Lesson6: Vector Data Analysis - Network Analysis

## INTRODUCTION

## In this lesson you will learn about network analysis tools and how to use them. You will also learn how to prepare vector data sets for network routing and about the importance of topology and how it relates to network analysis.

## LESSON OBJECTIVES

By the end of this lesson, you will be able to:

1. Prepare vector data sets for use in network routing.

2. Apply network techniques to create efficient routes including impedances.

3. Generate service areas based on network analysis.

**LEARNING SEQUENCE**

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| Required Reading | Read the following:  Vector Data Analysis - Network Analysis   * Network Analysis * Network Analysis Tools * Topology |
| Assignments | Complete the following:   * Lab: Vector Data Analysis – Network Analysis * Quiz: Vector Data Analysis – Network Analysis |

## INSTRUCTION

**Network Analysis**

## Applications for Network Analysis

Network analysis allows us to solve everyday questions.

* What is the quickest route to a restaurant?
* Which homes are 15 minutes from an elementary school?
* Which patrolman is closest to an incoming accident?
* Where is 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. Network analysis tools are used to address questions relating to these concepts.

## Benefits of Network Analysis

Network analysis can provide information needed to make strategic decisions. For instance, a business that transports goods based off of transportation networks would benefit by using optimal route selections that could reduce transportation costs.

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, rather than simply using straight-line distances.

## What is Network Analysis?

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

All networks include impedances, which are obstacles that slow travel time. Examples of impedances are a traffic accident on a road, a poor connection in 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 to travel cross-country, the salary of a bus driver ferrying passengers across the city, or any other cost related with traversing the network.

Typically, impedances are taken into account with traversing a network by determining which path is optimal through minimizing the time spent, money consumed, distance traveled, or some other specified cost.

