



Esri International User Conference | San Diego, CA
Technical Workshops | July 12, 2011

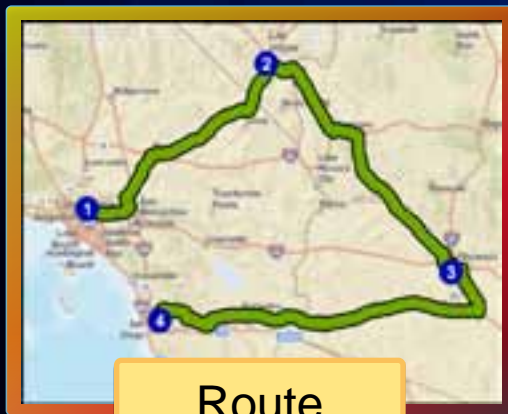
Network Analyst: Performing Network Analysis

Jay Sandhu

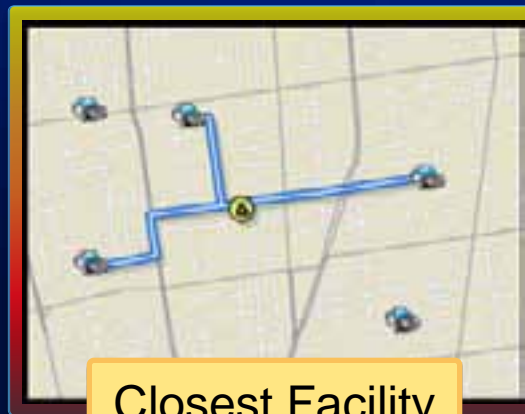
Deelesh Mandloi

Goals

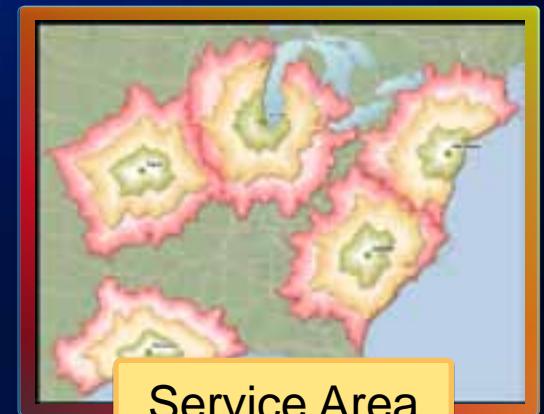
- **We assume you have some familiarity with ArcGIS Network Analyst**
- **We describe the capabilities of the solvers and will demonstrate them with several practical examples**
- **Areas of focus are:**
 - **Choosing the right solver**
 - **Configuring solvers for effective results**



