Esri International User Conference | **San Diego, CA**

**Technical Workshops** | **July 12, 2011**

Network Analyst:
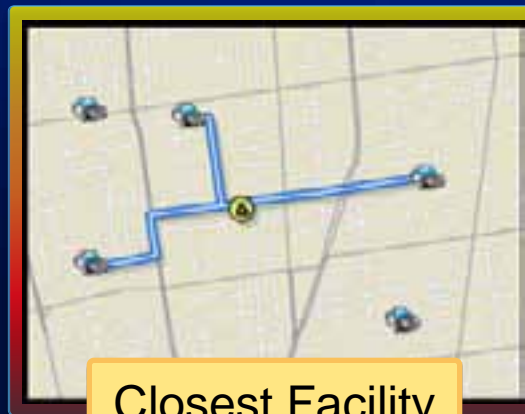# Performing Network Analysis
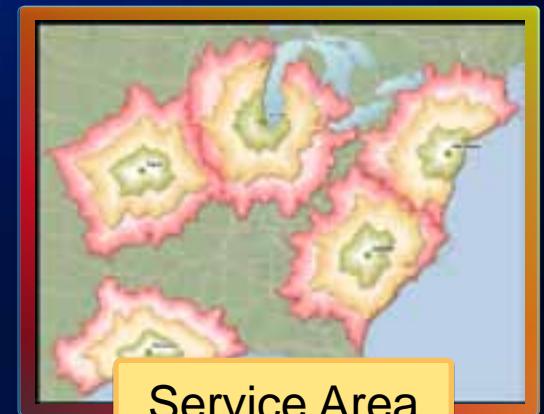
Jay Sandhu

Deelesh Mandloi

Goals

- **We assume you have some familiarity with ArcGIS Network Analyst**

- **We describe the capabilities of the solvers and will demonstrate them with several practical examples**

- **Areas of focus are:**
  - **Choosing the right solver**
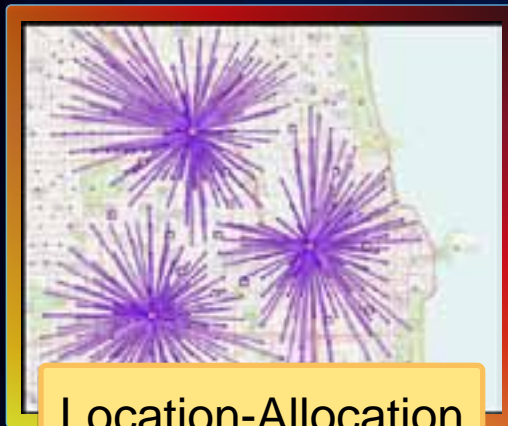 - **Configuring solvers for effective results**
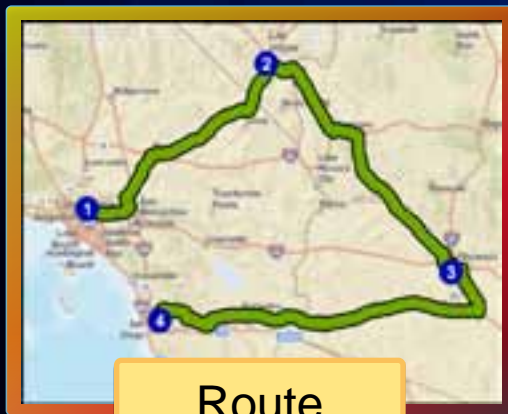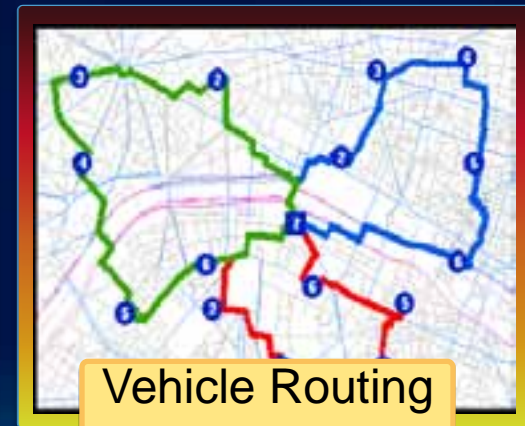
Route

Closest Facility

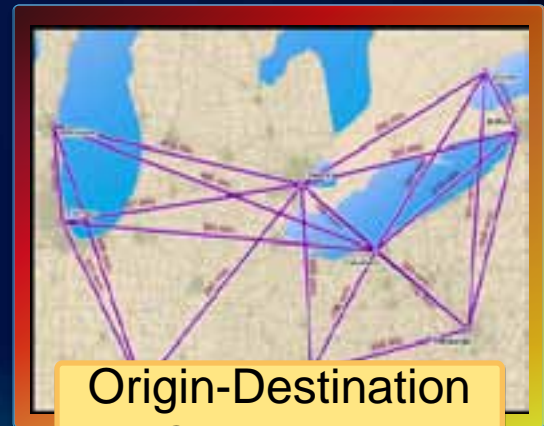Service Area

ArcGIS Network Analyst Extension
Solving transportation problems

Location-Allocation

Vehicle Routing Problem

Origin-Destination Cost Matrix

Where do you get street data?

