GEO/EVS 423 / EVS 523
Exercise 12: Network Analysis II

The previous exercises dealt with simple network analysis using pre-existing defined networks. In this exercise, you will create a network for a street system, and you will use the network analyst extension. To begin, copy the Cuyahoga directory from the P: drive to the X: drive, if it isn't there already. Open ArcMap and then open the ArcCatalog window.

Your first step is to make a geodatabase in which to store your network. It can be in the root directory of the X: drive, in the Cuyahoga directory, or anyplace else you want to put it. To make things easier for you, create the geodatabase using the catalog window, and make it your default geodatabase. When your geodatabase has been created, import the Cuyahoga Streets shapefile (cu98stre) into it. Add both streets files (i.e. the raw one you copied from P: and the one you imported into the geodatabase) to your layout.

Open the attribute table for the streets file. The file you copied directly from the P: drive does not contain any topology; The layer you imported into the geodatabase does – at least it includes the shape length for each polyline in the layer. You should verify that this is the case. You only need the version in the geodatabase, so you should probably delete the other layer from your layout. Add two columns to the attribute table. The first will be a reasonable velocity to be expected on each class of street; it can be a short integer. It doesn't matter what you call it. The second should be entitled Minutes (this is a special word; you have to call it that), and it should be type Double.

Your next step will be to populate the speed-limit column. Use Select-By-Attributes and choose 'Class' =. The unique values will give you a list of the street classes in the layer and show them as selections in the street map. For example, class ' ' is interstate highways, class 'A41' is residential streets, and class 'A74' is cul-de-sacs. Select each class of streets in turn (alternatively, you might find it useful to sort the attribute table by class, so that you can see what street segments belong to which classes); using what you know about the speeds that can be maintained on each class of streets, make an estimate of the rate of speed that you could maintain on each class; using the Field Calculator add that velocity into the speed column.

When you have completely populated the speed column, you should populate the Minutes column. First Clear Selections, so that you can populate all of the records in the table. Assuming you called your speed column Speed, use the Field Calculator to set Minutes equal to **[Shape_Length] / (([Speed] * 5280) / 60)**.

You are now ready to create your network. You first have to create a Feature Dataset. To do that, right-click on your geodatabase, choose New -> Feature Dataset. Give it an appropriate name, Import the projection system from your streets layer, and accept the defaults. Next, import the streets file to which you've added the Speed and Minutes columns into the feature dataset by right-clicking on the feature dataset name and choosing Import and the name of your streets file. Next, right-click again on the feature dataset name and choose New -> Network Dataset. Give your network dataset an appropriate name (you can just use the default if you want) and accept the defaults. When you're asked if you want to build the network, choose Yes, and choose also to add all of the feature classes to the network. When this is done, you will notice that the edges and junctions are all specified.

Now for the fun part! Turn on the Network Analyst extension, and add the Network Analyst toolbar (*not the Utility Network Analyst*).

Zoom to the general area in which you expect to find Cleveland State University. It is the large vacant area just west of the interstate between Euclid and Chester. You can click on the inquire icon and then click on street segments to verify that you've found it. Then on the Network Analyst toolbar, click on Network Analyst. Choose "New Service Area." Just to the right of the Network Analyst dropdown, you can click the Create a Network Location tool and then create a network location at the site of Cleveland State. Click on the Solve icon (it looks like a line graph). The resulting polygon is (supposedly) the area from which you can get to CSU within 5 minutes. Now right-click on the Service Area layer in the Feature

Dataset area of the Table of Contents and choose Properties. Go to the Analysis Settings tab and insert **5, 10, 15, 20, 25** into the Default Breaks window. Choose to evaluate the network Toward Facility. Click OK and then click on the Solve icon again. You now have polygons showing the time it takes to get to CSU in 5-minute intervals from 5 to 25 minutes. You might verify that this is consistent with your own travel time. To clear the search, right-click the Service Area portion of the Table of Contents window (not the part in the Feature Dataset) and choose to Remove it.