Route



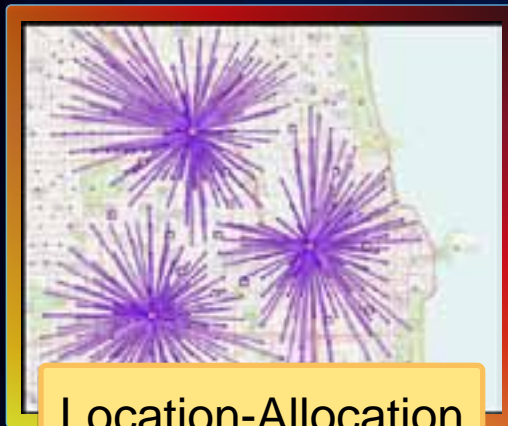
Closest Facility



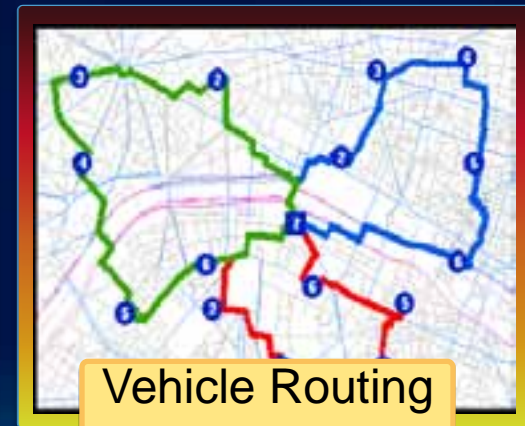
Service Area

ArcGIS Network Analyst Extension

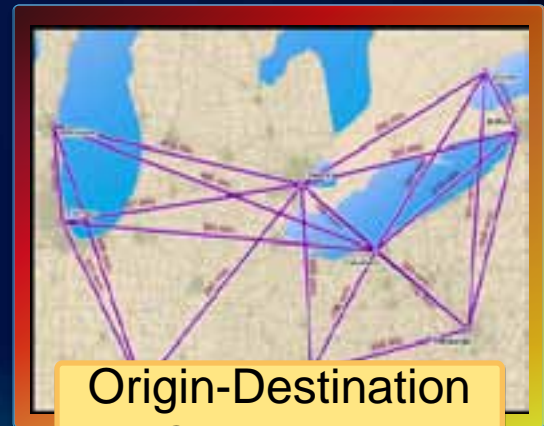
Solving transportation problems



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

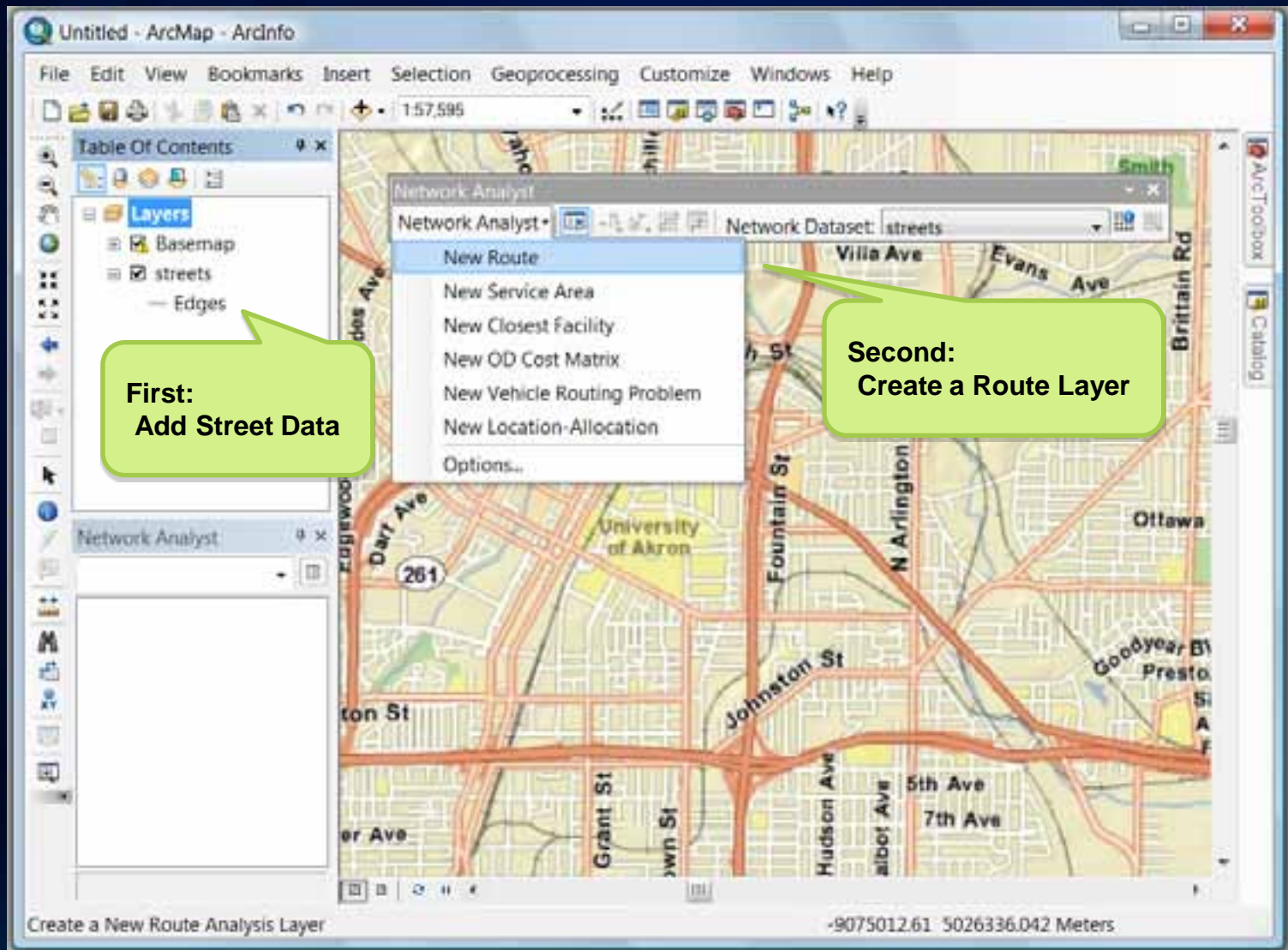
- Your data



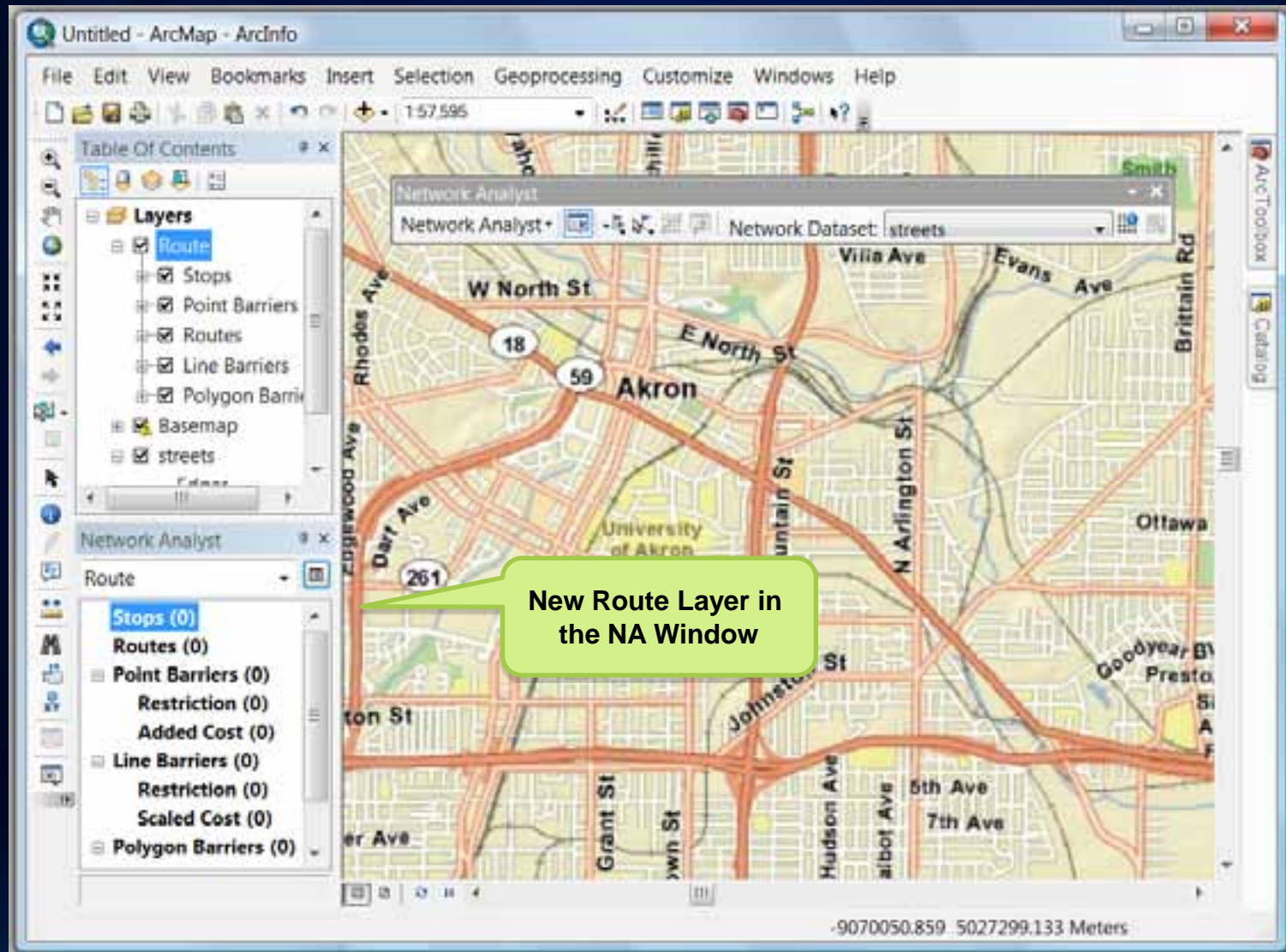
- Vendor data



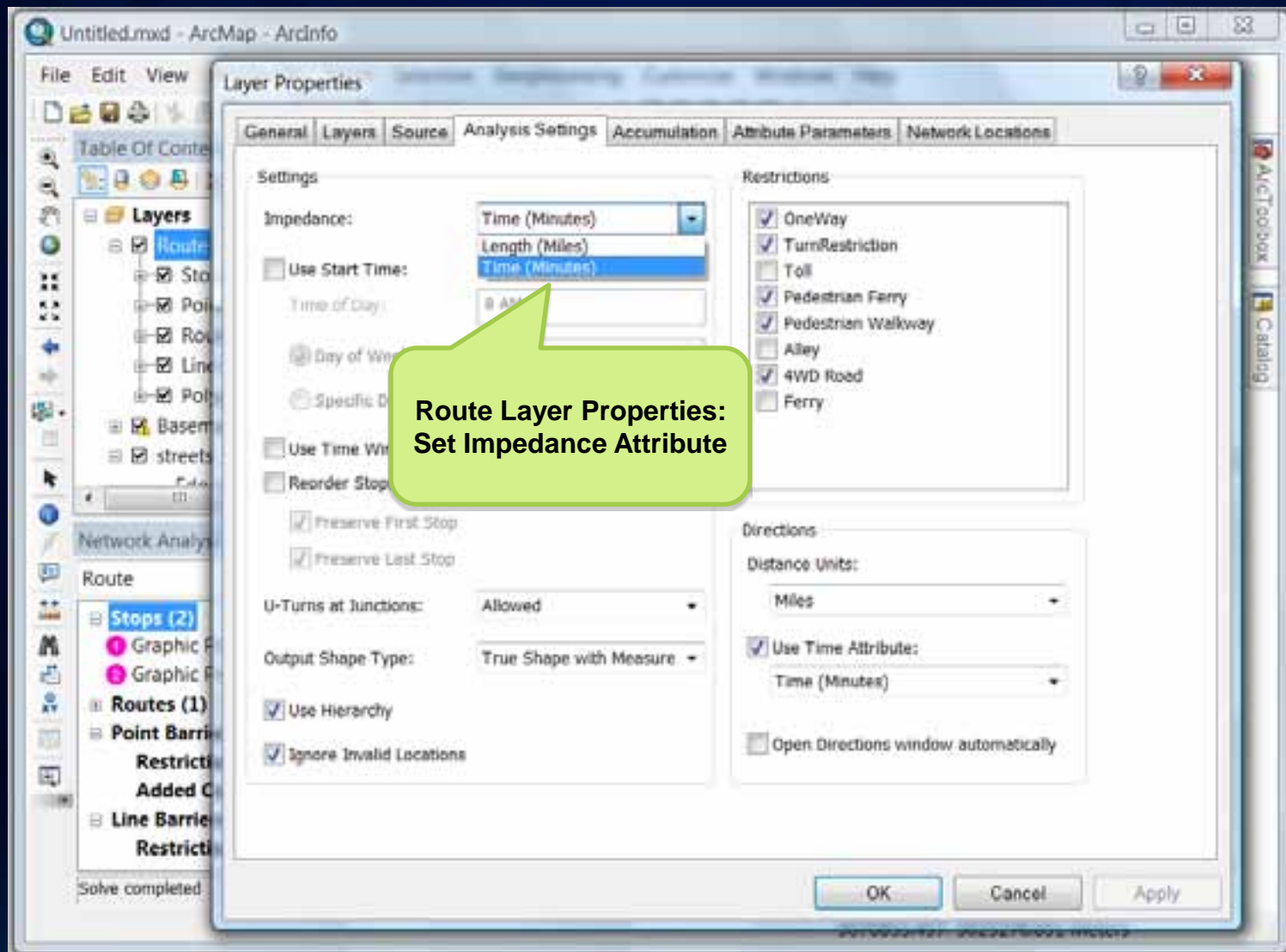
Network Analyst Workflow



Network Analyst – Creating a Route NA Layer



Network Analyst – Setting Analysis Properties



Network Analyst – Load Locations

The image shows the 'Load Locations' dialog box in the Network Analyst tool. The 'Load From' dropdown is set to 'Stores'. The 'Only show point layers' checkbox is checked. The 'Sort Field' dropdown is empty. The 'Location Analysis Properties' table lists various properties and their default values. The 'Location Position' section has 'Use Geometry' selected. The 'Search Tolerance' dropdown is set to '0'. The 'Use Network Location Fields' section is currently empty. The 'Advanced...' button is at the bottom left, and 'OK' and 'Cancel' buttons are at the bottom right.

