Network Analysis

Network Analysis

Solving Everyday Questions

- What is the quickest route to a restaurant?
- Which homes are 15 minutes from an elementary school?
- Which patrolmen is closest to an incoming accident?
- Where is the best place for a business to open a new branch?

Network analysis allows us to solve everyday questions such as what is the quickest route to a restaurant? Which homes or 15 minutes from an elementary school? Which patrolman is closest to an incoming accident? Where's the best place for a business to open a new branch? You may have noticed that all of these questions have some sort of distance measurement, route selection, or service area component. We use network analysis tools, to measure distances, to solve the sorts of questions.

Benefits

- More strategic decisions for businesses
- Transportation costs can be reduced
- Quicker response time for emergency vehicles
- Determine least-cost network paths between several destinations
- More accurate results by using network distances over straight-line distances

The benefit of network analysis is that it can provide more strategic decisions for businesses based off of transportation networks. A benefit to a business that transports goods, is that through optimal route selections, transportation costs can be reduced. With response emergency management, network analysis can analyze current traffic patterns, and the street network, to determine the quickest path for an emergency vehicle. Additionally, if there are multiple destinations, and multiple travelers, network analysis can work to route each of the travelers in the most optimal way to each of the destinations without each traveler having to cover too much ground and staying within a reasonable service area. Lastly, network analysis allows the calculation of more accurate results by using network distances, such as street networks, or navigable rivers, then simply using straight-line distances.

What is network analysis?

- System of interconnected points and lines that represent possible routes from one location to another
- Vectors datasets only
- Examples:
  - Telephone cables
  - Roads
  - Water distribution pipes
  - Powerlines

Network analysis is a system of interconnected points and lines that represent possible routes from one location to another. A network is composed of locations connected by links. For example, in a neighborhood, locations would be houses, and the links would be the roads throughout the neighborhood connecting the houses. These network data sets are provided in vector format only, as network links are best represented by line features. Examples of network data sets are telephone cables, roads, water distribution pipes, and power lines.

Impedances

- Obstacles that slow travel
- Travel time
- Demand for a specific goal
- How fast do you need to get somewhere?
- How much money do you want to spend on gas?

All networks include impedances, which are obstacles that slow the travel time. Examples of impedances would be a traffic accident on a road, a poor connection and a computer network, and power loss over long stretches of power lines. Impedances may also be expressed as the cost to travel some distance along the network, such as the amount of gasoline to travel between two cities, the cost of maintaining a vehicle traveling across country, the salary of a bus driver ferrying passengers across the city, or any other cost related with traversing the network. Typically, with traversing a network, impedances are taken into account to determine which path is optimal while minimizing the selected cost whether it be time, money, distance, for example.

Network Analysis Tools

Network analysis tools

Closest Facility

- Measures the cost going between facilities, determines which are nearest to an incident
- Can specify impedances along the way
- Displays the best routes between facilities, reports costs, and returns directions
- Possible use of an emergency management plan

The closest facility network analysis tool, measures the cost of going between facilities or determines which facility is nearest to an incident. When using the closest facility tool, you can specify impedances along the way. The result of the closest facility tool is that it will display the best routes between facilities, reports costs, and returns directions. A common example of when to use the closest facility tool would be to dispatch a fire truck to a fire from the closest fire house.
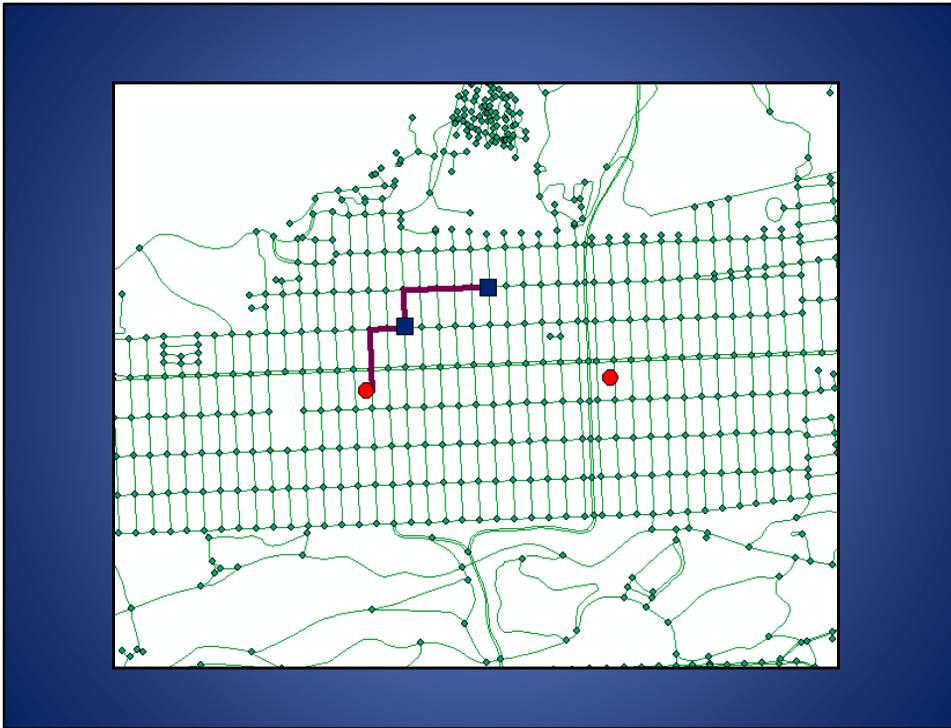
In this example, the two red dots represent to delivery warehouses, and the two blue squares represent customers that require deliveries. The warehouse manager wants to know from which of the two warehouses should the shipment originate, in which a be the most efficient paths for the delivery truck to take. In this case, the warehouse on the left was chosen as it is closer to the first customer, and since it must already liver to the first customer, it makes sense for that truck to drive just a little further to deliver to the second customer instead of a second truck from the other warehouse making a trip to the second customer.