Next, click on the Network Analyst dropdown again, and choose New Route. Create at least 2 Network Locations. You will start from location 1, go to location 2, and so forth. Click on the Solve icon to generate the route.

Now add some barriers to your work. To do that, make sure that the Network Analyst window is open. It typically exists to the left of the Table of Contents window. If it isn't, click on the Show/Hide Network Analyst Window tool. Using the Create Network Location tool, click on the particular type of barrier you wish to insert in the Network Analyst window (*not* the Table of Contents window) and insert your barrier. When you're satisfied, click on Solve.

Remove any existing routes, locations, barriers, etc. from your network. You will now see where simulated prospective students should attend Cleveland State University. That is, you will locate the closest campus to each student. In the Network Analyst toolbar, click on Network Analyst -> New Closest Facility. The addresses of the 3 campuses of CSU are: Main Campus, 2121 Euclid Avenue, Cleveland OH; East Center, 34055 Solon Road, Solon, OH; West Center, 26202 Detroit Road, Westlake, OH. You must first find each of these locations in your network and place a network location at those sites. To do that, go to the Network Analyst window and right-click Facility -> Find Address. Enter the address in full (e.g. 2121 Euclid Avenue, Cleveland, OH). Choose US Streets as your locator, and click Find. When you get your results, choose the one from US Streets. Right-click it and choose Add as Network Analysis Object. These are your 3 facilities.

For purposes of ArcGIS, students are treated as Incidents (obviously this tool is oriented toward facilities like Police or Fire stations, with incidents being calls for help). Click on Incidents in the Network Analyst window, and add a number of "students" to the map. If you want to use a specific address, you can find it the same way in which you located the CSU campuses; if you prefer you can simply add a dozen or so locations to the map. In any case, you should locate your "students" to all parts of the county. Note that your "students" are square icons (somehow that's appropriate), while the facilities are circles. When you're satisfied with your "student" distribution, click on the Solve icon. It will show the best routes to the nearest CSU campus.

You should try several permutations of network analyst tasks, barriers, etc.

You will now try a more ambitious network – a transportation network of Cuyahoga County. On the P: drive, locate the file geodatabase entitled RTA.gdb. Copy it to your X: drive, and take a look at all of the files located there. You should make sure that you understand all of them. You are used to the Streets file, and the BusRoutes, RedLine, and BlueGreenWFLLines files should be fairly obvious, as should the RapidStations file. The RapidStationEntrances and RapidStationWalkway files should be a little less so.

A bit of history is in order. The Streets file and the RTA files are from quite different sources. We received the bus and rapid lines and the rapid stations files from RTA. The streets file came from OGRIP. A close-up look at the bus lines and streets files should quickly indicate that they were digitized differently from each other and don't exactly correspond. You will have to correct that if you want to put them into a network. Likewise, the rapid stations as we received them from RTA were the locations of the actual stations – they didn't fit either on the rapid-tracks polyline or on a street. If we are to make a network of the transportation network for the county, it is necessary for the streets and the tracks to be joined in some fashion. Hence the Entrances and Walkways files. The Stations points were moved from the actual location of the station to a point on the tracks (i.e. where passengers actually board the trains), and the Entrance points were digitized at appropriate points on the Streets file. The Walkway file is a line file that was digitized to connect the entrances (on the streets) and the stations (on the tracks). In this way, there is some line or other that connects all of the streets throughout the County to the RTA rail system.

We now have to fix the lack of correspondence in the bus-route file. There are several ways to do this, and you should think about what would really be the best way. Here, we will use a total kludge. Make a buffer around the bus routes in the BusRoutes file wide enough to encompass the street in the Streets file on which the bus actually travels (when I did this, 150 feet managed to get almost all of the streets; you might want to try other buffer widths). Then intersect your buffer and the Streets file to find a line file that includes most, if not all, of the bus routes. Like I said, this is a total kludge, but it's quick.