Location Analysis Properties

Property	Field	Default Value
Name	NAME	
RouteName		
TimeWindowStart		
TimeWindowEnd		
CurbApproach		Either side of vehicle
Attr_Length		0
Attr_Time	ServiceTime	0

Location Position

☒ Use Geometry

Search Tolerance: 0

☐ Use Network Location Fields

Use Network Location Fields

Property	Field
SourceID	
SourceOID	
PosAlong	
SideOfEdge	

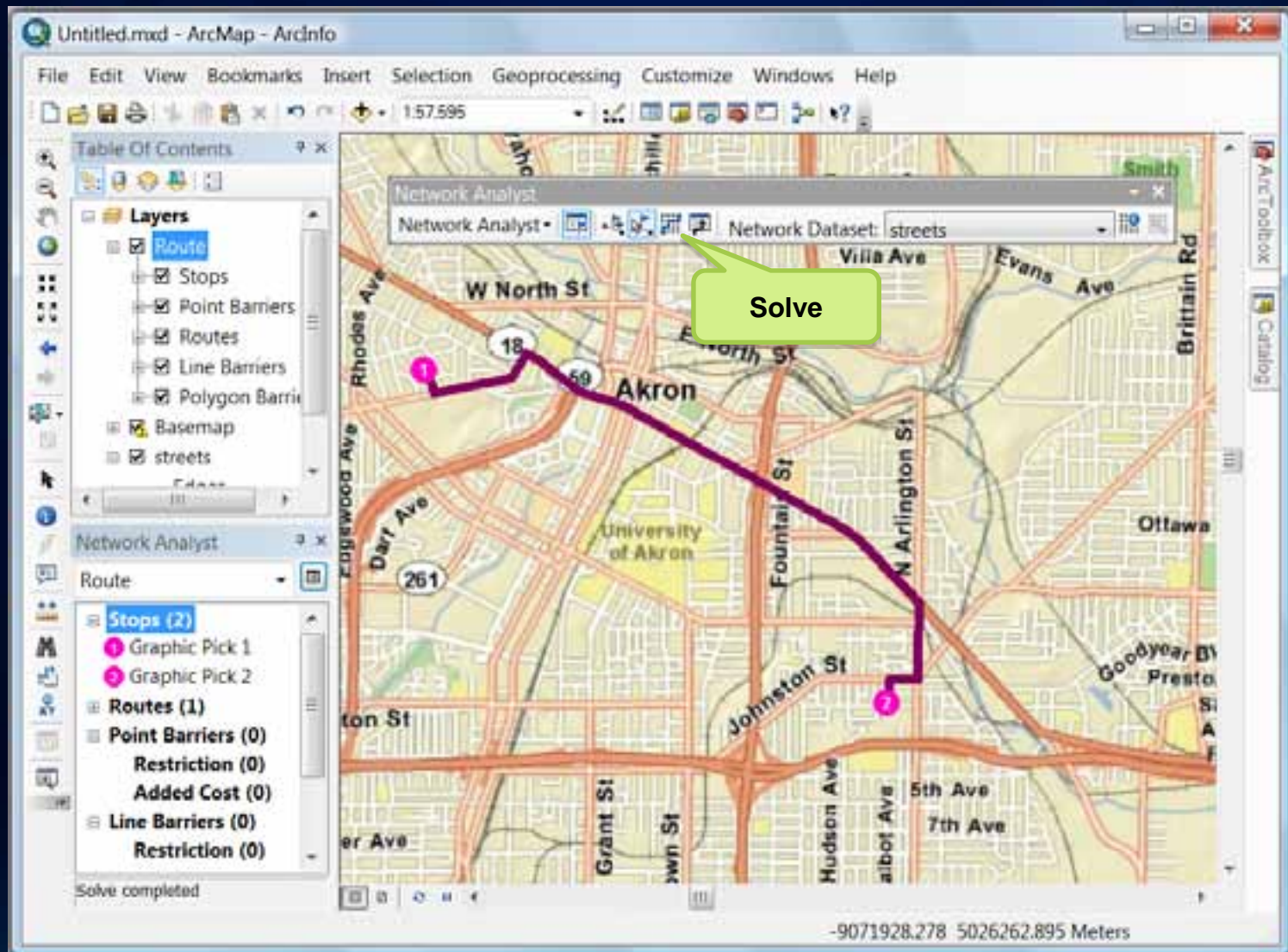
Context Menu:

- Cut
- Copy
- Paste
- Delete
- Delete All
- Selection
- Open Attribute Table
- Export Data...
- Zoom To Layer
- Find Address...
- Load Locations...**
- Recalculate Location Fields
- Properties...

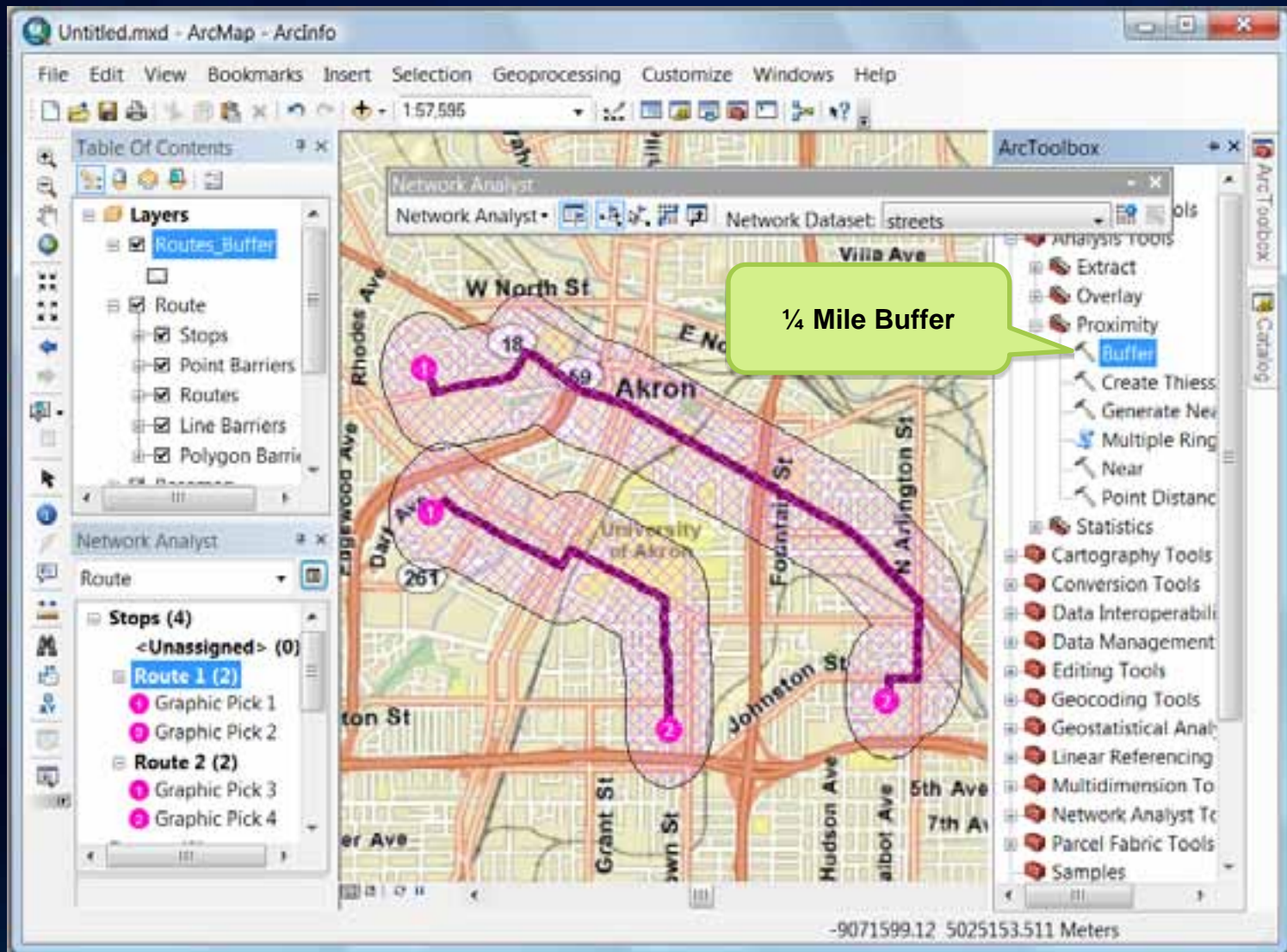
Annotations:

- Add more fields such as ID's to NA sub-layers and map them here** (points to the 'Load Locations...' menu item)
- Map fields to load additional attributes** (points to the 'Use Network Location Fields' section)

Network Analyst – Solving a Route



Network Analyst – Analyze the results



Common Workflow – With Load Locations

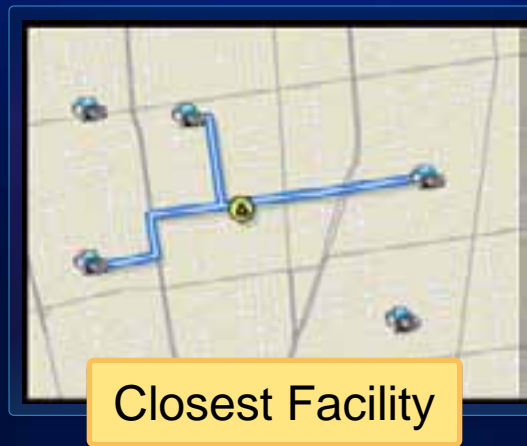
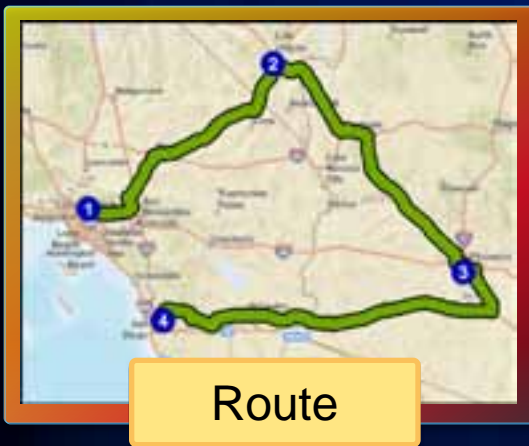
- Use Calculate Location tool to pre-compute network locations for faster load of locations
 - Can also exclude locating on restricted elements
 - Use SQL Where clause for more control on where to locate locations such as avoid freeway ramps
- Use the **1** key to see where a point is located on a network.
- 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)