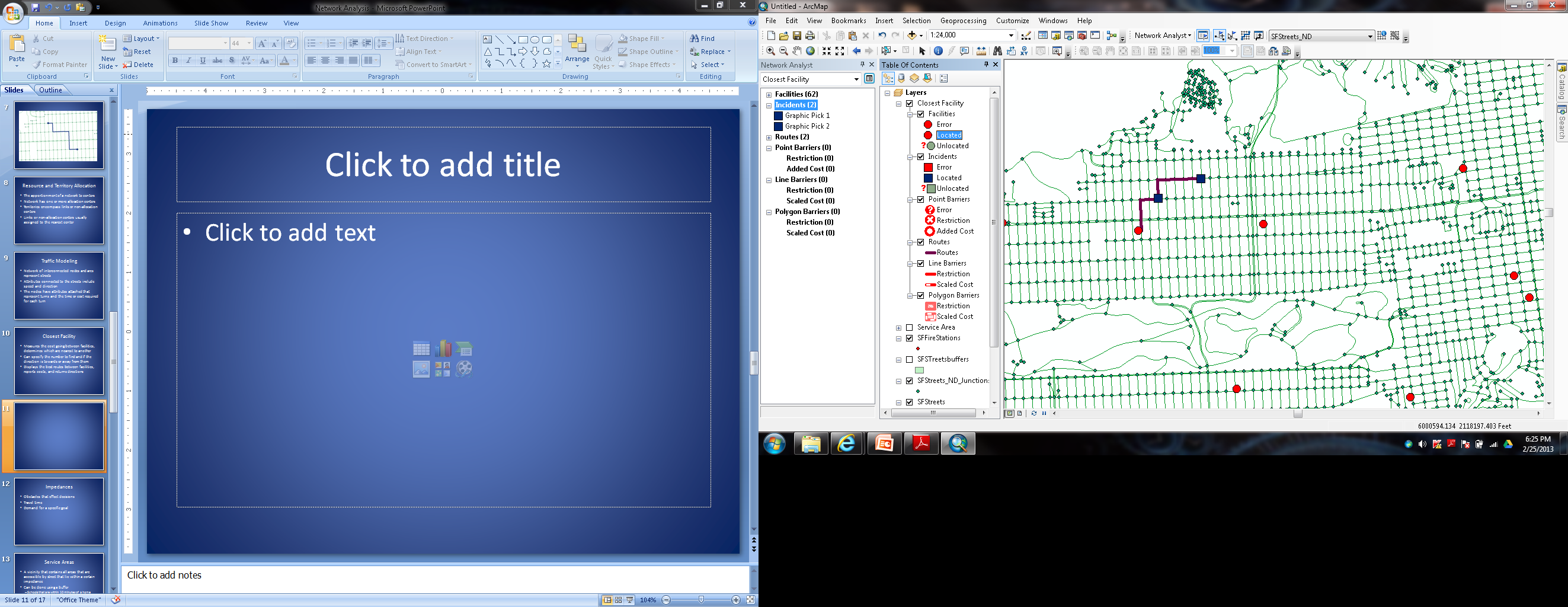
**Network aAnalysis tTools**

## Closest Facility

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 the example below, the warehouse manager wants to know from which of the two warehouses should the shipment originate while utilizing the most efficient path for the delivery truck to take. In this case, the warehouse on the left was chosen, as it is closer to the first customer. Since it must already deliver to the first customer, it makes sense for that truck to drive just a little further to deliver to the second customer instead of dispatching a second truck from the other warehouse to make the delivery needed for the second customer.

**Closest Facility Example**

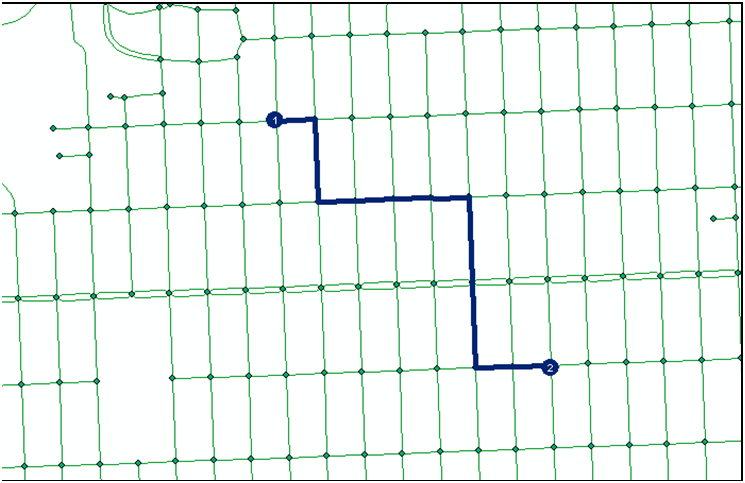


Delivery Warehouse Customer Location

## Route Selection

Another 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 a path that uses the least amount of time and gas, assuming gas and time are the two impedances you wish to minimize the cost of. In addition to the graphic output from the route selection tool, a list of directions is provided from the origin to the destination.

**Route Selection Example**



The origin is at the blue circle labeled number one. The path that is outlined that

minimizes distance and gas when traveling from the origin to the destination

blue circle labeled two.

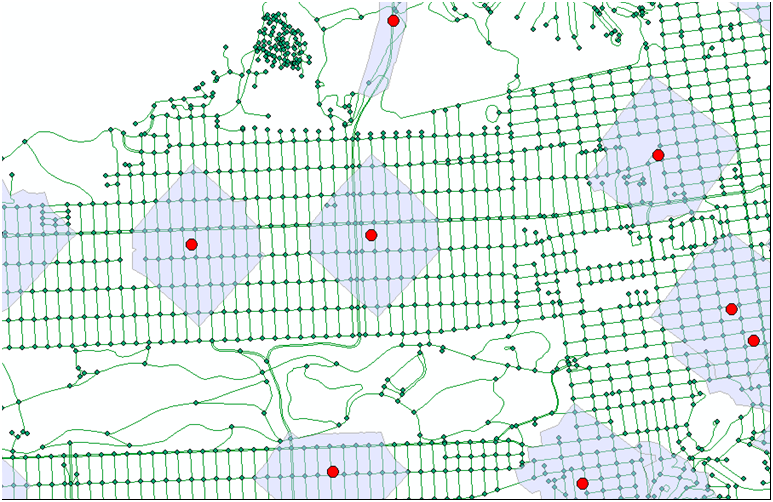
**Directions**



Directions are provided from the origin to the destination.