Route Selection

- Identifies the best route based on certain criteria
- Often used to find the least costly route that visits a number of facilities
- i.e. Finding the route that uses the least amount of time as well as the least amount of gas

And other network analysis tool, is the route selection tool. The route selection tool identifies the best route to take based on certain criteria. The route selection tool is often used to find the least costly route that visits a number of facilities. In other words, the route selection tool will find the router uses the least amount of time and gas along Route, assuming gas and time are the two impedances you wish to minimize the cost of.
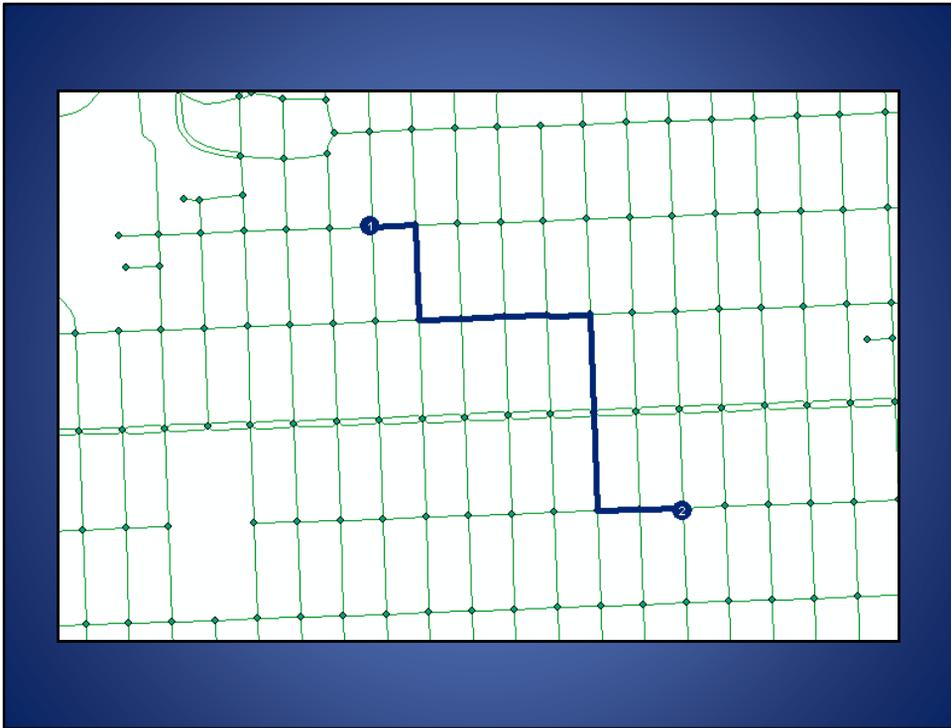
This is an example of a selected route. The origin is at the blue circle labeled number one, and the path is outlined that minimizes distance and gas when traveling from the origin to the destination the blue circle labeled to.

Directions

In addition to the graphic output from the route selection tool, a list of directions is provided from the origin to the destination.

Service Networks

- Identifies accessible streets within specified impedances
- Can see what is along these streets using proper travel along the networks and not straight-line distances.
  - Ex. Finding other services (fire hyrdants, businesses, etc.)