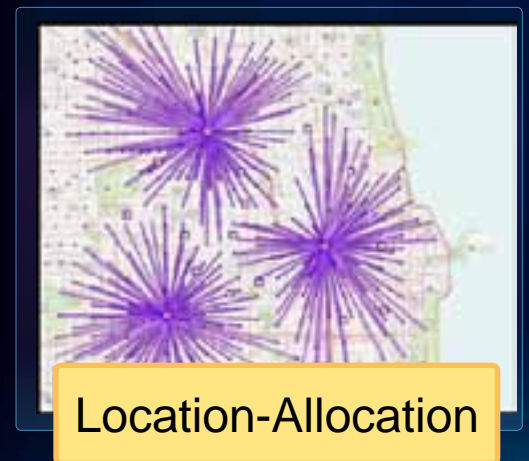
Network Analyst Traversal results

- **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**



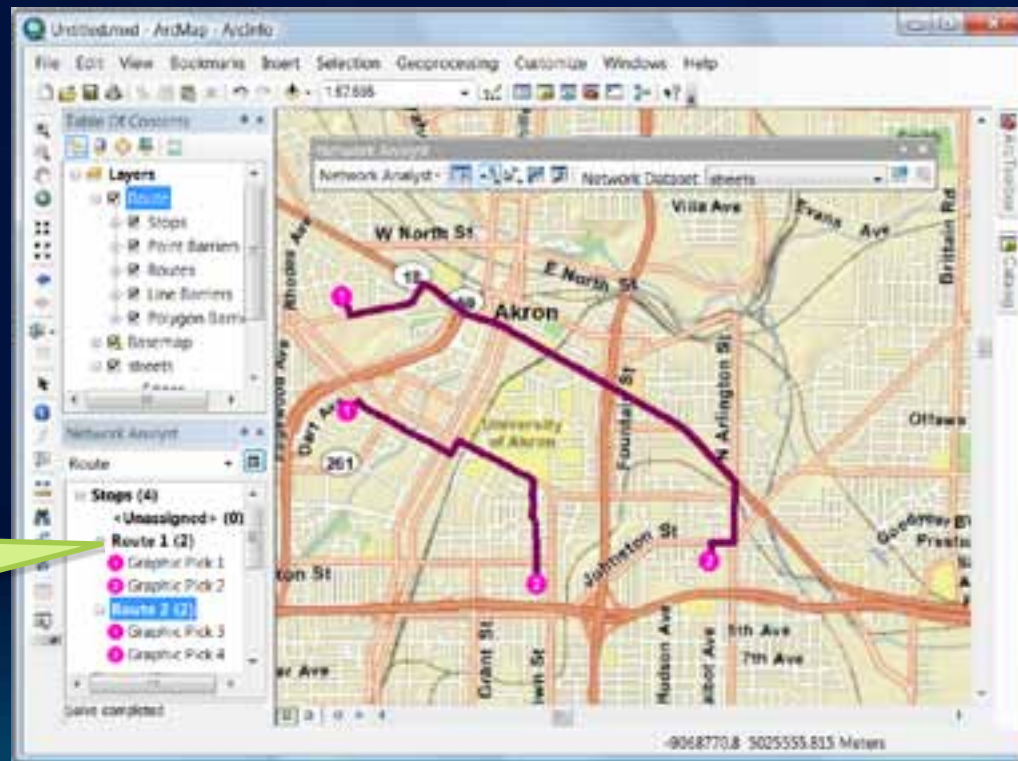
ArcGIS Network Analyst Extension

Solving transportation problems



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



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

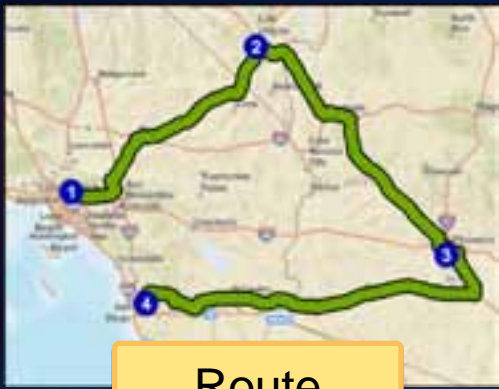
- Also called the Travelling Salesperson Problem
 - Use when you have a single vehicle or person that needs to visit a set of discrete locations in the shortest sequence