- **Free data**
  - **Data and Maps DVD**
  - **TIGER**
  - **ArcGIS Online**
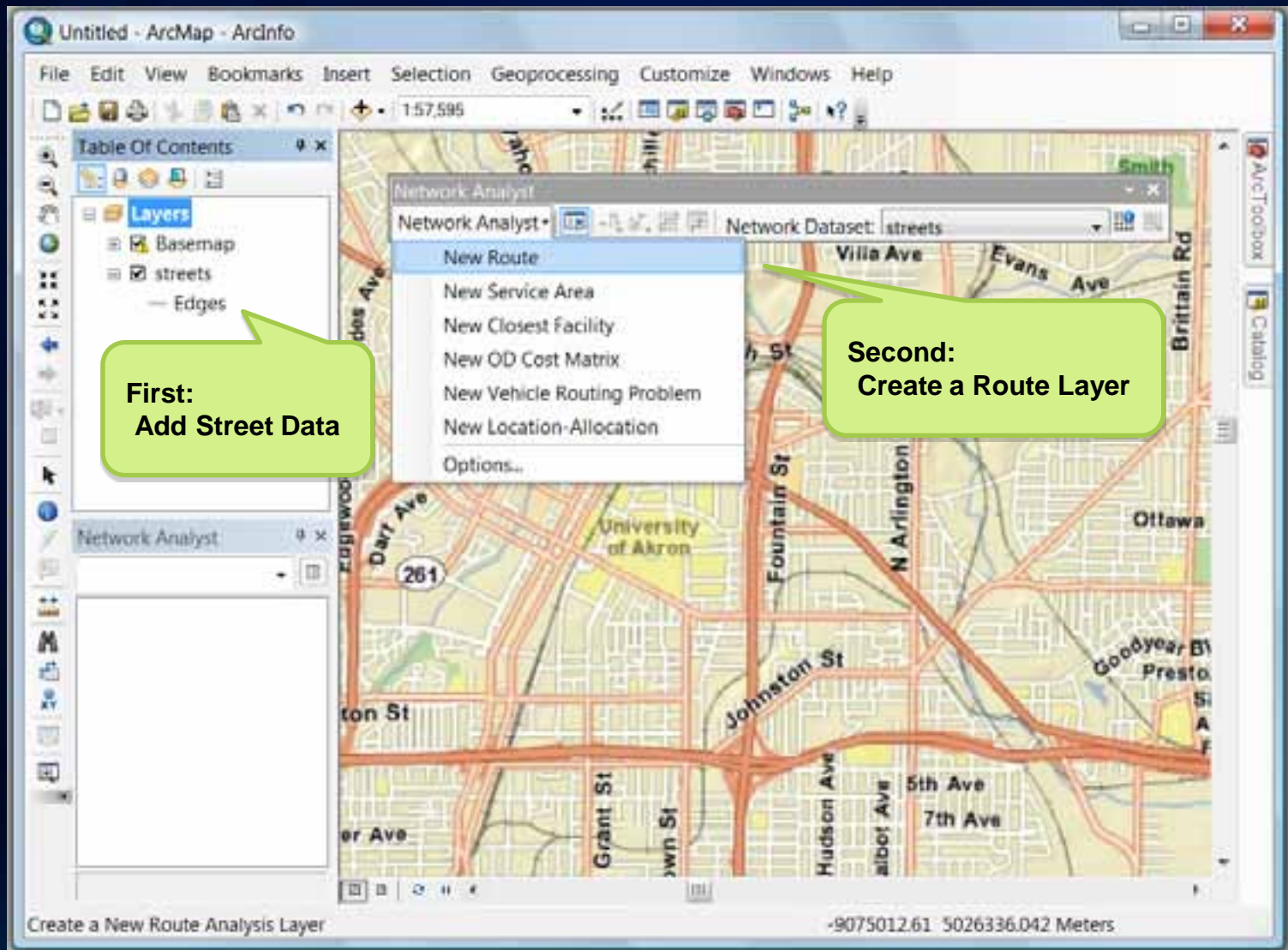
- **Community data**
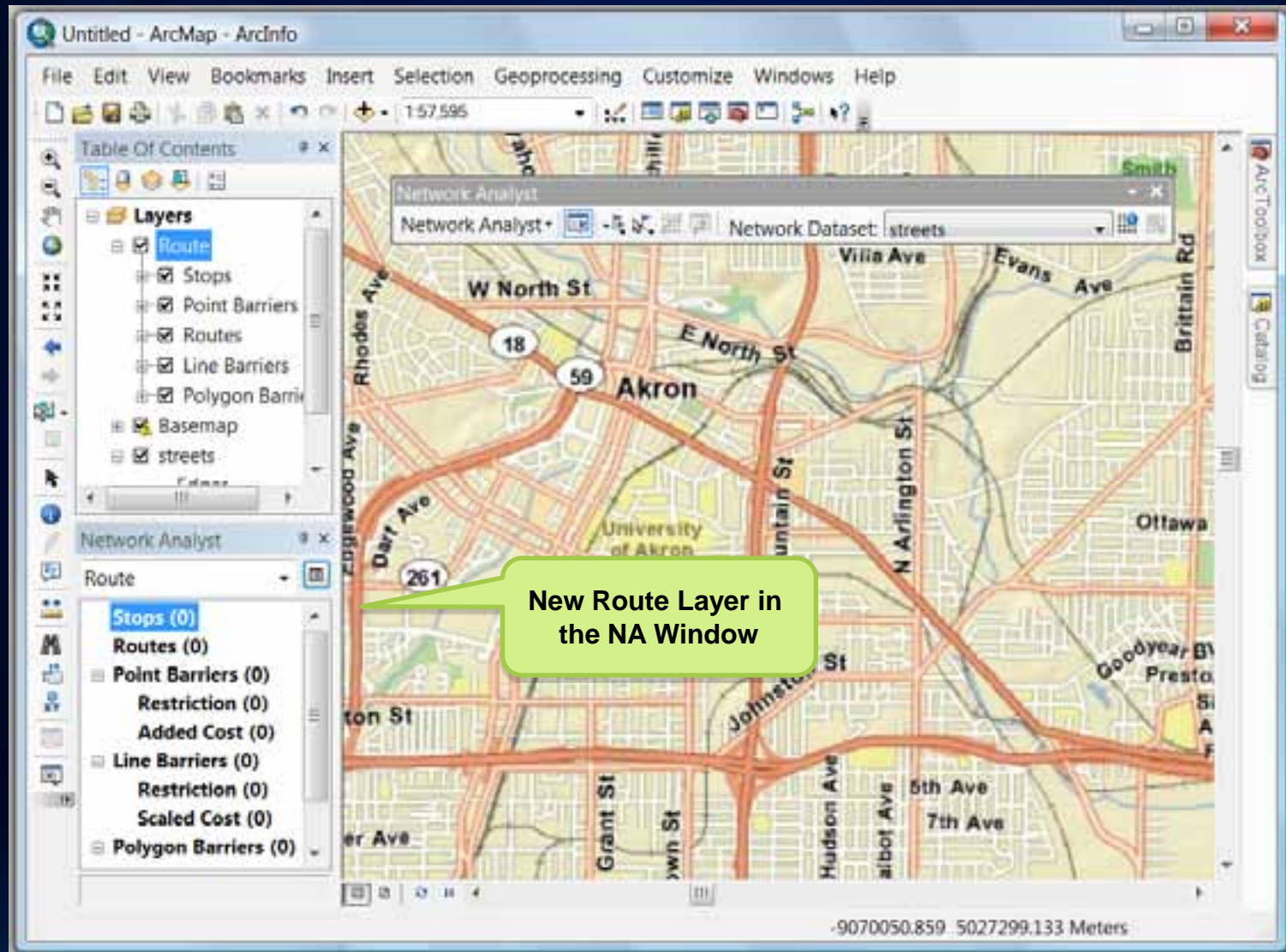 - **OpenStreetMap**
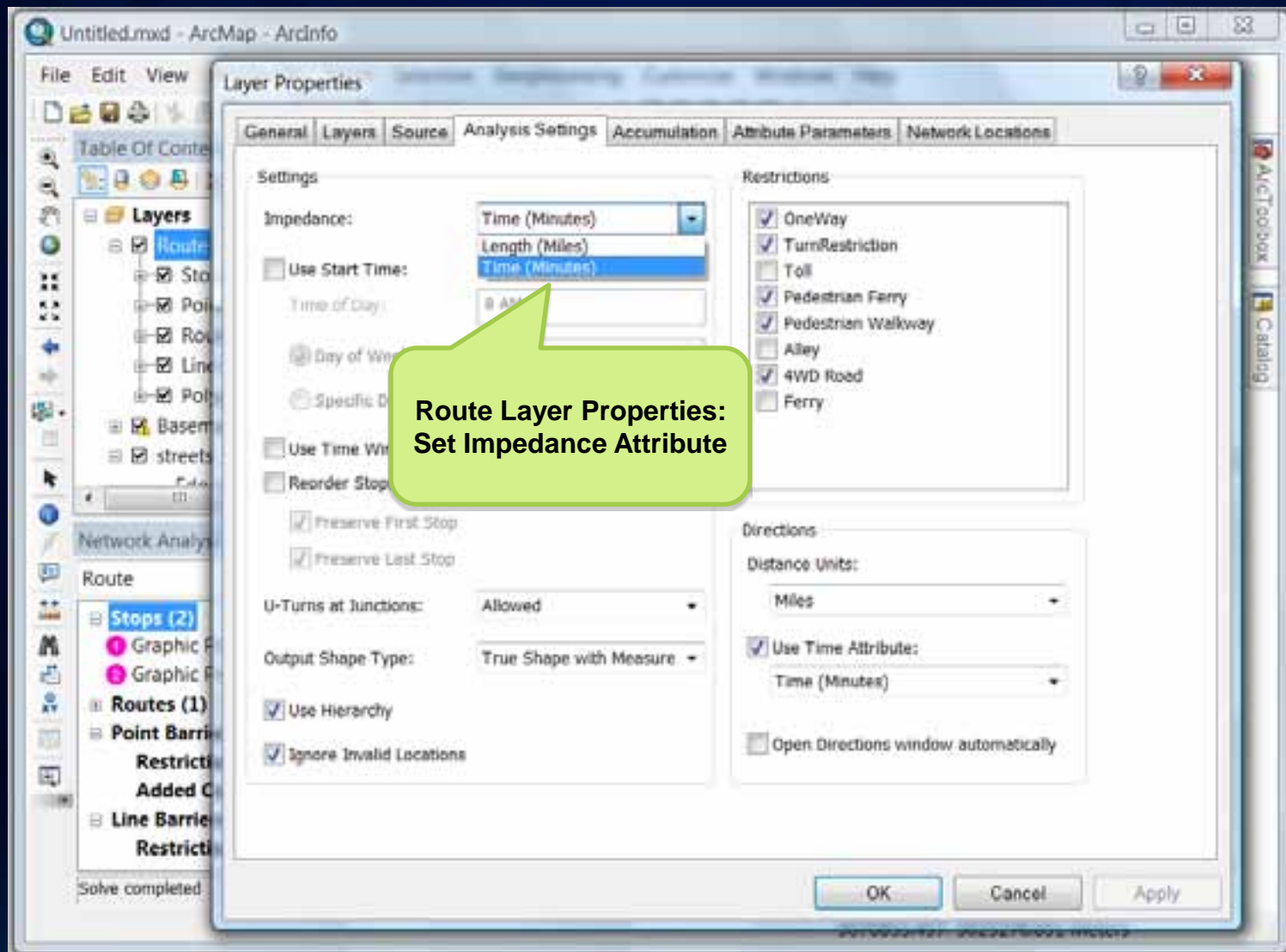
- **Your data**

- **Vendor data**

Network Analyst Workflow

Network Analyst – Creating a Route NA Layer

Network Analyst – Setting Analysis Properties

Network Analyst – Load Locations

Add more fields such as ID's to NA sub-layers and map them here

Map fields to load additional attributes

Network Analyst – Solving a Route
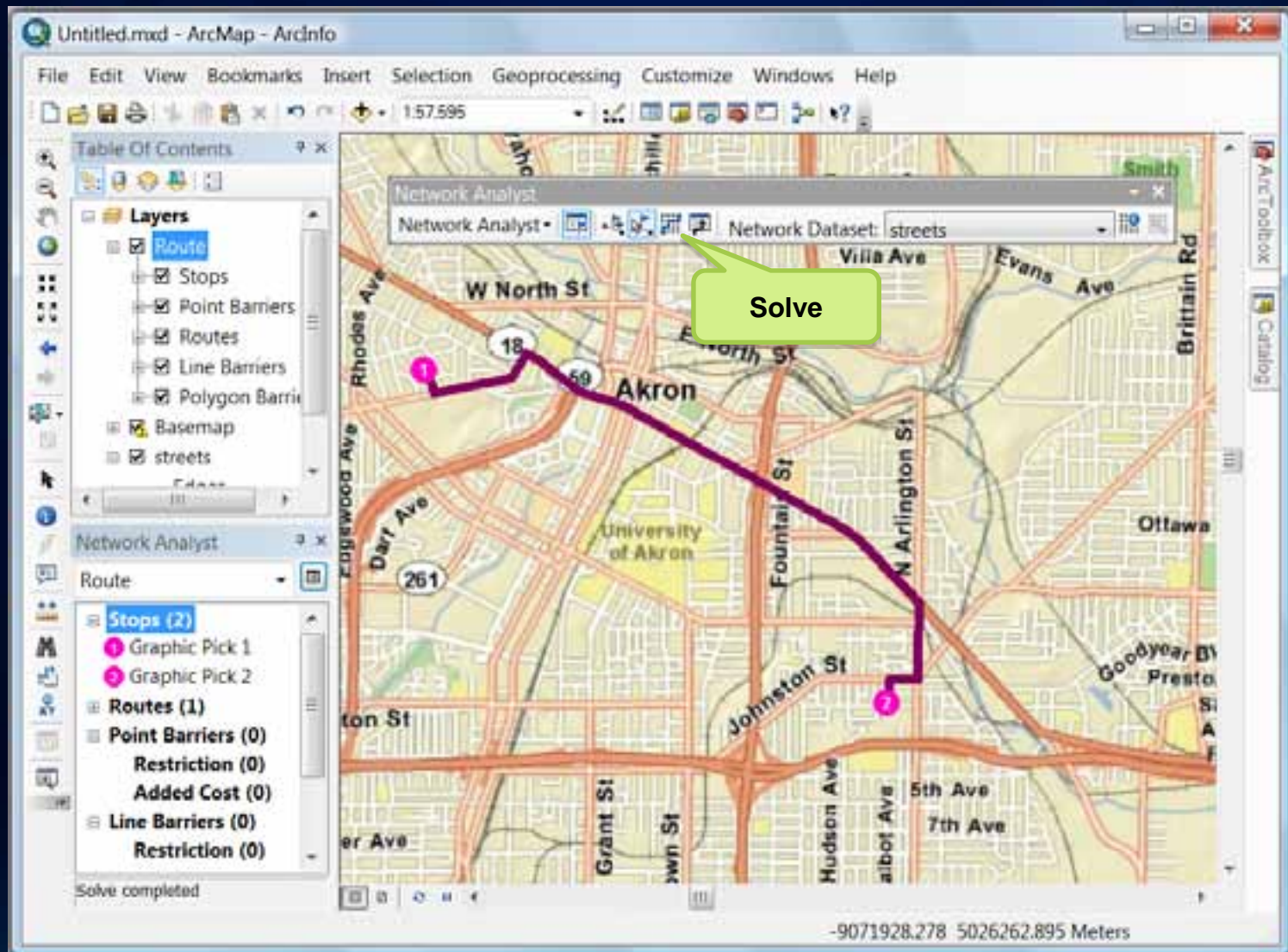
Network Analyst – Analyze the results
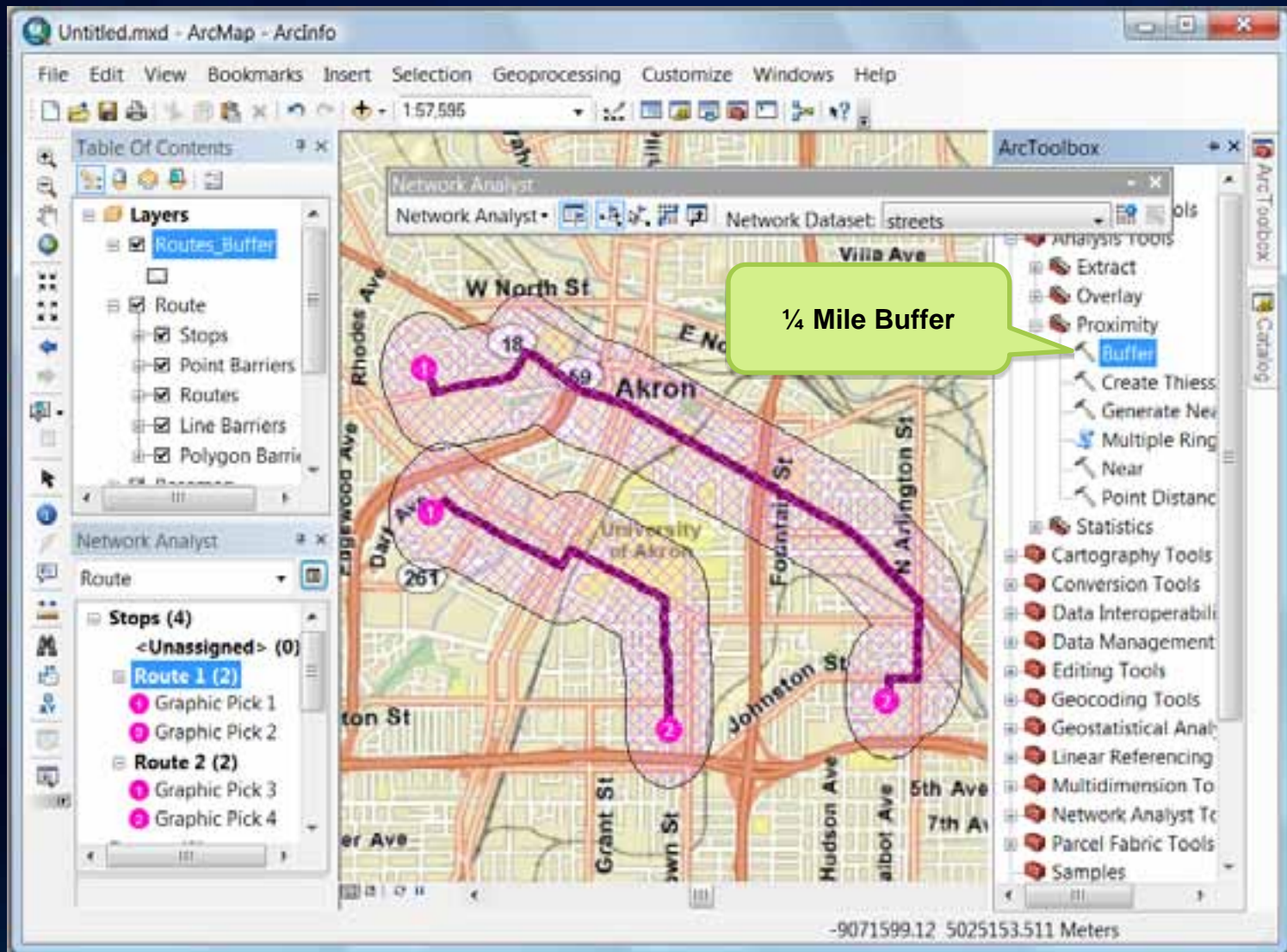
Common Workflow – With Load Locations