You are now ready to calculate the costs involved with driving and using public transportation. On the Streets file, add two short-integer fields, one of which will be the average drive speed for each road section in the file; the other of which will be the average walking speed for each road section. You can use the same drive speeds for the road classes as you did earlier in this exercises; you can make any assumptions you want for walking speeds. It should probably be very slow for the interstate highways (you don't want to use 0, since you will be using the speed in the denominator of a calculation) and about 3 miles per hour (i.e. you can walk a mile in about 20 minutes) for other street classes. Then add two double fields to the Streets file, one for the DriveMinutes (derived from the DriveSpeed column), the other for the PedestrianMinutes (derived from the PedestrianSpeed column) using the algorithm you used earlier – i.e. **[Shape_Length] / ((<the Appropriate Speed> * 5280) / 60)**.

Similarly, add appropriate Speed and Minutes columns to the other line files. Bear in mind that the Red Line is always separated from the county road system and that the Blue, Green, and Waterfront lines are separated from the road system only between E 55th street and the Terminal Tower. This will make a difference in the speeds that they are able to maintain in different parts of the system. The Walkway file represents pathways along which people will walk, presumably around 3 mph. You might also build into this file the time spent waiting for the rapid. The BusRoute file to use is the one you created with the kludge above, not the original BusRoute file.

When you have the appropriate Minutes columns added to each of the 5 line files, you are ready to build them into a feature dataset. Create a new feature dataset in the geodatabase, and add the line files, one at a time. Your feature dataset will include 7 files, of which 5 are line files and 2 are point files. When your feature dataset is complete, create a new network dataset. Choose the default 10.1 network type, add all 7 layers to your network, and choose to model turns. When you get to the connectivity page, click the Connectivity button. Here you will have to do some thinking.

If you consider how transportation works, there are really two separate systems in operation – the road system, supporting cars, pedestrians, and buses, and the rail system, supporting the rapid. ArcGIS deals with this difference by connectivity groups. The default organization of the network is for a single group. You will need to add a second group column. Each edge (i.e. line layer) can belong to a single group. Junctions (i.e. point layers) provide points of connection among groups. The transportation media using streets (pedestrians, cars, and buses – and hence the Streets and BusRoute files) will end up checked in one group; the files describing the rail system (RedLine, BlueGreenWFLLine, and RapidStationWalkway files) will end up checked in the other group. The two junction files (RapidStation and RapidStationEntrance files) will end up checked in both groups. You should be sure that you understand the logic of these connections.

You aren't done with the Connectivity page yet. Note that the junctions are labeled "Honor." This means that they honor the spatial logic of the edges they connect. As you can see, all of the edges are labeled "End Point." If a junction happens to be coincident with an end point on an edge, then fine. Otherwise, it doesn't connect. You need to insure that the junctions can connect with *any* point on an edge. Hence you need to change both of the "Honor"s to "Override." When you've done that, click OK to return to the main Connectivity page. Click Next to go to the Elevations page. Since there are no elevation attributes in any of these files, click the "None" radio button and Next to move to the Attributes page. The yellow triangles indicate that you need to add information. Double-click the "Feet" attribute. A window opens with each layer listed. Most of the layers don't contain an attribute entitled Feet, so you have to indicate what field indicates feet. Note that the layers that need that information are already grayed. Right-click on the gray zone, and click “Type” -> “Field.” When you do that, the notation Field will be added to each layer, the gray zone will turn blue, and the yellow triangle will change to a red X. Right-click in the blue zone, and click “Value” -> “Shape_Length.” You really don’t need the Meters or the Miles attributes, but it is useful to know how to calculate one and delete the other. Right-click on the Meters attribute, and choose “Remove.” Then double-click on Miles. Again, the attribute window opens, and those layers without a Miles attribute are grayed. Right-click in the gray zone, and choose “Type” -> “Function.” Then right-click the blue zone that appears, and choose “Value” -> “Properties.” When the Properties window opens, the appropriate attribute is “Feet,” the appropriate operator is “/,” and the appropriate parameter is “5280.” This leaves only one attribute with a yellow triangle: Minutes. Bear in mind that you will be evaluating two different modes of transportation, driving and public transportation. For each, you will want to evaluate Minutes. You should probably rename the Minutes attribute to one or the other of these two modes and add a new attribute (click the Add button) for the other. For the Public-Transportation mode, insure that the calculation of Minutes for all edges refers to minutes spent walking or on either a bus or the rapid. You will need to include all of the edges for this calculation. For the Driving mode, insure that the calculation of Minutes for the Streets file refers to minutes spent driving. You will need to remove the other edges from the calculation of driving minutes for this mode. To do this, select all of the rapidoriented layers, and right-click the blue zone that emerges. Click “Type” -> “Constant.” Then right-click the blue zone again, and click “Value” -> “Properties.” Change the value in the Properties window from “0.000" to “-1.” Click OK to move to the Directions page.