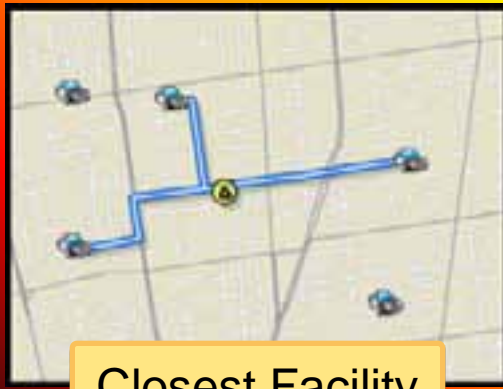
Route Demo

Mileage summary by State

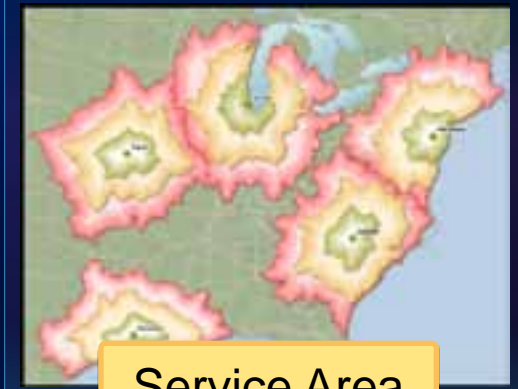




Route



Closest Facility



Service Area

ArcGIS Network Analyst Extension

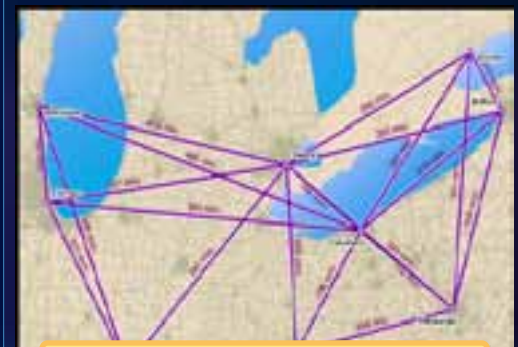
Solving transportation problems



Location-Allocation



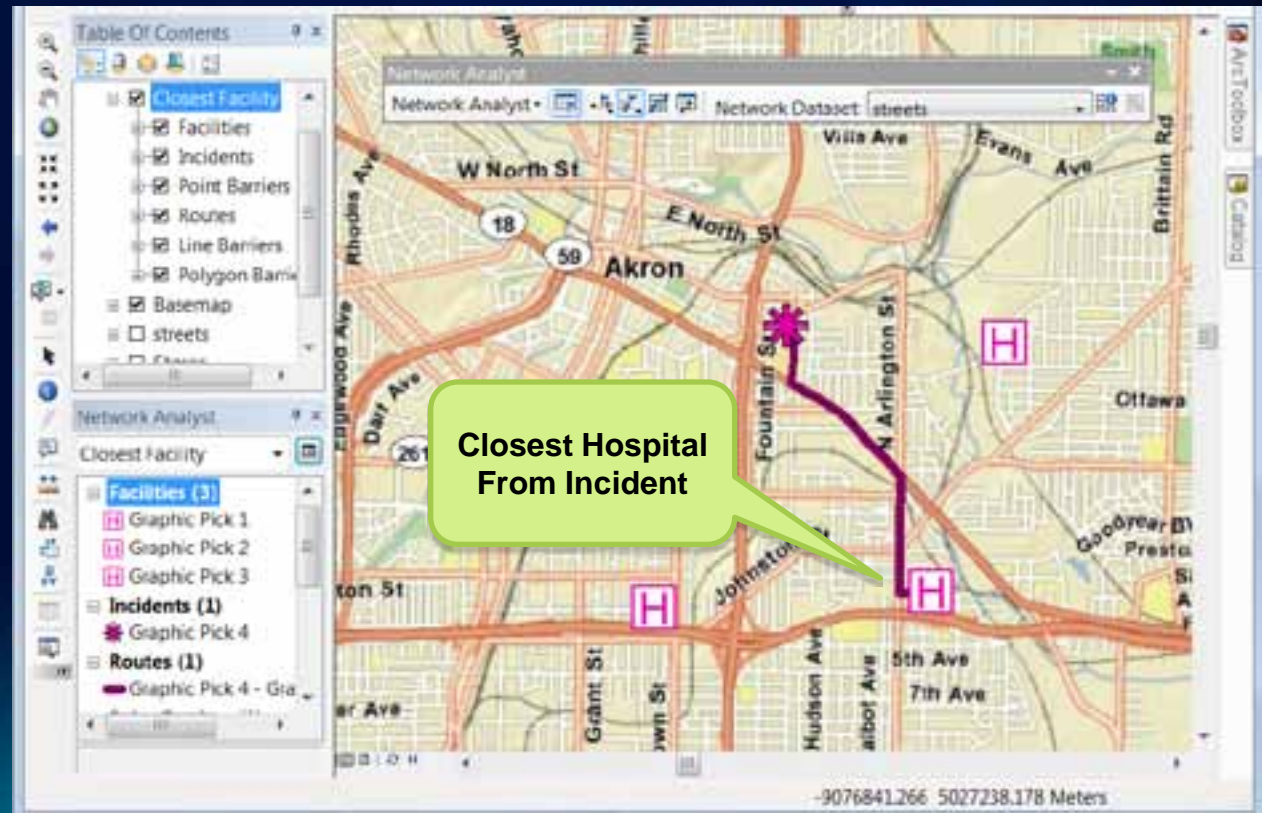
Vehicle Routing Problem



Origin-Destination Cost Matrix

Closest Facility – Typical Applications

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



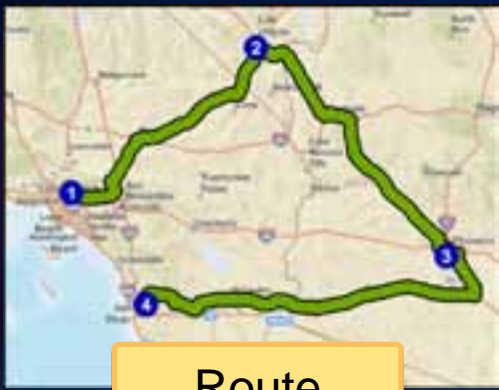
Closest Facility

- **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

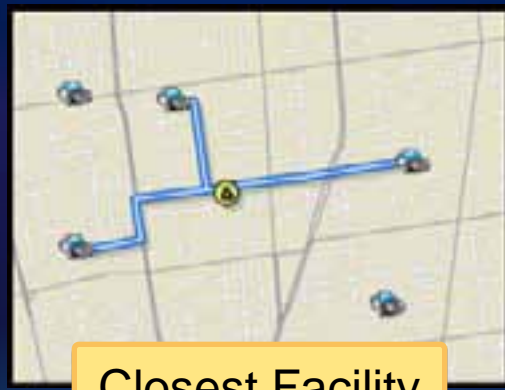
Closest Facility Demo

Most traversed streets





Route



Closest Facility



Service Area

ArcGIS Network Analyst Extension

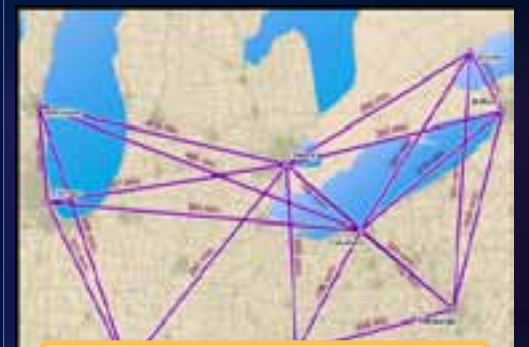
Solving transportation problems



Location-Allocation



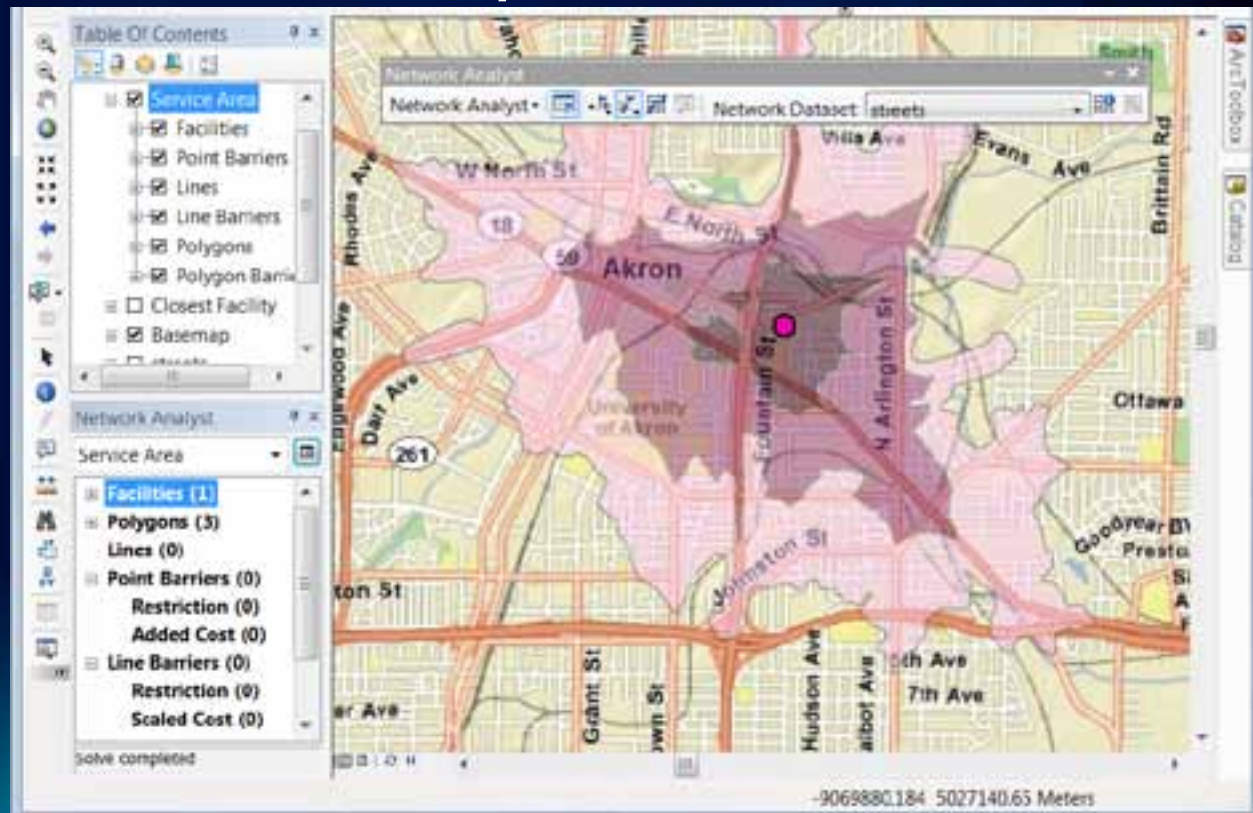
Vehicle Routing Problem



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

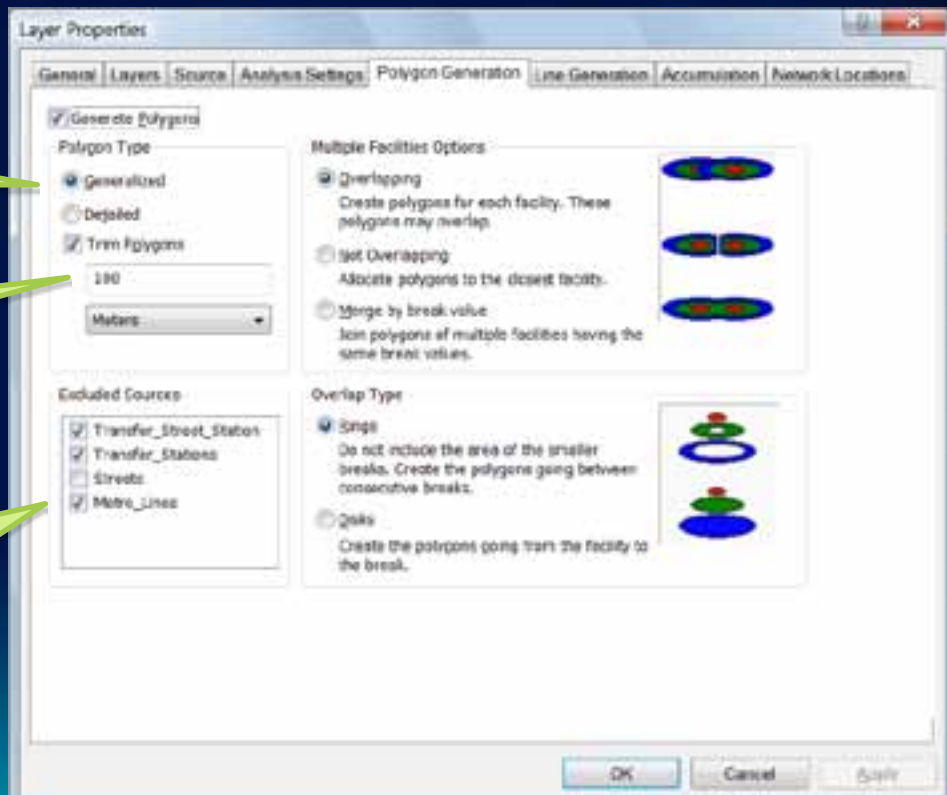
Service Area

- 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

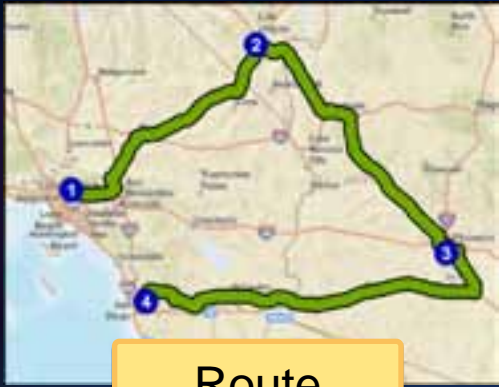