- **Use Calculate Location tool to pre-compute network locations for faster load of locations**
  - Can also exclude locating on restricted elements
    - Use SQL Where clause for more control on where to locate locations such as avoid freeway ramps

- **Use the** **1** **key to see where a point is located on a network.**

- **Use the** **2** **key for reverse geo-coding**

Network Analyst solver settings

- **Barriers – scaled or restricted**
  - **Point, line and polygon**

- **Restrictions**
  - **One-way, height, weight, left-turn, etc**

- **Accumulations**
  - **Pick a list of attributes to accumulate and report**

- **Output Shape type**
  - **Measures – enables linear referencing**

- **Hierarchy**
  - **For fast performance with very long routes (nationwide)**

Network Analyst Traversal results

- **Route, Closest Facility and Service Area keep the traversal results in memory**

- **Use ArcGIS AddIn to access them and turn them into feature class in the ArcMap table of contents**

- **Very detailed and useful for summary applications**

Route

Closest Facility

Service Area

ArcGIS Network Analyst Extension
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Origin-Destination Cost Matrix
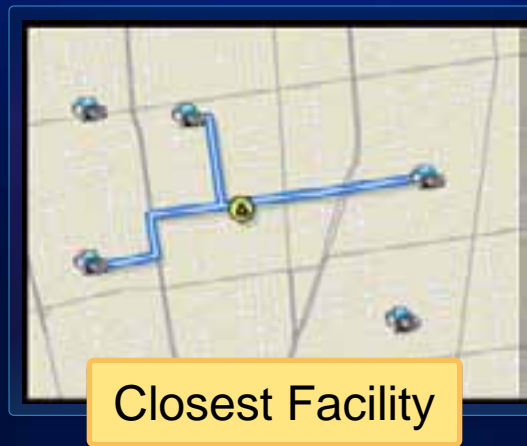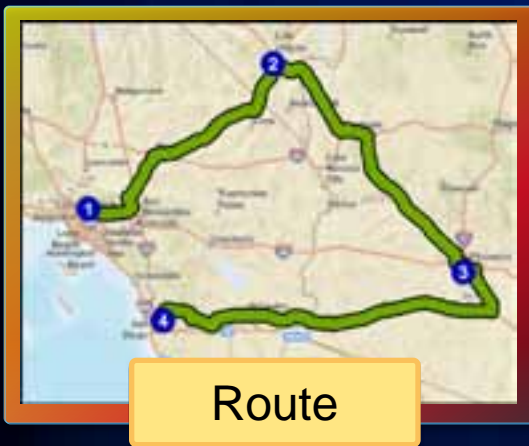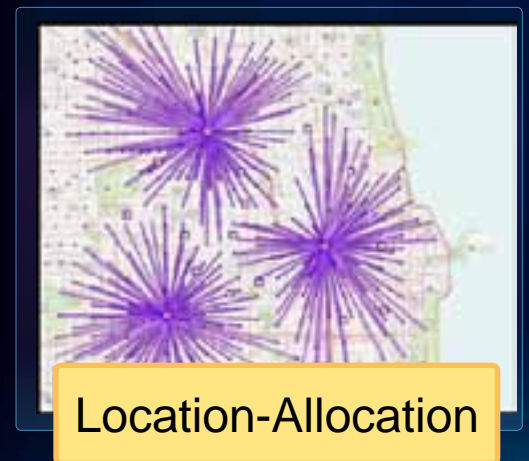
Route – Find Shortest Paths

- **For a set of locations**

- **For many groups of locations or Multi-Route**
  - **Or between pairs of Origin and Destination locations**

Multi-Route
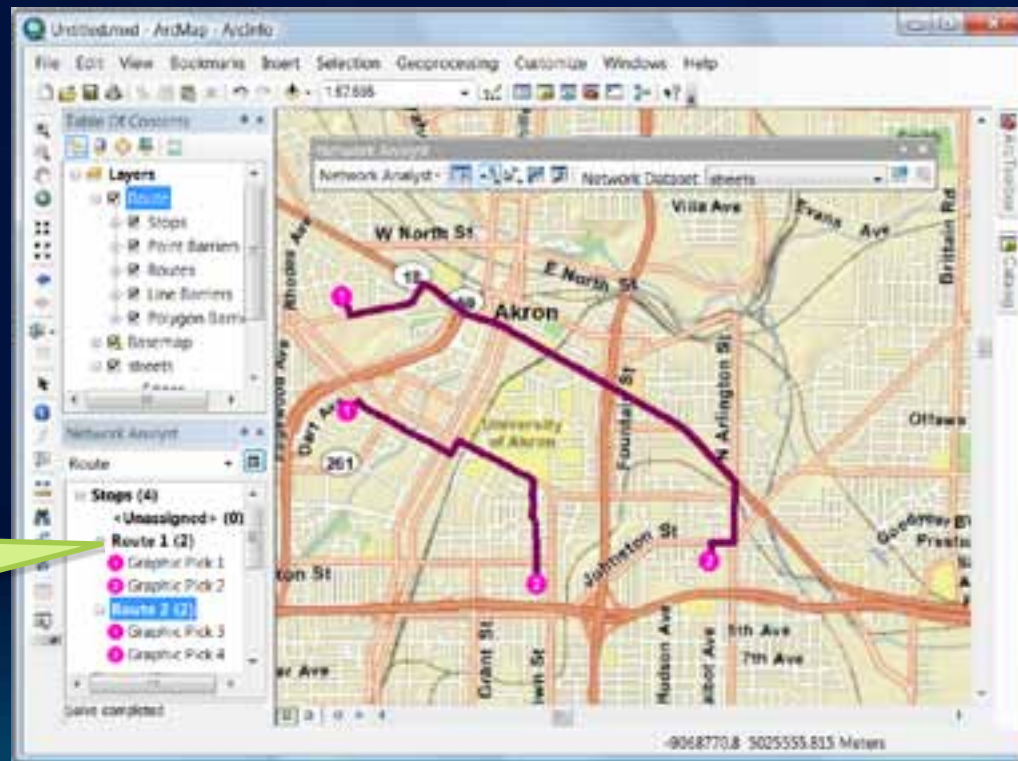
Route – Options

- **Minimize any network attribute like travel time and distance**

- **Honor navigation necessities such as**
  - **Curb approach**
  - **U-turn rules**
  - **Turn delays**
  - **Street restrictions**
    - **Height**
    - **Weight**
    - **One-way**
  - **Time of day by using historical traffic information**

Route – Optimal Shortest Paths

- **Also called the Travelling Salesperson Problem**
    - Use when you have a single vehicle or person that needs to visit a set of discrete locations in the shortest sequence

Route Demo

Mileage summary by State

Route

Closest Facility

Service Area

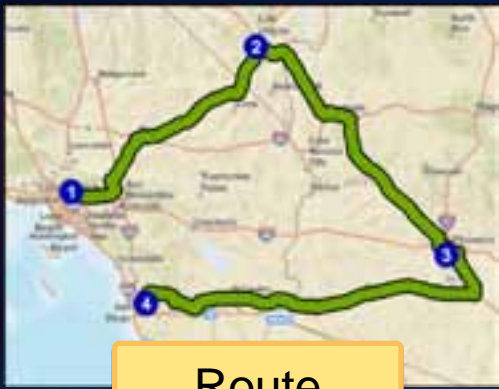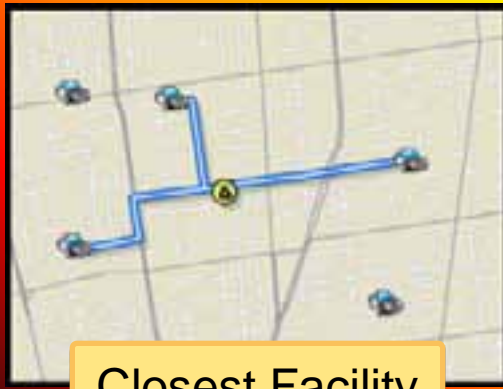# ArcGIS Network Analyst Extension
Solving transportation problems