## Service Networks

The service networks tool identifies accessible streets within specified impedances. 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 costs along the network from the origin outwards.



This is an example of the output of a service networks tool showing the extent where they can travel 1000 feet from the origin along the network.

## Location Allocation

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

**Example Location Allocation Problem**

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 that already exist, whether they are another one of this fast food chain’s restaurants, or whether the location is a competitor’s 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.

Once all of the inputs have been specified, the location allocation tool will perform an analysis based upon the time traveled attribute in this network, in order to specify which candidate facility would be the optimal site for your new fast food location.

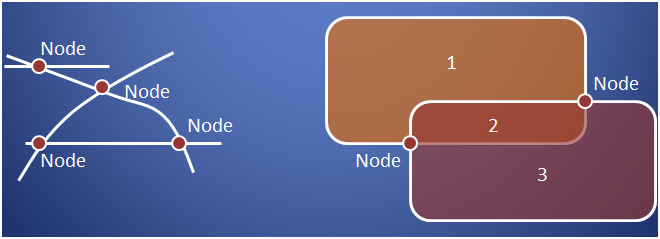
**Topology**

## What is Topology?

Topology is the study of the geometric properties that do not change when features undergo transformations or modifications. The topology represents and enforces the geometric relationships between features. In this brief introduction to topology, it is perhaps best explained visually. Let us continue this brief introduction to the concept of topology by examining its two types: planar topology and non-planar topology.

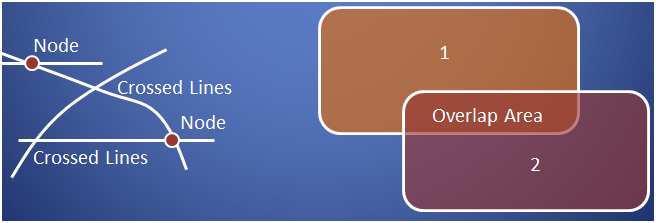
### Planar Topology

In planar topology, the geometric representations are considered to exist on a single two-dimensional surface. No overlaps of polygons 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 in 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 that the polygons always be jointed.



### Non-Planar Topology

In non-planar topology, features may be considered to exist on different planes, overlapping slightly at an edge. Therefore, it is not necessary to have intersections where lines cross if they are on different planes. The same goes for polygons.



## Advantages of Topology

There are several advantages to enforcing topology. The first advantage is that it ensures data quality. For instance, if you are 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.

A second advantage of enforcing topology is that it can prevent sliver polygons. For instance, if you are 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 boundaries of all counties vertices are moved.

A third advantage of enforcing topology is that it ensures line connectivity. For example, if you are 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. Topology assists in maintaining the integrity of data by enforcing logical rules.

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| **Key Facts**  **Advantages**   * Ensures Data Quality * Prevents sliver polygons * Ensures line connectivity * Keeps data integrity |

## Disadvantages of Topology

Although enforcing topology has its advantages, there are a few disadvantages. First, enforcing topology is a time-intensive process where humans must ensure that all lines connect, all polygons close, and all data begins and ends with node.

Second, humans must set up the topological rules for a computer to follow. The computer must expend additional processing time to build topological tables, and to maintain the connectivity and adjacency information. Additionally, the computer has to assign codes to features so that the individuals enforcing topology can keep up with the bookkeeping required.

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| **Key Facts**  **Disadvantages**  Humans must ensure that:   * All lines connect * All polygons close * All data must begin and end with a node   Computers must be able to:   * Build topological tables * Connectivity and adjacency information * Assign codes |

## SUMMARY

## In this lesson you learned what network analysis is, how it works, benefits of network analysis, and impedances that affect the process. Network analysis tools were explained with examples of choosing the closest route and administering the route selection through software. You learned that topology is the study of the geometric properties that do not change when features undergo transformations or modifications and that this concept is important to network analysis.

## ASSIGNMENTS

1. Lab: Vector Data Analysis – Network Analysis

2. Quiz: Vector Data Analysis – Network Analysis