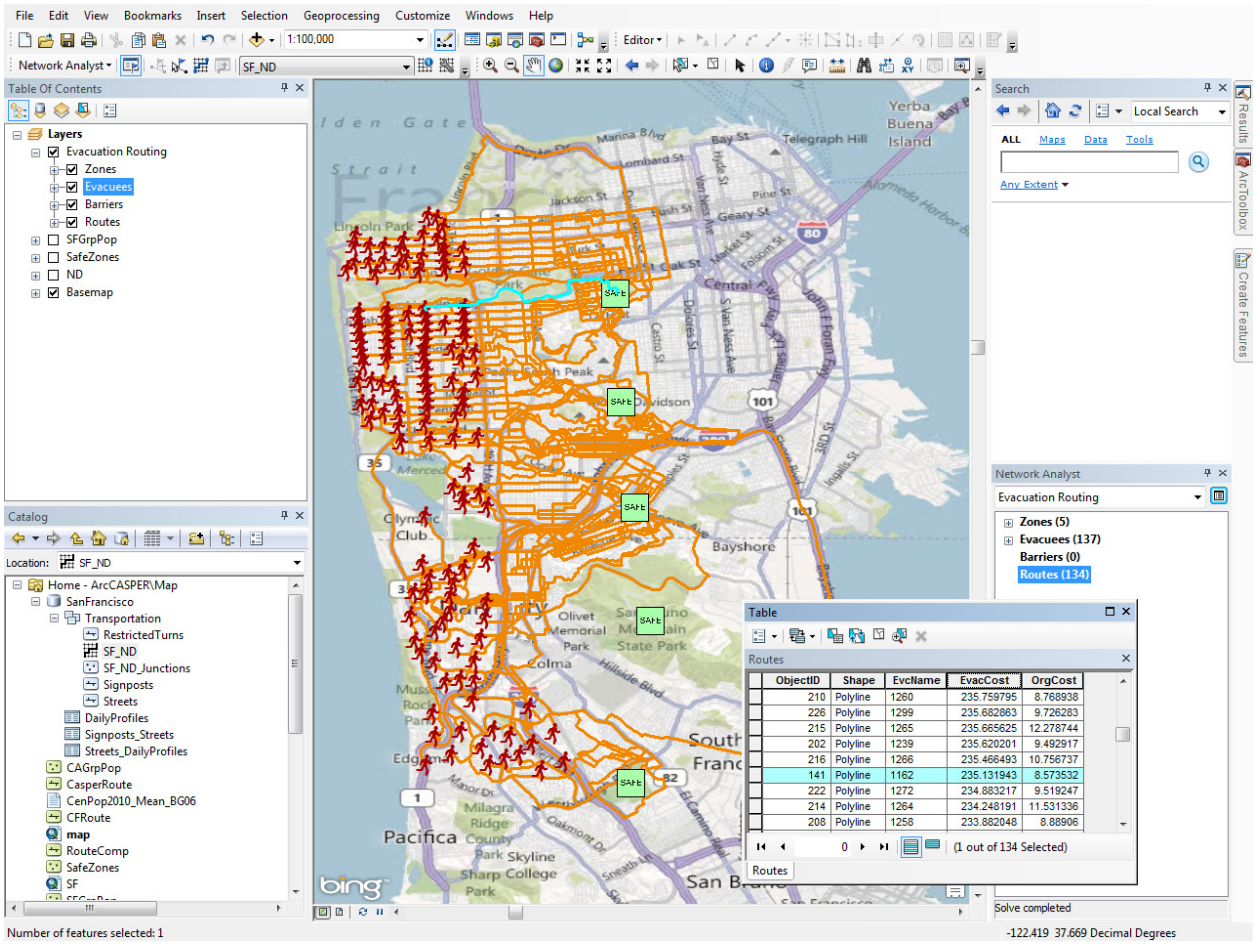

Figure 4: Calculated Evacuation Routes for Bay Area

Acknowledgement

We would like to thank ESRI APL and Network Analyst teams to support us during the development of this tool.

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