Location-Allocation

Vehicle Routing Problem
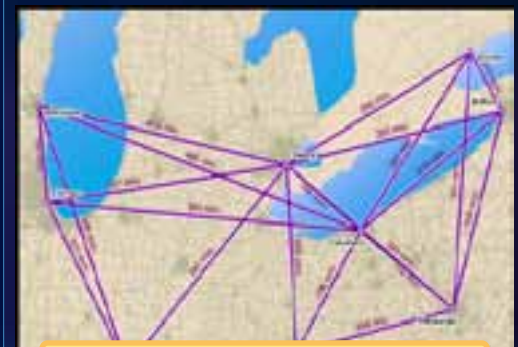
Origin-Destination Cost Matrix

Closest Facility – Typical Applications

- **Find closest application**
  - **Closest ATM or Store locator**
  - **Emergency roadside assistance dispatch**

Closest Hospital From Incident

Closest Facility

- **Use CF when shape, directions or traversal results are needed**
  - Else, use OD Cost Matrix solver for computing costs

- **Tips on effective use:**
  - Use hierarchy only for large distances (~30 miles)
  - Set a reasonable cutoff
  - Pre-process the facilities and load only those that are near the incidents

- **Use chunking for large number of facilities**
  - Enabled via registry keys/details in online KB article

Closest Facility Demo
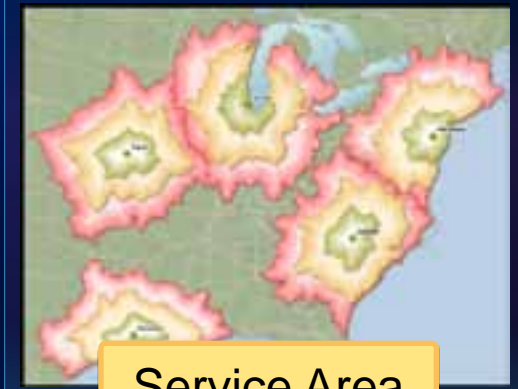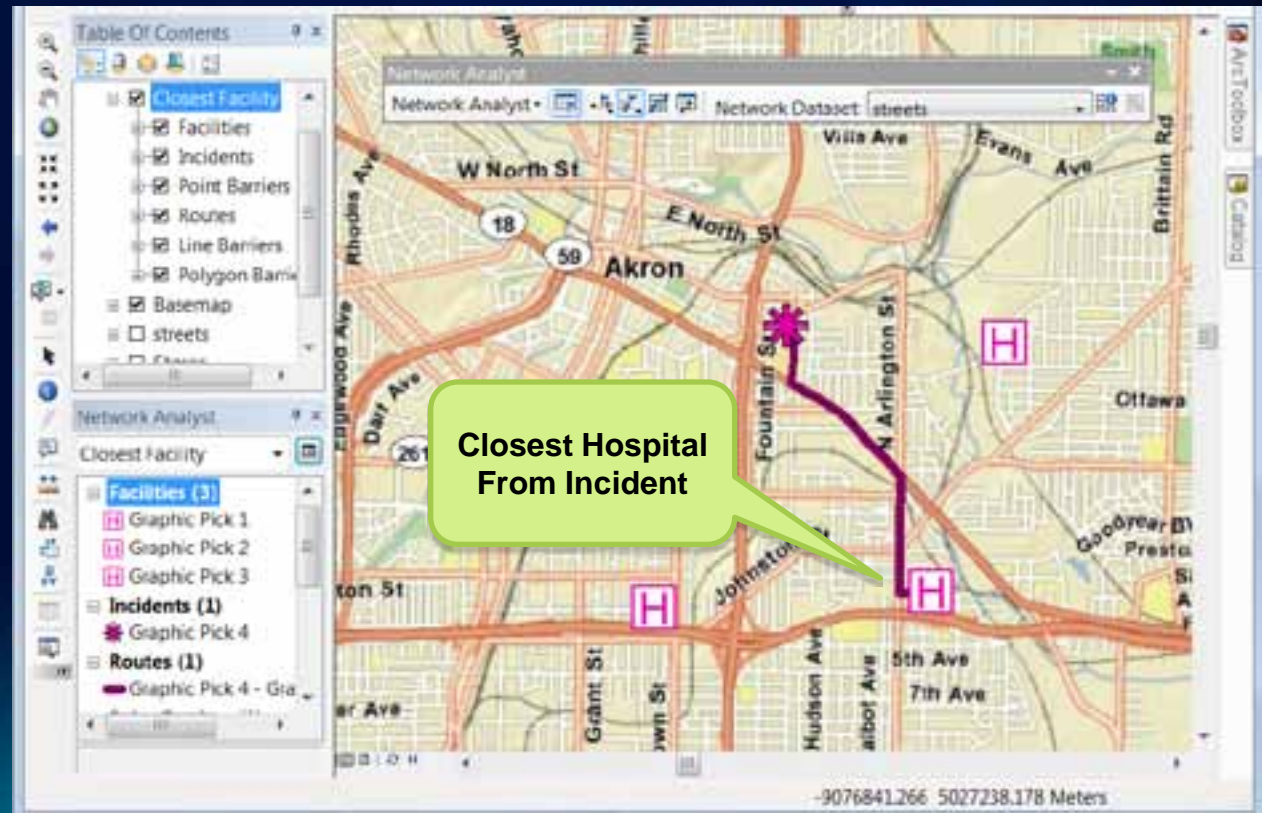
Most traversed streets
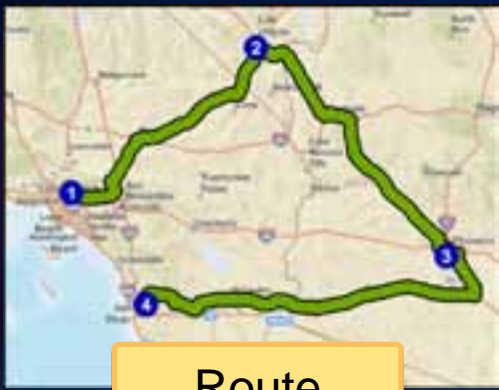
Route
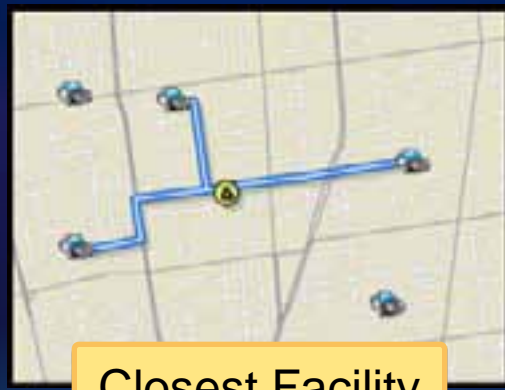
Closest Facility

Service Area

ArcGIS Network Analyst Extension
Solving transportation problems

Location-Allocation

Vehicle Routing Problem

Origin-Destination Cost Matrix

Service Area

- **What areas are within 30 minutes of a location**
- **Retail/demographic analysis – sum up demand within a 5 minute drive time of a potential store location**
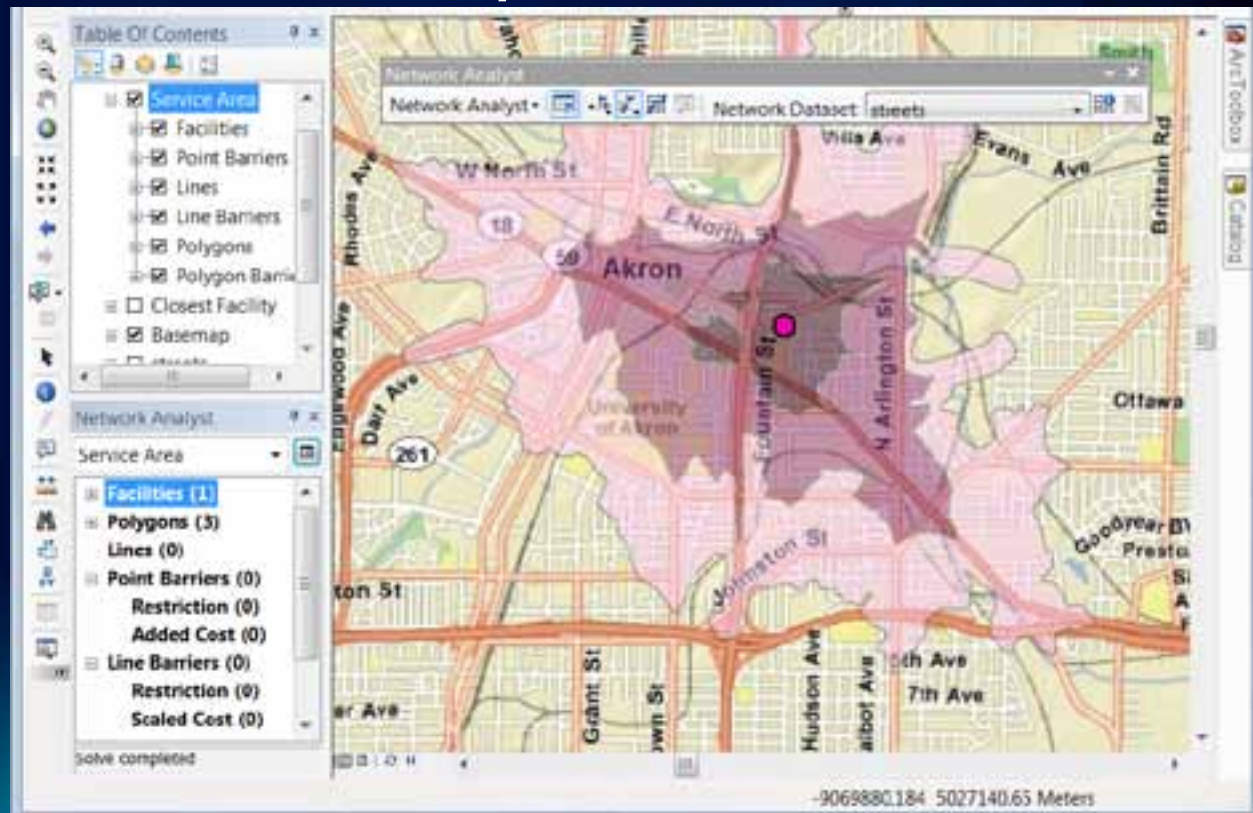
Service Area

Detailed Option Has Holes

Generalized Option

Service Area

- **To avoid holes:**
  - **Use Generalized option**
  - **When using a multi-modal network dataset, use Exclude Sources option**

Generalized Option

Use Appropriate Trim Distance

Exclude Metro sources

Service Area Uses

- **Use Lines options to check the connectivity in the network**

- **Makes very appealing visuals on a map**

- **For larger service areas, use a thinned out network with only the major streets**

- **For large number of facilities use chunking**
  - **Enabled via registry keys/details on online KB article**