- **Use Lines options to check the connectivity in the network**
- **Makes very appealing visuals on a map**
- **For larger service areas, use a thinned out network with only the major streets**
- **For large number of facilities use chunking**
 - **Enabled via registry keys/details on online KB article**

Service Area Demo

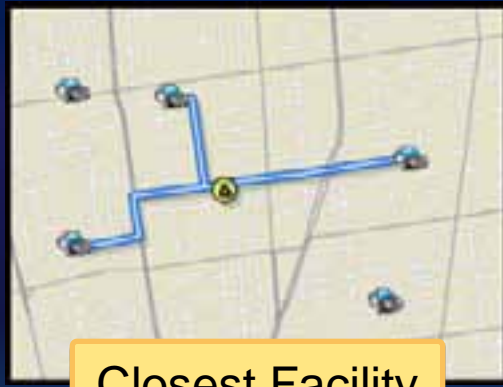
Demographic summary

Ad Placement

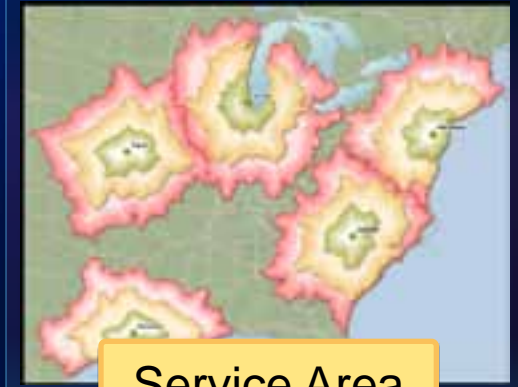




Route



Closest Facility



Service Area

ArcGIS Network Analyst Extension

Solving transportation problems



Location-Allocation



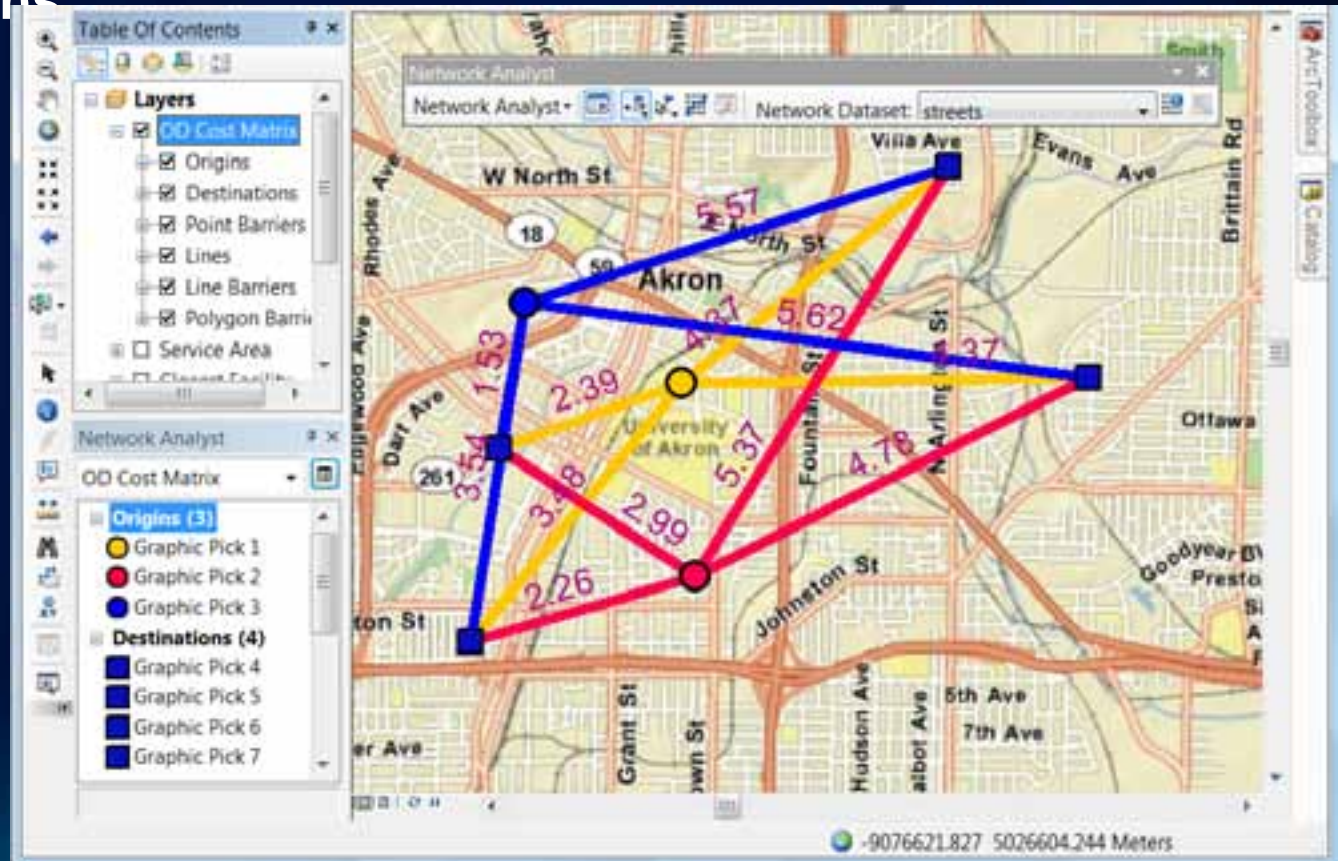
Vehicle Routing Problem



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
 - [Deeleesh's Allocation Tools on Resource Center](#)

Origin-Destination Cost Matrix

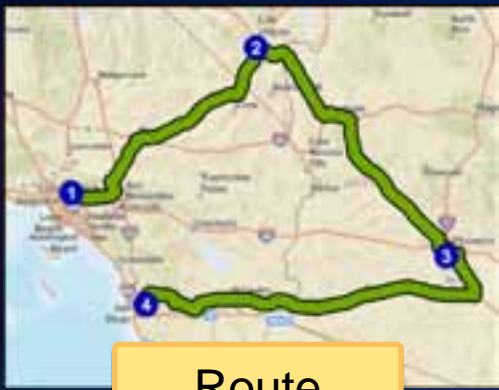
- **Tips on effective use:**
 - **Use hierarchy only for large distances (~30 miles)**
 - **Set a reasonable cutoff**
 - **Do not solve as the active analysis layer (use GP)**
 - **Use ArcObjects for very large OD with no output lines**
 - **Use 64 bit OS which allows ArcGIS 10 to use 4 GB of RAM**