The service networks tool identifies accessible streets within specified in pieces. For instance, if we want to select all homes that are within 10 miles of a school, the service networks tool takes into account travel cost along the network from the origin outwards.
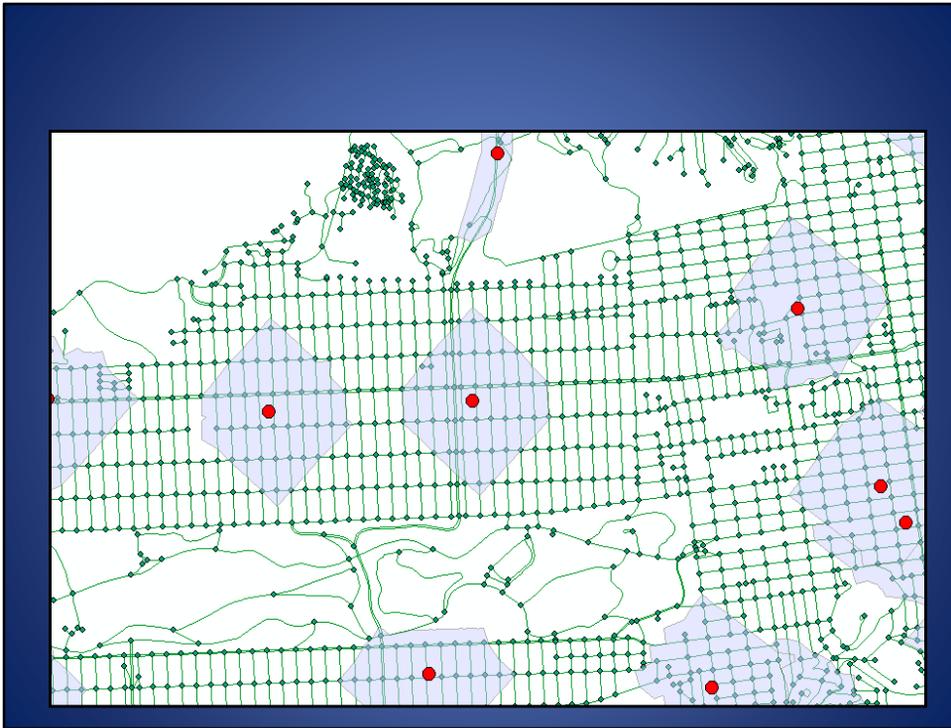
This is an example of the output of a service networks tool showing the extent where he can travel 1000 feet from the origin along the network.

Location Allocation

- Site selection analysis
- Locates best location for new facilities
- Takes into account demand points
- Can take into account locations of existing and competing facilities

Finally, the location allocation tool provides a means to perform site selection analysis. Using appropriate input parameters, the location allocation tool locates the best location for new facilities taking into account the man points. You can also take into account locations of existing and competing facilities if it has a bearing on the allocation.

Location – Allocation: Example

- Where should a fast food restaurant be located to minimize travel time for customers?
  - Customers are the demand points (locations requiring goods)
  - Proposed fast food restaurant locations are Candidate Facilities (sight suggestions)
  - Facilities that already exist (can be current fast food restaurant locations and/or competitor fast food restaurants)
  - Analysis will be controlled with time travel attribute and the number of possible candidates that are to be selected

Let's consider an example of the location allocation problem. Suppose our question is "where should a fast food restaurant be located to minimize travel time for customers?". In our location allocation problem, the customers are the demand points, and the proposed fast food restaurant locations are the candidate facilities. You can also enter the facilities of arty exist, where that they be another one of the fast food restaurants, where the location of the competitors fast food restaurant. You may want to include these so that you do not place your new fast food restaurant very close to one of your existing fast food restaurants, the may want to place your fast food restaurant close to where competitor has theirs. With all of your input specified, the location allocation tool will perform analysis that will be controlled with the time travel attribute in the network and will specify which of the number of possible candidates is the best location for your new fast food restaurant.
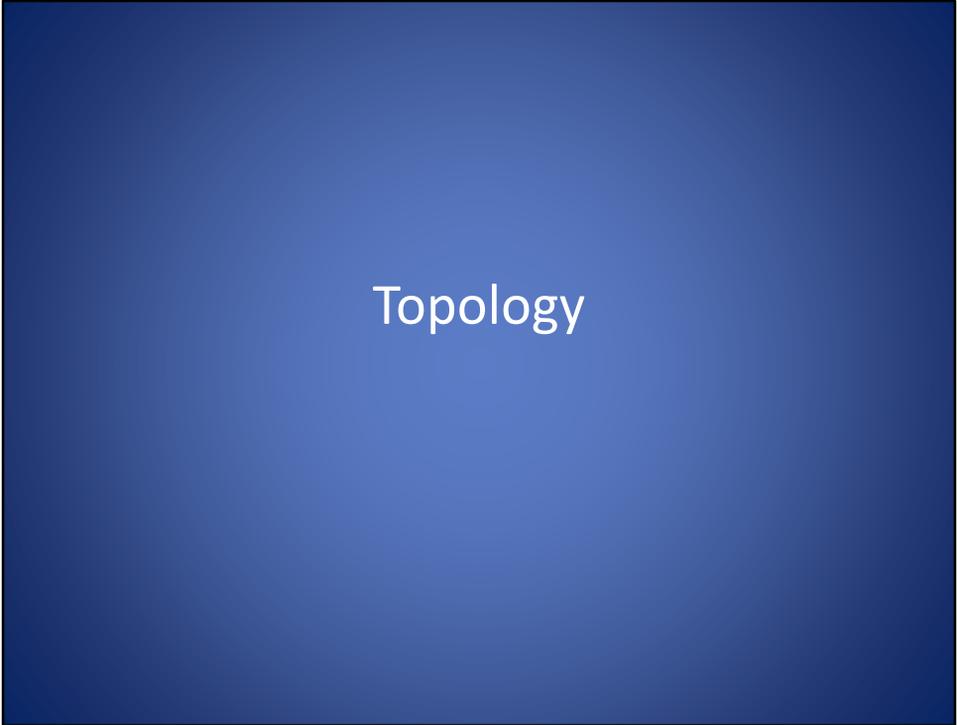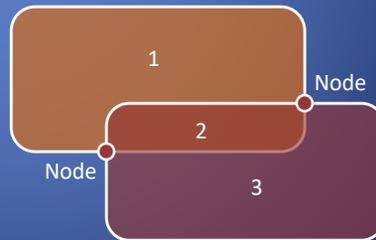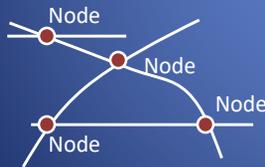
Topology