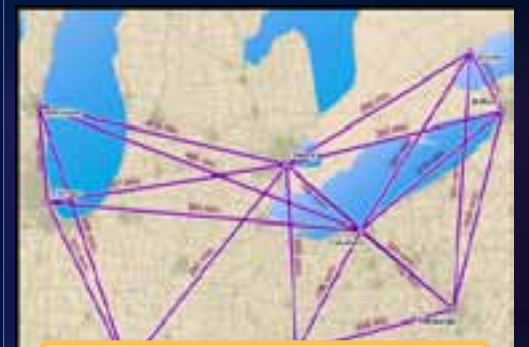# Service Area Demo

Demographic summary

Ad Placement

Route

Closest Facility

Service Area

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Location-Allocation

Vehicle Routing Problem
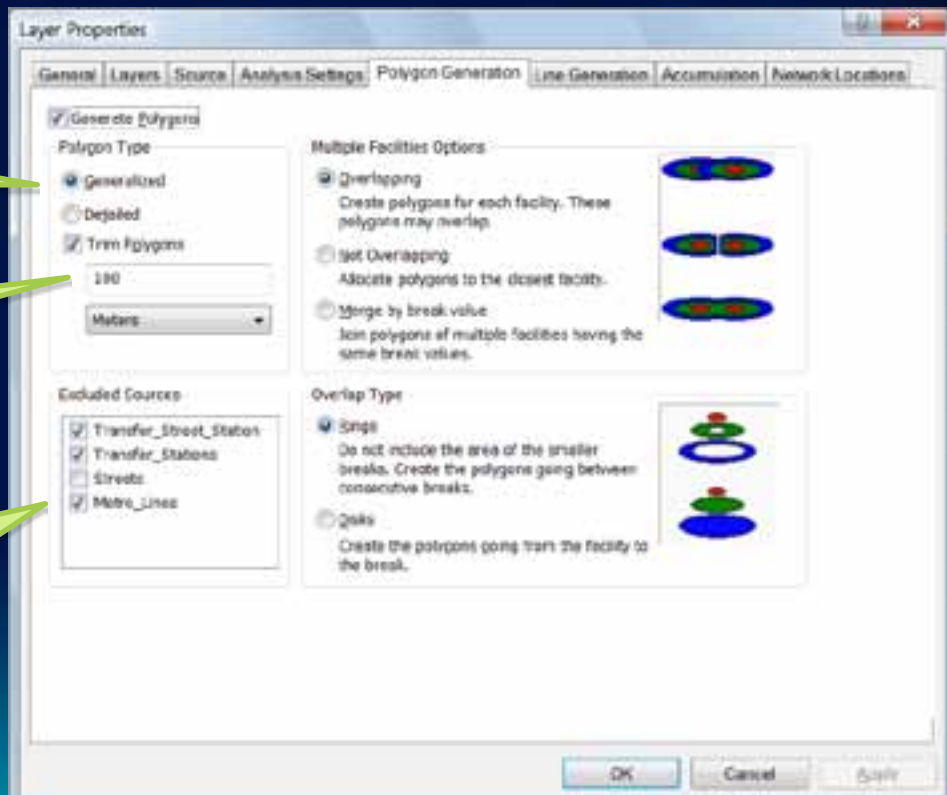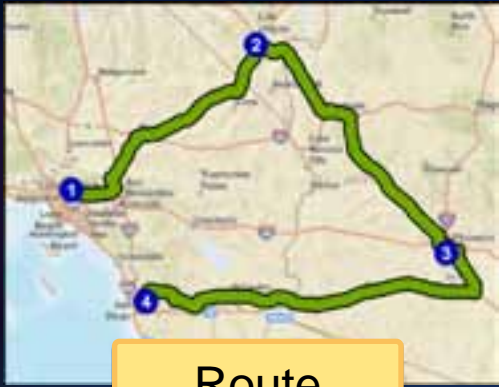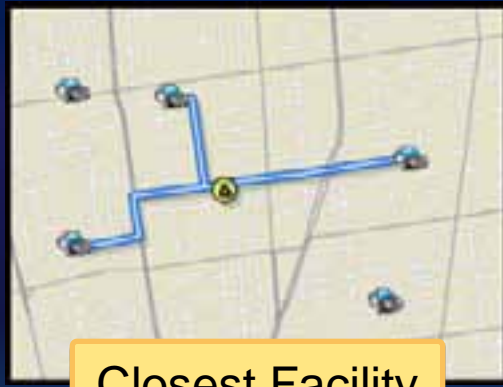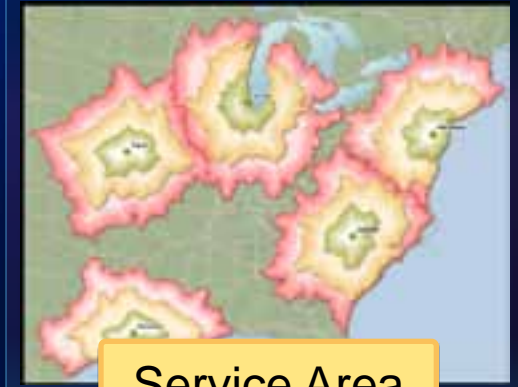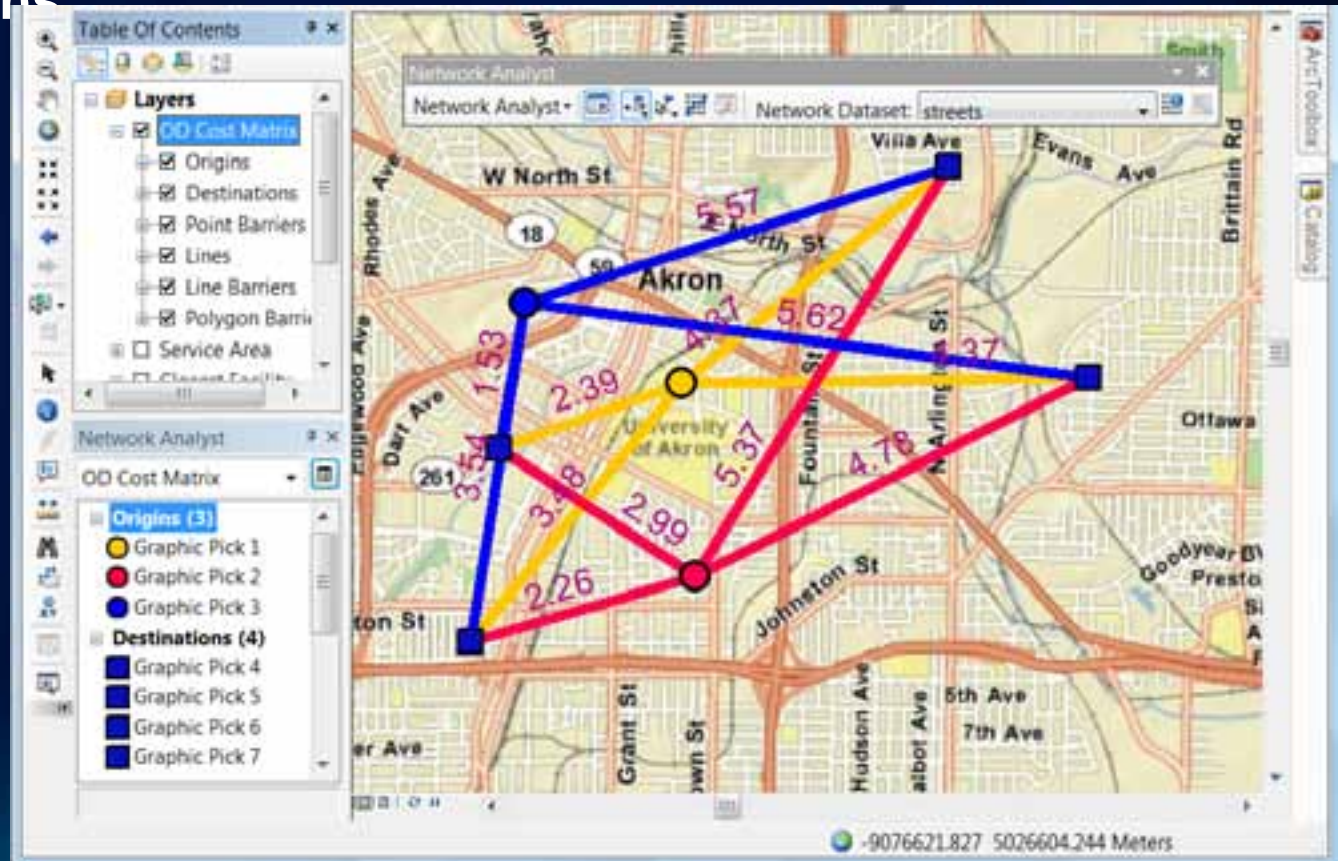
Origin-Destination Cost Matrix

Origin-Destination Cost Matrix Solver

- **Computes network distances between sets of locations**

Origin-Destination Cost Matrix Solver

- **Internally used by**
  - **Reorder Stops to Find Optimal Route option**
  - **Vehicle Routing Problem**
  - **Location-Allocation solvers**
  - **ArcLogistics product**
  - **Generate Network Spatial Weights tool in the Spatial Statistics toolbox**

- **Can use with external processes like custom VRP or Linear Programming for advanced analysis**
  - **Deelesh's Allocation Tools on Resource Center**
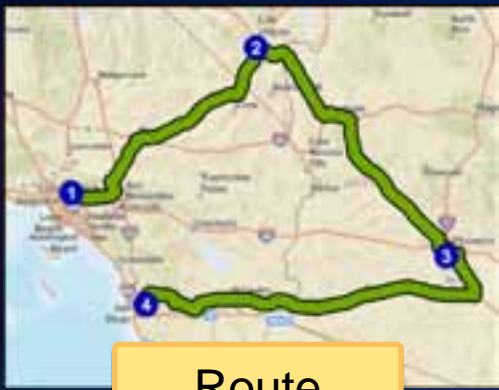
Origin-Destination Cost Matrix

- **Tips on effective use:**
  - Use hierarchy only for large distances (~30 miles)

  - Set a reasonable cutoff

  - Do not solve as the active analysis layer (use GP)

  - Use ArcObjects for very large OD with no output lines

  - Use 64 bit OS which allows ArcGIS 10 to use 4 GB of RAM
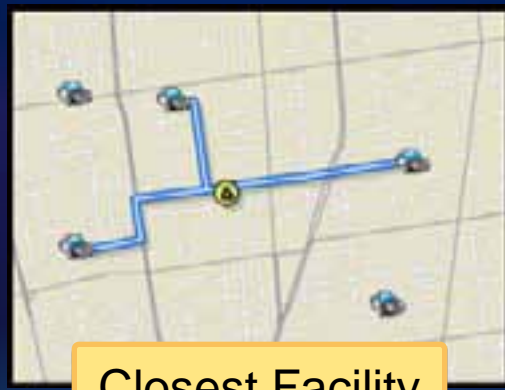
OD Cost Matrix Demo
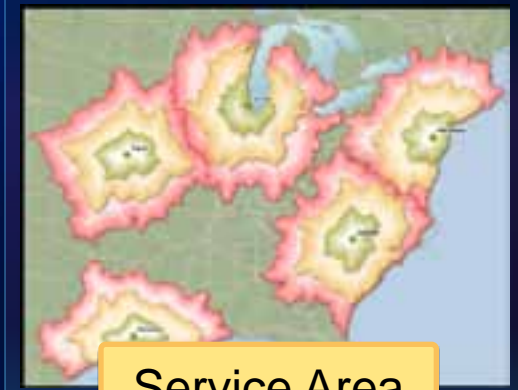
Accumulate Attributes