Choose Next to accept “No” as your choice. This will take you to the Summary page. You may want to look at the summary of your network, although you may find it a bit overwhelming. Click “Finish.” Then choose to Build the Dataset; then Add it to your view. Because of the way your feature dataset is constructed, there will be some build errors. They won’t matter too much in your network, so Close the error message you get before adding the network to your active layout.

Go back to the Table of Contents window, and try some routes using both the driving mode and the pedestrian + public transit mode. To change from one to the other, you will have to right-click on the Network Dataset icon in the Catalog window, change the default mode, and click the Build Network Dataset icon on the Network Analyst toolbar. Does it behave as you expect?

Now let’s do something more interesting. Add the grocery stores layer to your viewer, and Select the PRClass 1 (i.e. large) stores. From the Network Analyst toolbar, choose New Service Area. In the Network Analyst window (not the Table of Contents window), right-click on Facilities and choose Load Locations. The layer you will load from is the Grocery Stores, and you will load only the selected stores. You need to create a virtual buffer around each store in order to insure that each store can be associated with an edge, so that it enters the network. You should use geometry and pick a search tolerance large enough to allow for a typical parking lot – e.g. 1000-1500 feet.

When the stores have been loaded, right-click on the Service Area in the Table of Contents window (not the Network Analyst window), and go to the Analysis Settings tab. Set breaks at 5, 10, 15, 20, etc. minutes. You will have to go up to 60 minutes for the public-transportation scenario and 20 minutes for the drive scenario. Pick your scenario from the Impedance drop-down. Run both scenarios using the “Toward Facility” option by clicking Solve. This will take some time! In both cases, you will generate polygons indicating the range of times it takes to get from people’s homes to the nearest large grocery store. Save each scenario by right-clicking on Polygons in the Service Area section of the Table of Contents window and choosing Data -> Export Data.

You should then develop some algorithm for discriminating areas in which people are likely to be able to drive to a major grocery store, as opposed to areas in which they are more likely to take public transportation. This might be communities; it might be a free-hand sketch; it’s up to you. In any case, you should have two areas, one dominated by public-transport users, the other dominated by drivers. Intersect the two polygons you created in the previous paragraph with your driver/transport polygons, and make a single map showing the county as it breaks down by distance from food sources and rich and poor.

Portfolio

12-1 Your map showing the service area of Cleveland State University with minutes of travel from all points in Cuyahoga County

12-2 Your map showing the route of travel between two interesting places in Cuyahoga County, based on driving.

12-3 Your map showing the routes of travel from at least 10 different points in Cuyahoga County to the closest campus of Cleveland State University

12-4 Your map showing the route of travel between the same two interesting places in Cuyahoga County as you used for 12-2, based on a person's using public transportation

12-5 Your map showing the service areas for the large grocery stores in Cuyahoga County, based on estimated travel times for *both* driving and public transportation, showing polygons for 5-minute increments around each store. You should include a statement of the assumptions you made in constructing this map.

12-6 Your map showing the service areas for the large grocery stores in Cuyahoga county, assuming that people in poorer areas will use public transportation and that people in richer areas will drive. You should include a statement of how you determined richer and poorer areas.