Topology

What is topology?

- The study of the geometric properties that don't change when features undergo transformations/modifications

- Geometric relationships features

Topology is the study of the geometric properties that do not change teachers undergo transformations or modifications. The toplogy represents and enforces the geometric relationships between features. In this brief introduction to topology, it is perhaps best explained visually.
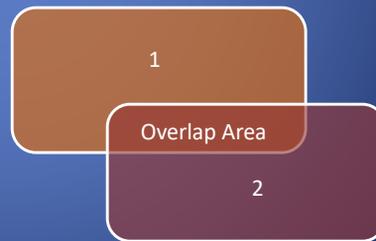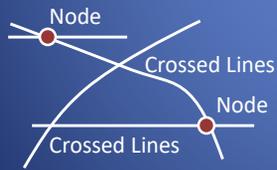
Planar topology

- 2 dimensional surface
- No overlap, overlaps create another polygon
- Must be an intersection at each line crossing

There are two types of the topology: planar topology, and nonplanar topology. In planar topology, the geometric representations are considered to exist on a single two-dimensional surface. No overlaps are allowed without overlaps creating another polygon. With respect to lines, if lines cross, there must be an intersection at each line crossing. Additionally, if one line an topology moves, then the node representing the intersection also moves thereby maintaining the property of the intersection between the two lines. The same also applies to polygons. As one polygon moves, connected polygons will deform with it if the topology requires of the polygons always be a joint.

Non-Planar Topology

- 2 polygons overlap slightly at an edge
- Not necessary to have an intersection where lines cross

Node

Crossed Lines

Node

Crossed Lines

1

Overlap Area

2

In nonplanar topology, features may be considered to exist on different planes. Therefore, it is not necessary to have intersections where lines cross if they are on different planes. The same goes polygons.

Advantages

1.) Ensures Data Quality

2.) Prevents sliver polygons

3.) Ensures line connectivity

4.) Keeps data integrity

The advantages of enforcing topology, is that ensures data quality. For instance, if you're representing houses built on parcels of land, you can set up topology rules that do not allow houses to be built across parcel boundary lines. Another advantage of the topology, is that I can prevent sliver polygons. For instance, if you're digitizing County outlines, then it is important that adjacent counties share a common boundary. In this case, you can set topology rules that require adjacent polygons to share common vertices, and if one vertex is moved, the boundary of all counties that utilize advert tax are moved. Another advantage is that ensures line connectivity. For example, if you're representing a street network, you would want all street intersections to fully connect, without any spacing between the end of one road and the beginning of the intersection. In summary, topology helps keep data integrity by enforcing logical rules.

Disadvantages

1.) Humans must ensure that:
    a.) all lines connect
    b.) all polygons close
    c.) all data must begin and end with a node
2.) Computers must be able to:
    a.) build topological tables
    b.) connectivity and adjacency information
    c.) assign codes

There are some disadvantages of topology, however. First, it is a time intensive process where humans must ensure that all lines connect, all polygons close, and all data begins and ends with a note. Additionally, the humans must set up the topological rules for the computer to follow. The computer must expend additional processing time to build topological tables, to maintain the connectivity and adjacency information, and to assign codes to features so that I can keep up with the bookkeeping required for topology.