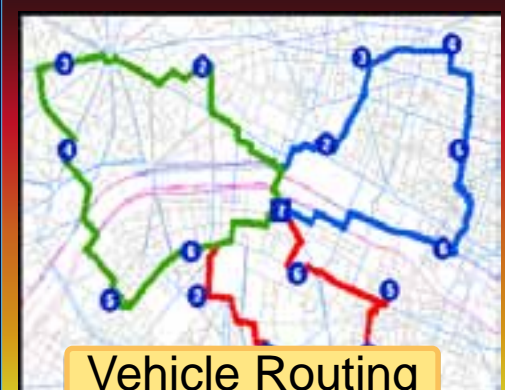School Allocation

Route

Closest Facility

Service Area

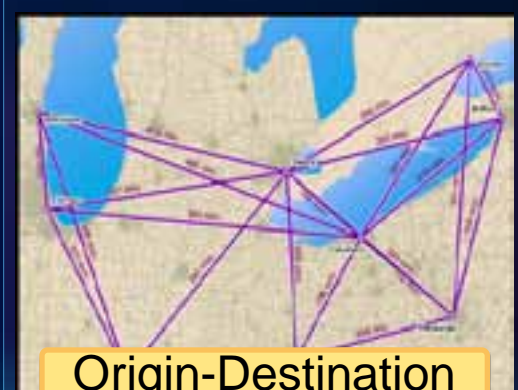# ArcGIS Network Analyst Extension
Solving transportation problems
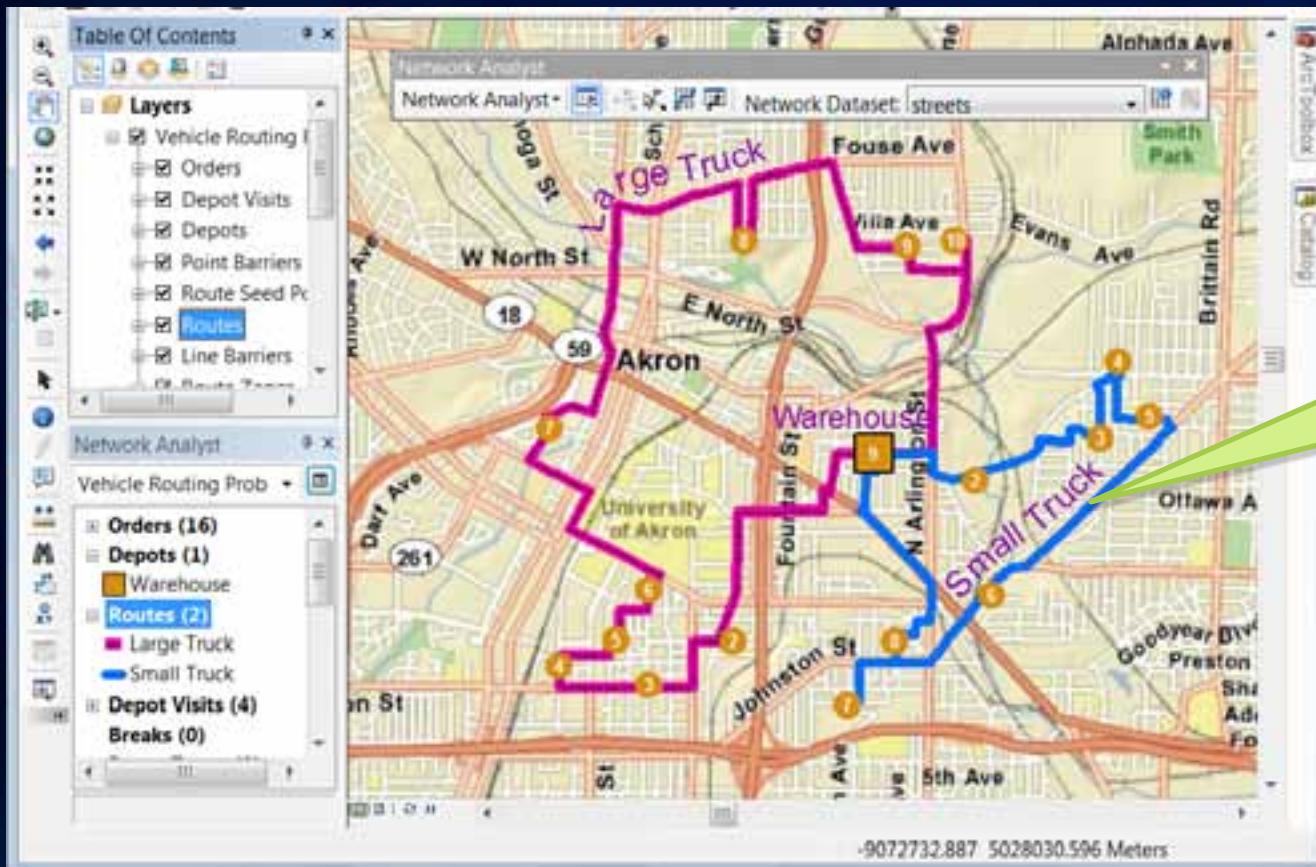
Location-Allocation

Vehicle Routing Problem

Origin-Destination Cost Matrix

Vehicle Routing Problem

- **This is not the simple Travelling Salesperson Problem!**

Multiple Vehicles with different capacities

Vehicle Routing Problem .vs. TSP

- **Use VRP solver when you have**
  - **A fleet of vehicles with defined capacities**
  - **One or more warehouse or dispatch locations**
  - **Customers have delivery time preferences**

- **Additional capabilities**
  - **Drivers can take multiple-breaks**
  - **Routes can be generated around seed points, e.g. driver home**
  - **Drivers with technical specialty can be matched to service order**

Vehicle Routing Problem Capabilities

Order Properties

Warehouse Properties

Route/Driver Properties

Vehicle Routing Problem Capabilities

- **For more information, see the online help!**
- **VRP Online Help**

Vehicle Routing Problem Uses

- **Service problem:**
  - Send technicians to service clients on-site, *i.e.* pest control

- **Delivery problem:**
  - Deliver packages from the warehouse to clients, *i.e.* hardware deliveries

- **Paired-order service problem:**
  - Pick up people from one location and deliver them to another location, *i.e.* bus tour problem

- **Paired-order delivery problem:**
  - Deliver packages from one location to another, *i.e.* package deliveries

VRP Demo

Flag Fundraiser
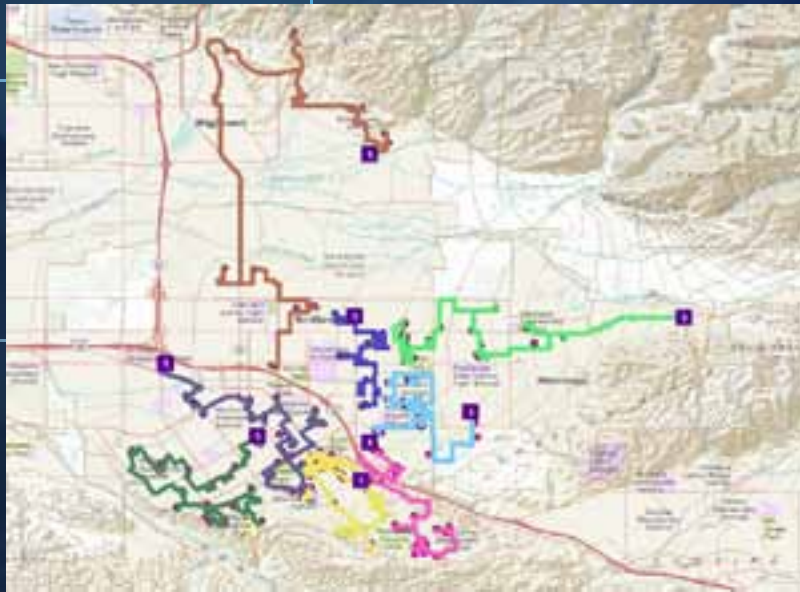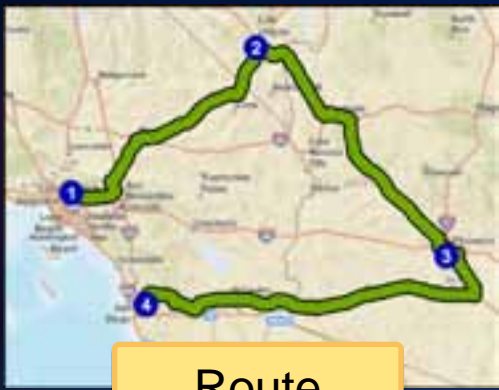
Route
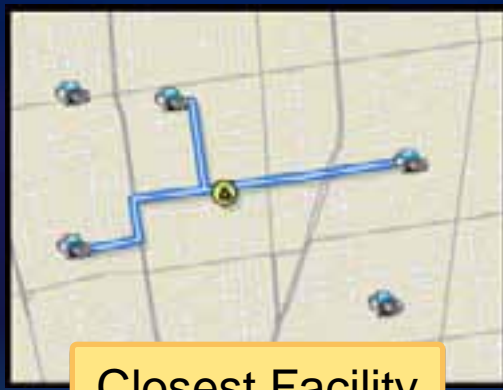
Closest Facility
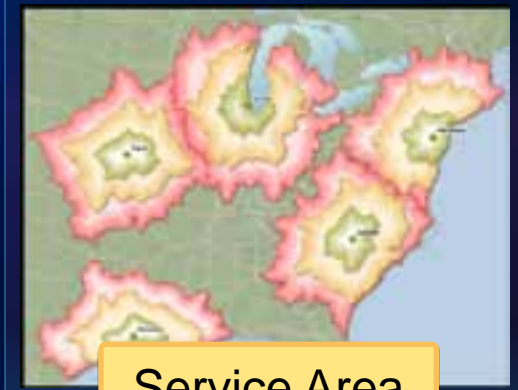
Service Area