OD Cost Matrix Demo

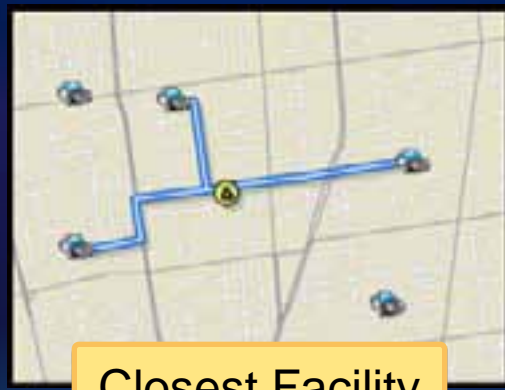
Accumulate Attributes

School Allocation

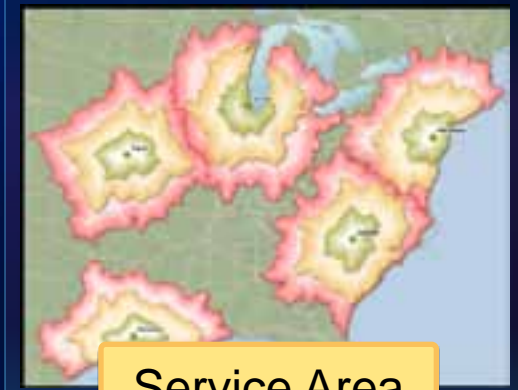




Route



Closest Facility



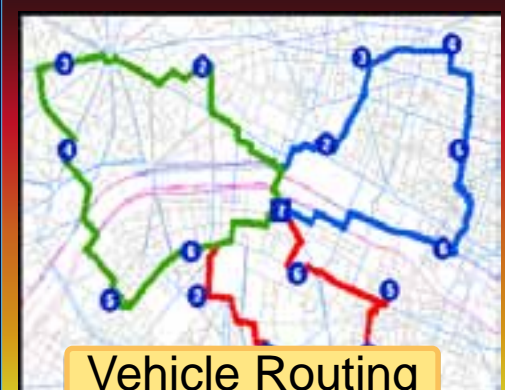
Service Area

ArcGIS Network Analyst Extension

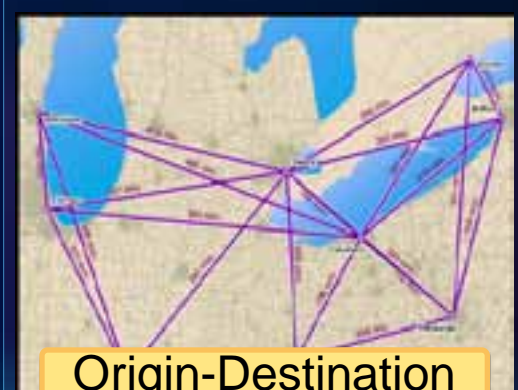
Solving transportation problems



Location-Allocation



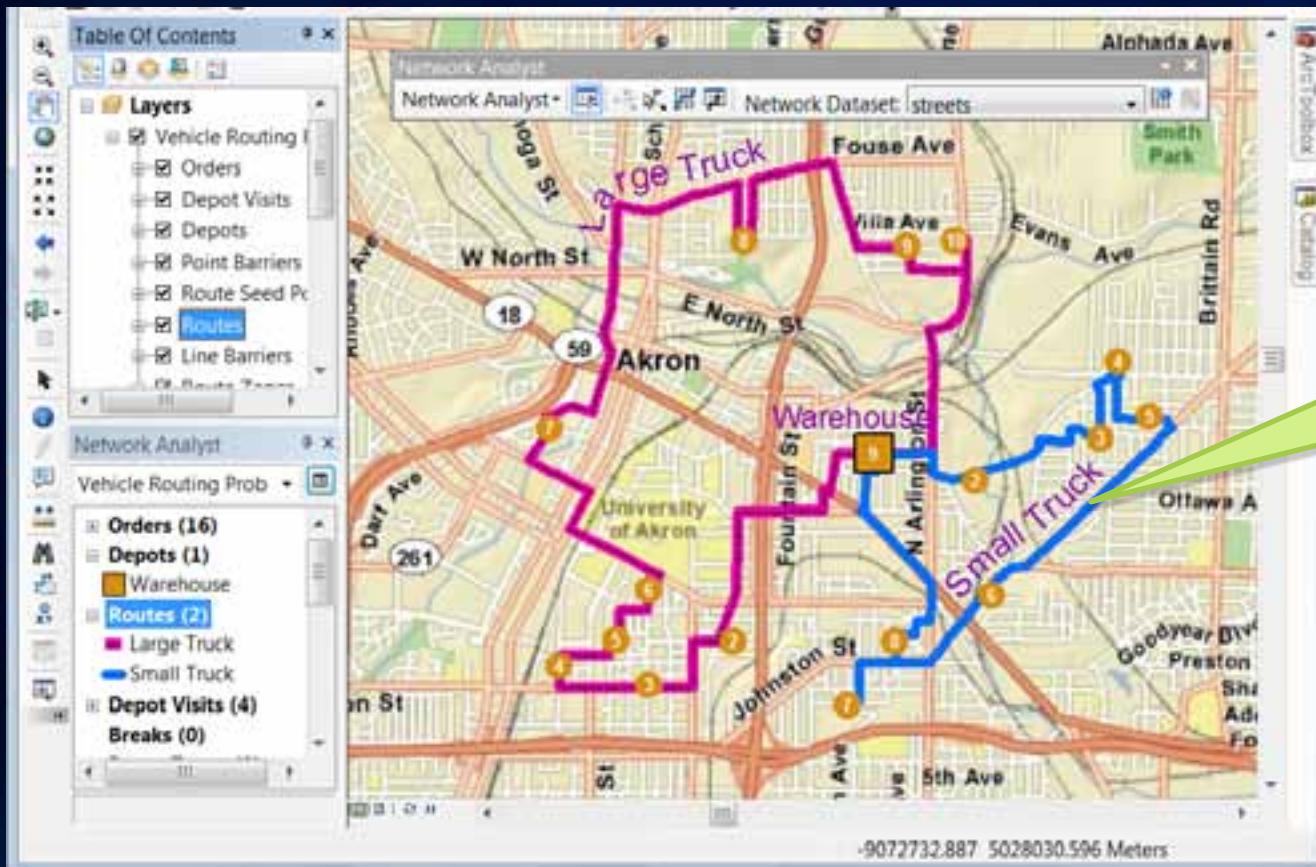
Vehicle Routing Problem



Origin-Destination Cost Matrix

Vehicle Routing Problem

- This is not the simple Travelling Salesperson Problem!

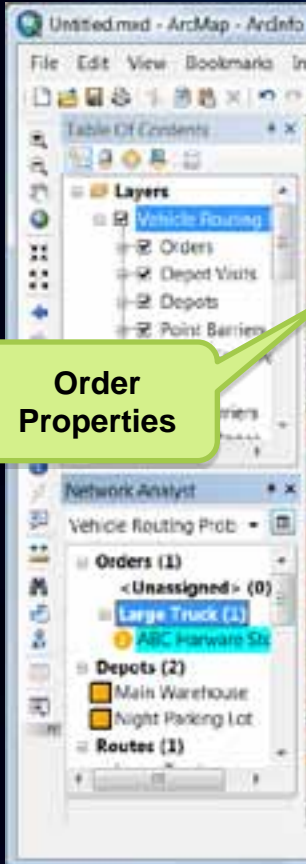


Multiple Vehicles
with different
capacities

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



Attribute	Value
ObjectID	1
Name	ABC Hardware Store
RouteName	Large Truck
Sequence	2
Description	Four boxes of christmas lights
ServiceTime	0.5
TimeWindowStart1	10:30:00 AM
TimeWindowEnd1	11:30:00 AM
TimeWindowStart2	<Null>
TimeWindowEnd2	<Null>
MaxViolationTime1	0.5
MaxViolationTime2	<Null>
DeliveryQuantities	4
PickupQuantities	<Null>
Revenue	<Null>
SpecialtyNames	<Null>
AssignmentRule	Override
SourceID	SDC Edge Source
SourceOID	26127604
PosAlong	0.557154
SideOfEdge	Right Side
CurbApproach	Either side of vehicle
Status	OK
ViolatedConstraints	<Null>
FromPrevTravelTime	6.459101
FromPrevDistance	0
CumulTravelTime	6.459101
CumulDistance	0
CumulTime	60.5
ArriveCurbApproach	Either side of vehicle
DepartCurbApproach	Either side of vehicle
ArriveTime	7/8/2010 9:51:28 AM
DepartTime	7/8/2010 10:30:38 AM
WaitTime	38.540899
ViolationTime	0
CumuWaitTime	38.540899
CumuViolationTime	0

Warehouse Properties

Attribute	Value
ObjectID	1
Name	Main Warehouse
Description	Hardware Warehouse
TimeWindowStart1	7:00:00 AM
TimeWindowEnd1	6:00:00 PM
TimeWindowStart2	<Null>
TimeWindowEnd2	<Null>
SourceID	SDC Edge Source
SourceOID	26127661
PosAlong	0.249967
SideOfEdge	
CurbApproach	
Status	

Route/Driver Properties



Attribute	Value
ObjectID	1
Name	Large Truck
Description	Ron Smith
StartDepotName	Main Warehouse
EndDepotName	Night Parking Lot
StartDepotServiceTime	15
EndDepotServiceTime	10
EarliestStartTime	7:30:00 AM
LatestStartTime	9:30:00 AM
ArriveDepartDelay	5
Capacities	30
FixedCost	40
CostPerUnitTime	0.5
CostPerUnitDistance	<Null>
OvertimeStartTime	480
CostPerUnitOvertime	0.75
MaxOrderCount	30
MaxTotalTime	<Null>
MaxTotalTravelTime	<Null>
MaxTotalDistance	<Null>
SpecialtyNames	<Null>
AssignmentRule	Include
ViolatedConstraints	<Null>
OrderCount	1
TotalCost	76.208368
RegularTimeCost	36.208368
OvertimeCost	0
DistanceCost	0
TotalTime	76.416736
TotalOrderServiceTime	0.5
TotalBreakServiceTime	0
TotalTravelTime	12.375837
TotalDistance	0
StartTime	7/8/2010 9:38:00 AM
EndTime	7/8/2010 10:46:25 AM
TotalWaitTime	38.540899
TotalViolationTime	0
RenewalCount	0
TotalRenewalServiceTime	0