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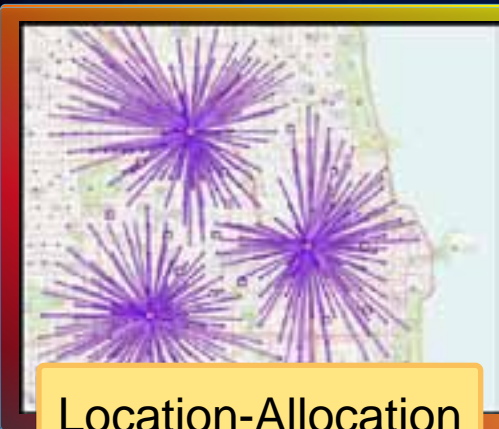
Location-Allocation
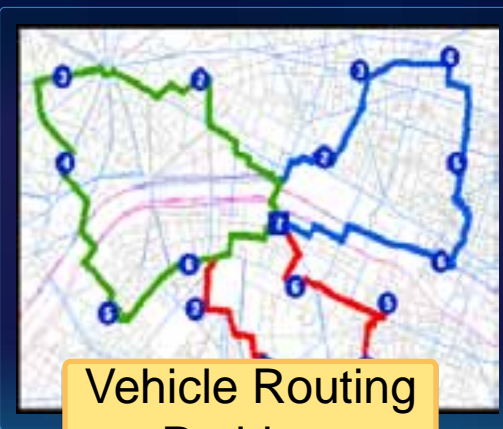
Vehicle Routing Problem

Origin-Destination Cost Matrix

Location-Allocation

- **Useful for locating**
    - **Warehouses**
    - **Retail Stores**
    - **Fire Stations**
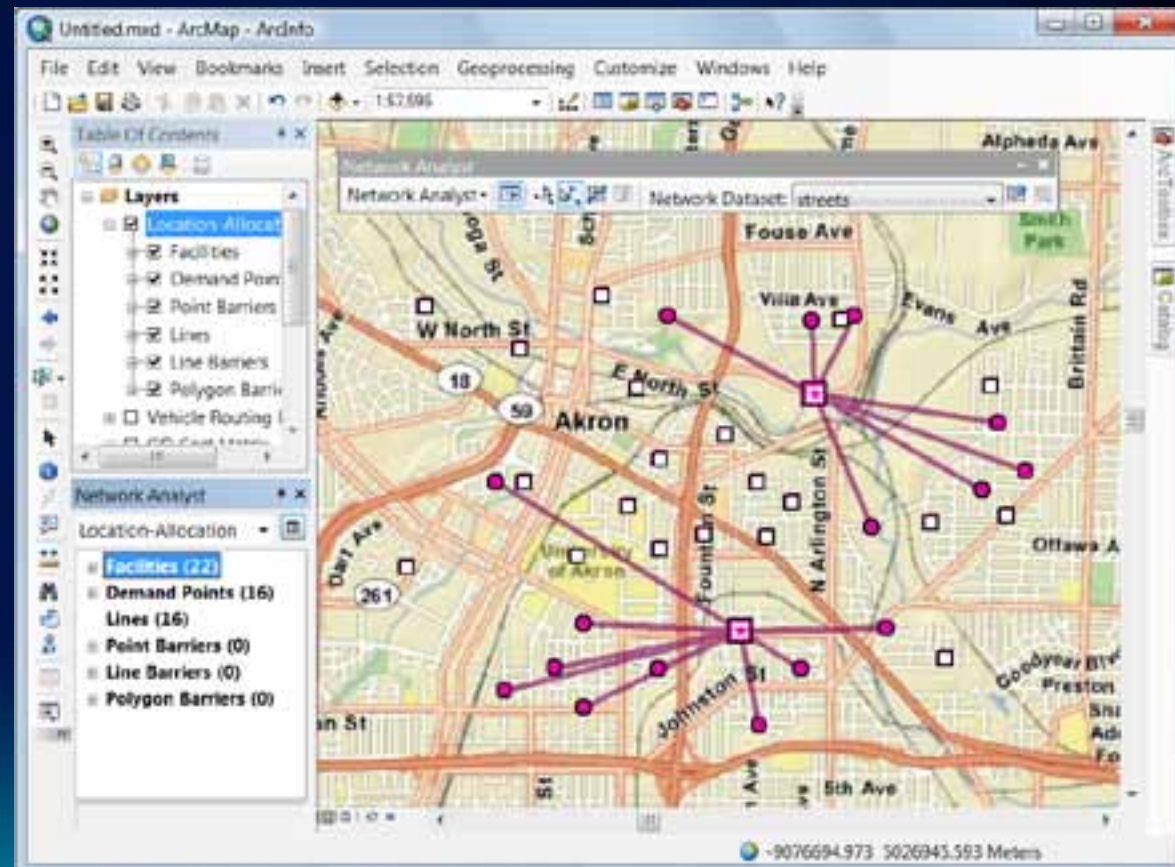
Location-Allocation

- **Optimize warehouse location for VRP**
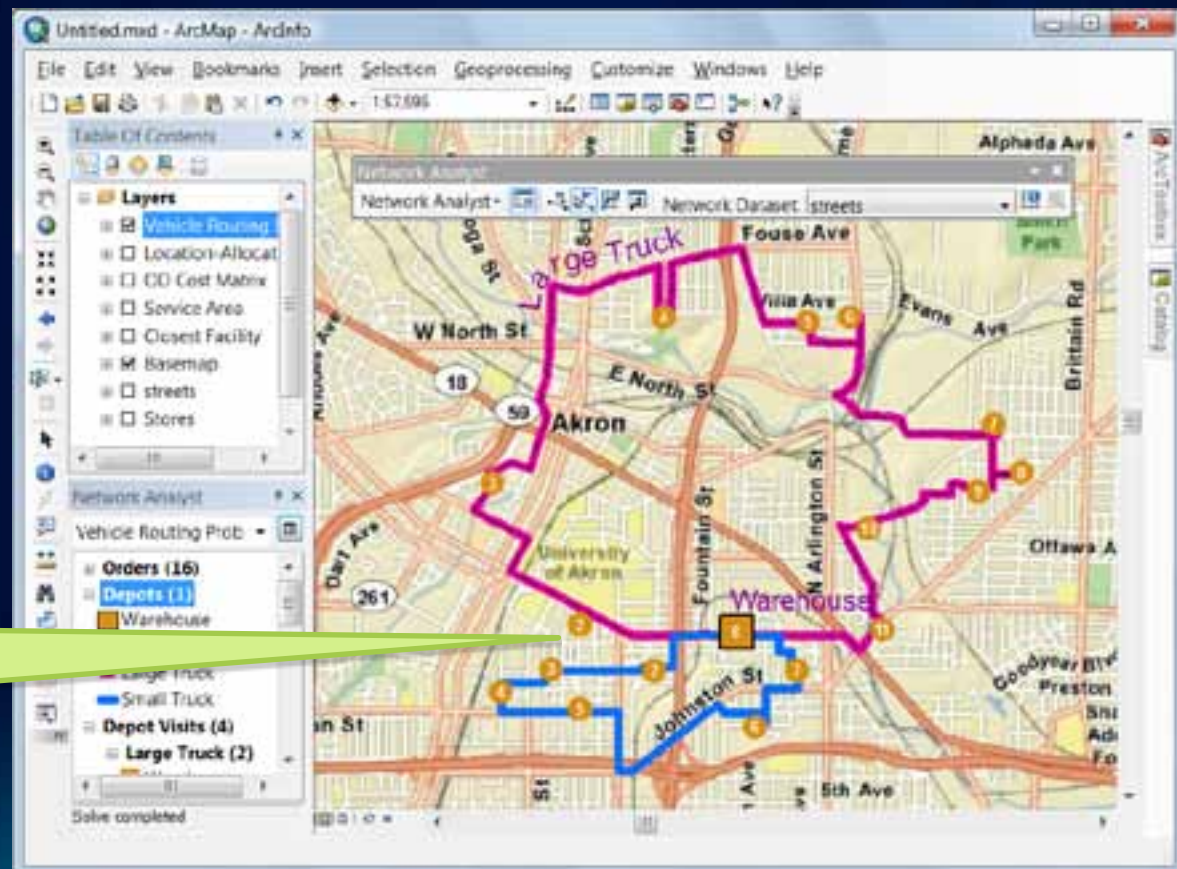
Re-locating Warehouse Saves five percent fuel

Location-Allocation – Gravity Models!

- **Location-Allocation supports the gravity model (also called the Huff model) for competitive locations.**

- **Inputs:**
  - **Your locations**
  - **Your competitor locations**
  - **Demand locations**
  - **Distance decay parameters**
  - **Market share - Locates sites to maximize market share**
  - **Target market share – Computes number of sites needed to achieve a target market share (say 24%)**

- **If all inputs are fixed then you can use Location-Allocation to compute spatial-interactions!**

Location-Allocation Gravity Models example
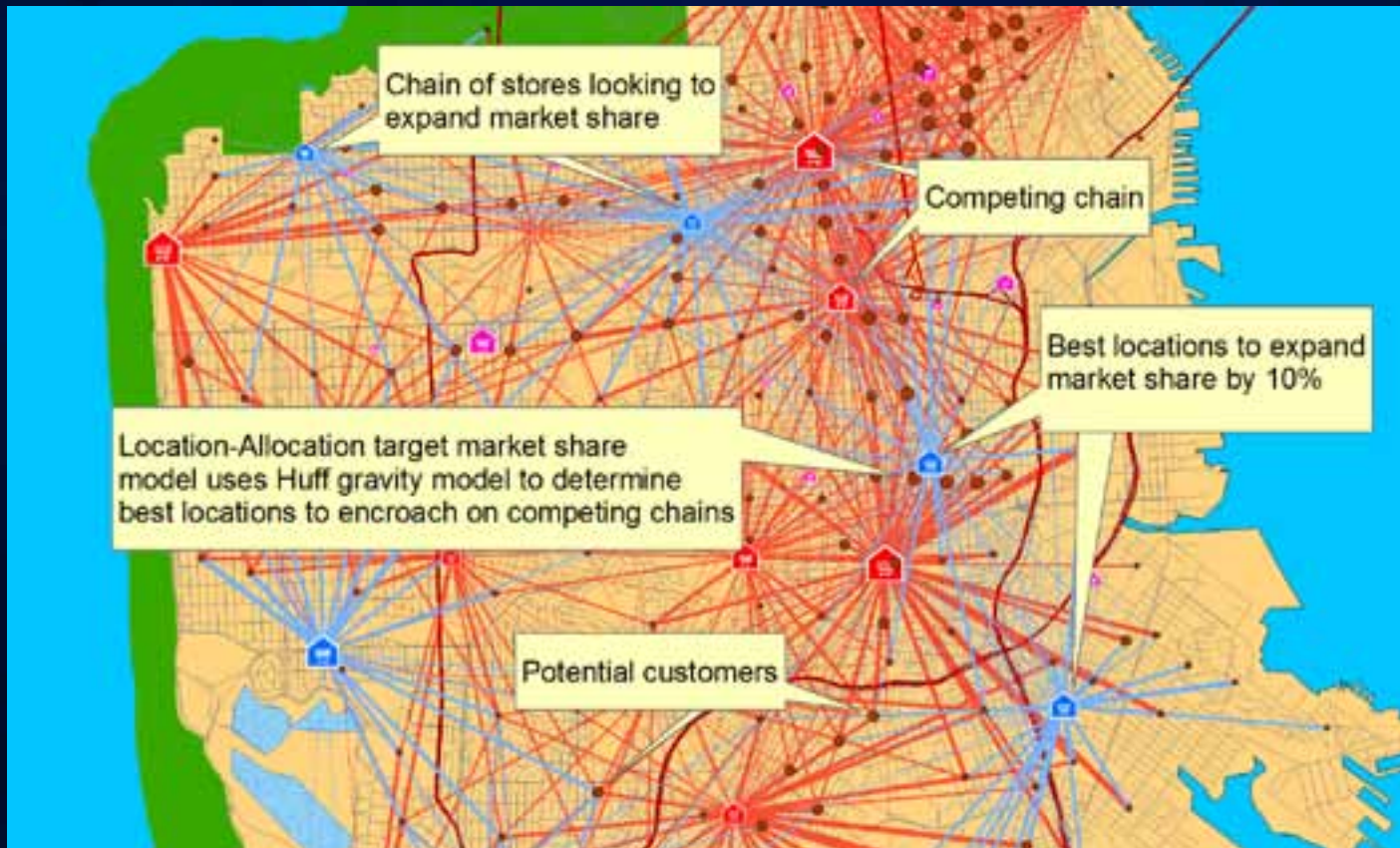
Location-Allocation – Estimating Beta

- **Tobler's First Law of Geography:**
  - **Everything is related to everything else, but near things are more related than distant things**
- **Also called distance decay**
- **Start with a survey of distance travelled by customers to come to a typical location**
- **Make a table of cumulative trips**
- **Make an inverse and create an XY scatter plot**
- **Fit an appropriate trend line**

Location-Allocation Beta trend line in Excel
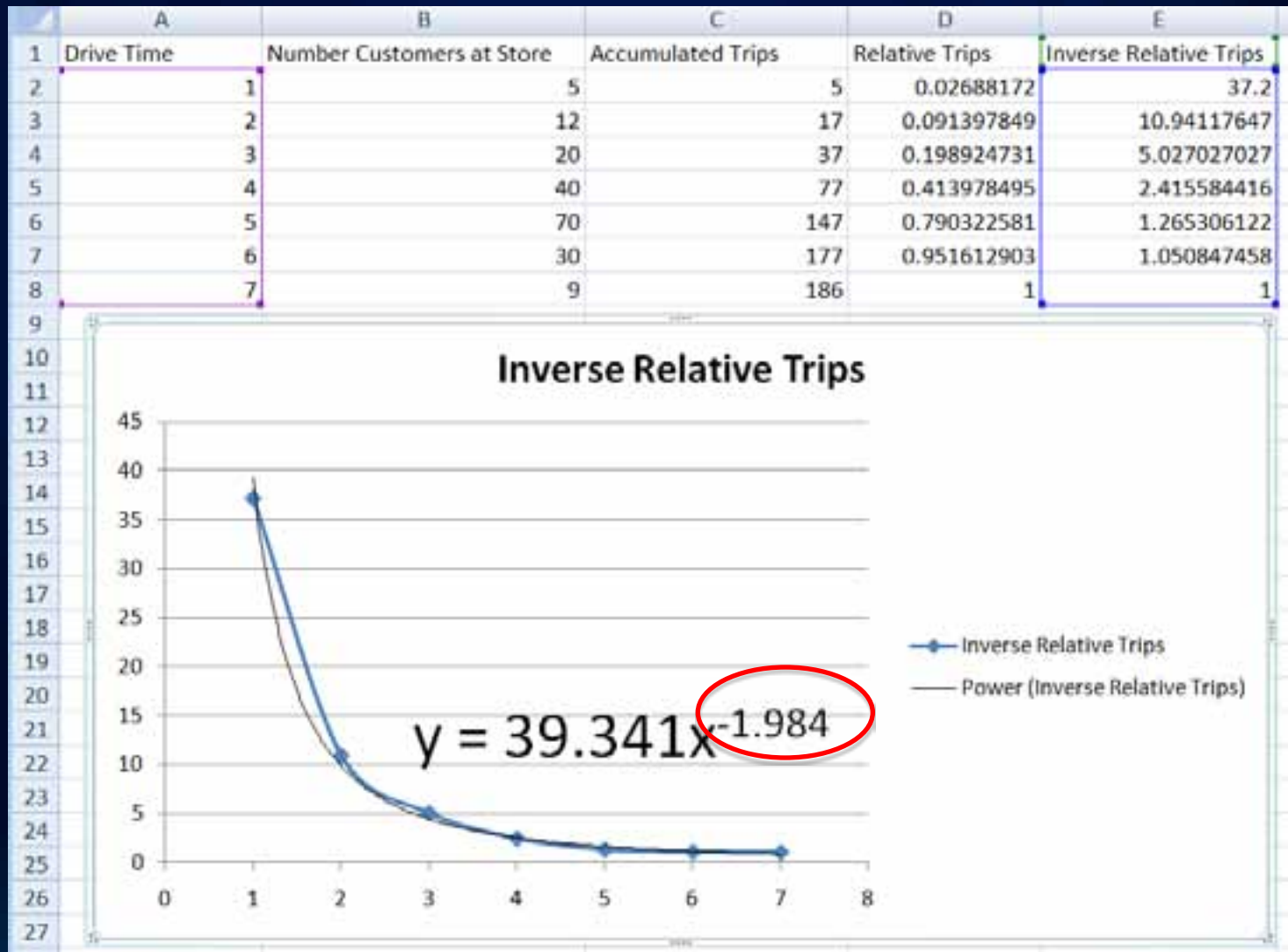
Location-Allocation

- **Tips on effective usage:**
  - Use an appropriate distance cutoff
    - Each demand point can have it's own cutoff
      - Urban .vs. Rural populations

  - Pick suitable candidates

  - If large number of demand/candidate points then aggregate
- **Use LA to generate many alternatives and feeding into a Decision Support System**

Location-Allocation Demo

Maximize Coverage
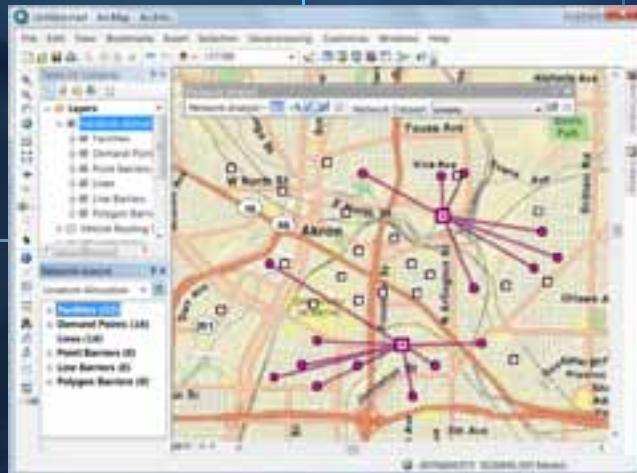
Things to watch out for

- **Do not include your start/end locations as junctions in the network dataset**
  - This causes your locations to "snap" on to these junctions which are usually not connected to any edges and no paths are found.

- **Travel times are computed at posted speed limits and are too optimistic**
  - Use new historic traffic information
  - Use global turn delays

- **De-compose problems regionally if performance is an issue**

Summary

- **Pick the right solver for the task**

- **Choose appropriate analysis settings**

- **To learn more**
  - **Go through the NA Tutorials**
  - **Lot of help available on-line**
  - **Visit the ArcGIS resource centers for useful utilities and data**

What's new ArcGIS 10.1

- **Real-time traffic support**

- **All solvers are time aware**

- **Enhanced restrictions**
  - avoid or prefer certain roads

- **Fast service area polygons**

- **Traversal results via geoprocessing**

- **Network analysis services on ArcGIS Online**

- **ArcPY Network Analyst module**

Network Analyst at UC2011
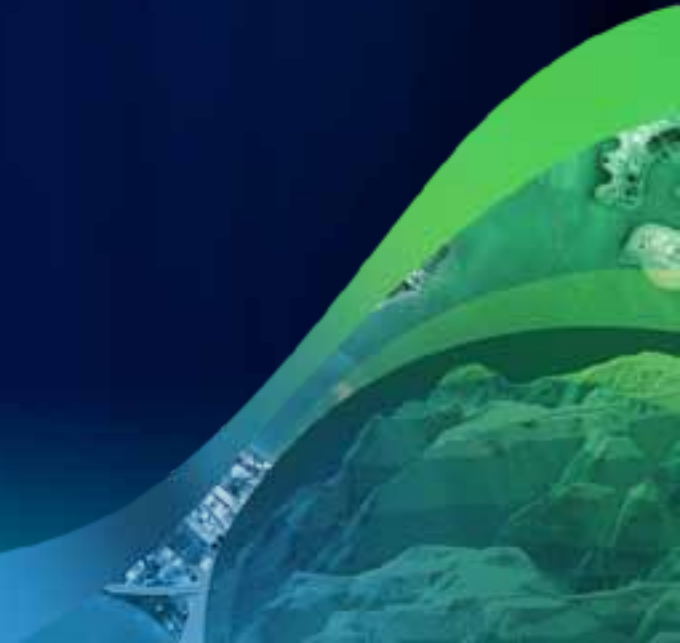
Tech Workshops

- **ArcGIS Network Analyst – An Introduction**

- **ArcGIS Network Analyst – Performing Network Analysis**

- **Performing Network Analysis with ArcGIS Server**

- **ArcGIS Network Analyst – Creating Network Datasets**

- **ArcGIS Network Analyst – Automating Workflows with Geoprocessing**

Demo Theaters

- **Patterns for Measuring and Mapping Access Using Network Analysis**

- **ArcGIS Network Analyst – Modeling Real-World Problems with the VRP Solver**

- **What is ArcGIS Network Analyst and Why Should I Use It?**

- **ArcGIS Network Analyst – Routing Inside Buildings with 3D Networks**

- **ArcGIS Network Analyst – Location-Allocation and Accounting for Competition in Site Selection**

	Tuesday	Wednesday	Thursday
8 am			
9 am	ArcGIS Network Analyst - An Introduction	ArcGIS Network Analyst - Automating workflows with Geoprocessing	ArcGIS Network Analyst - Performing Network Analysis
10 am	ArcGIS Network Analyst - Performing Network Analysis	ArcGIS Network Analyst - Creating Network Datasets	
11 am			
12 pm	Patterns for Mapping Access		
1 pm	Modeling Real-World Problems with the VRP Solver		
2 pm		ArcGIS Network Analyst - An Introduction	ArcGIS Network Analyst - Creating Network Datasets
3 pm	Performing Network Analysis with ArcGIS Server	ArcGIS Network Analyst – Routing Inside Buildings With 3D Networks	Room 3 / Room 9 / Room 6B / Spatial Analyst Island Demo Theater / Mapping and Visualization Island Demo Theater
4 pm	What is Network Analyst?	ArcGIS Network Analyst – Location-Allocation in site selection	

Online Survey

- **www.esri.com/sessionevals**

Questions?