Vehicle Routing Problem Capabilities

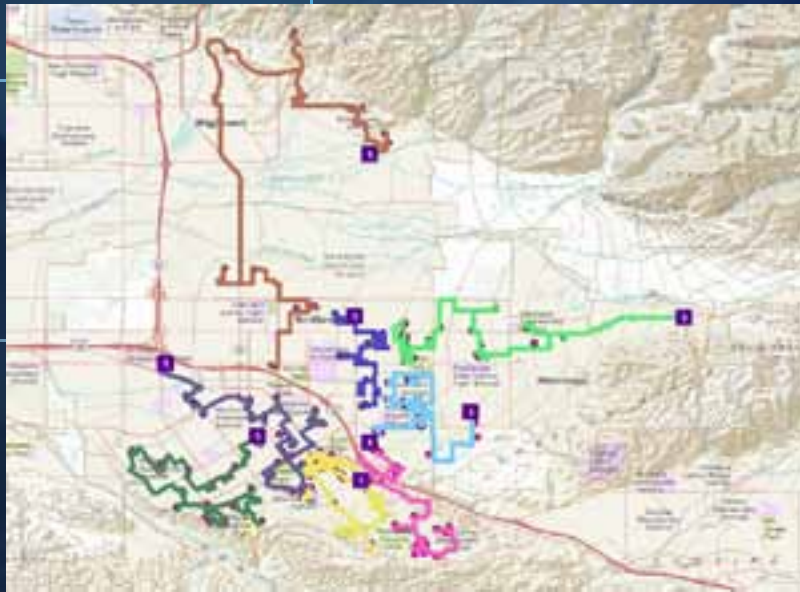
- For more information, see the online help!
- [VRP Online Help](#)

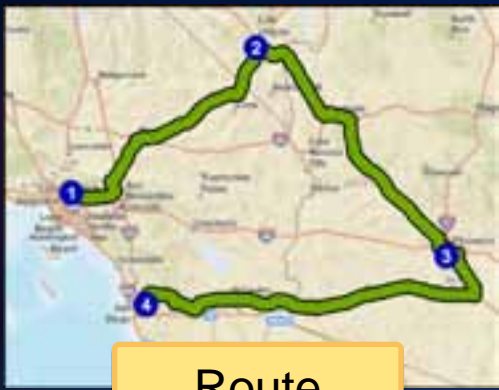
Vehicle Routing Problem Uses

- **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

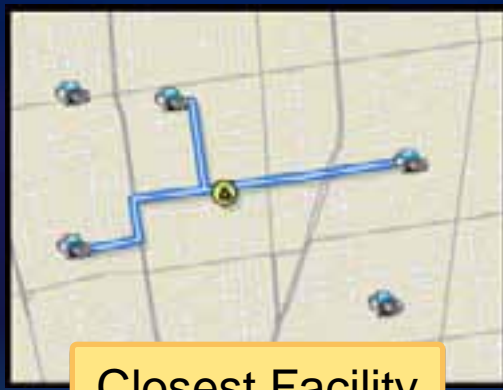
VRP Demo

Flag Fundraiser

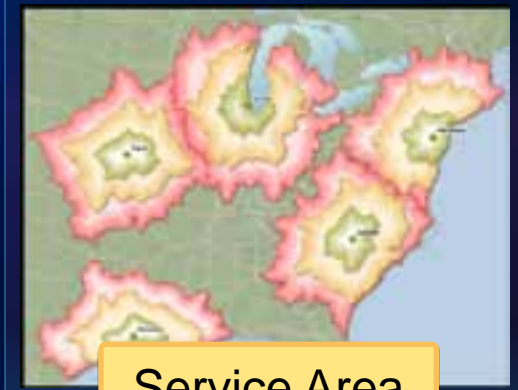




Route



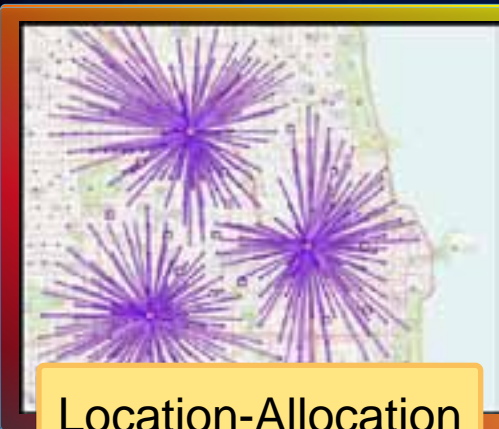
Closest Facility



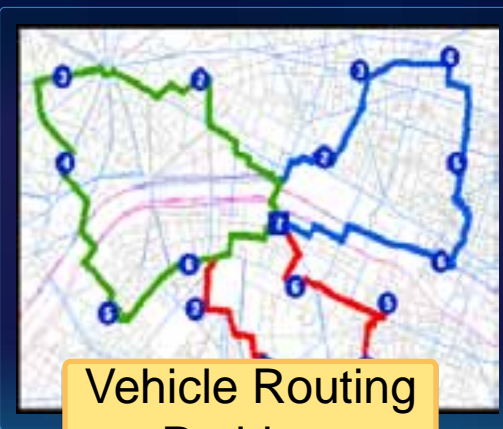
Service Area

ArcGIS Network Analyst Extension

Solving transportation problems



Location-Allocation



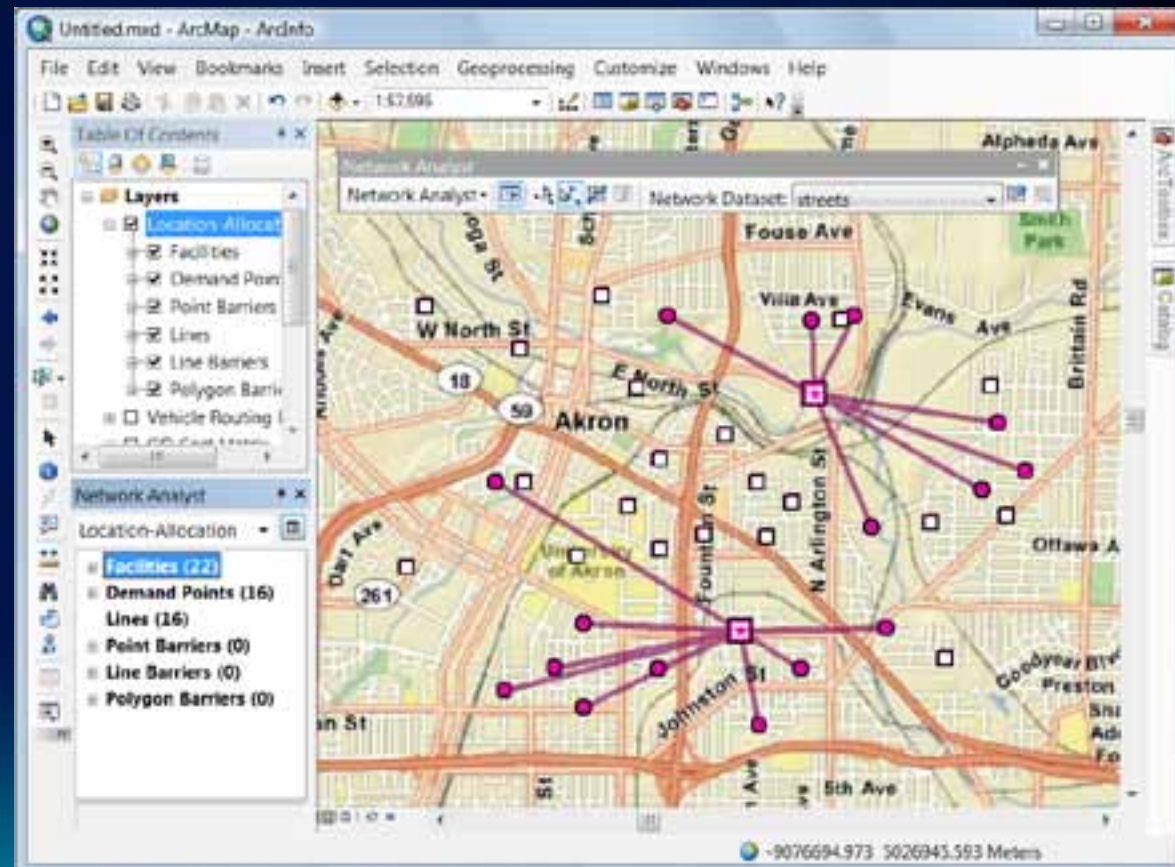
Vehicle Routing Problem



Origin-Destination Cost Matrix

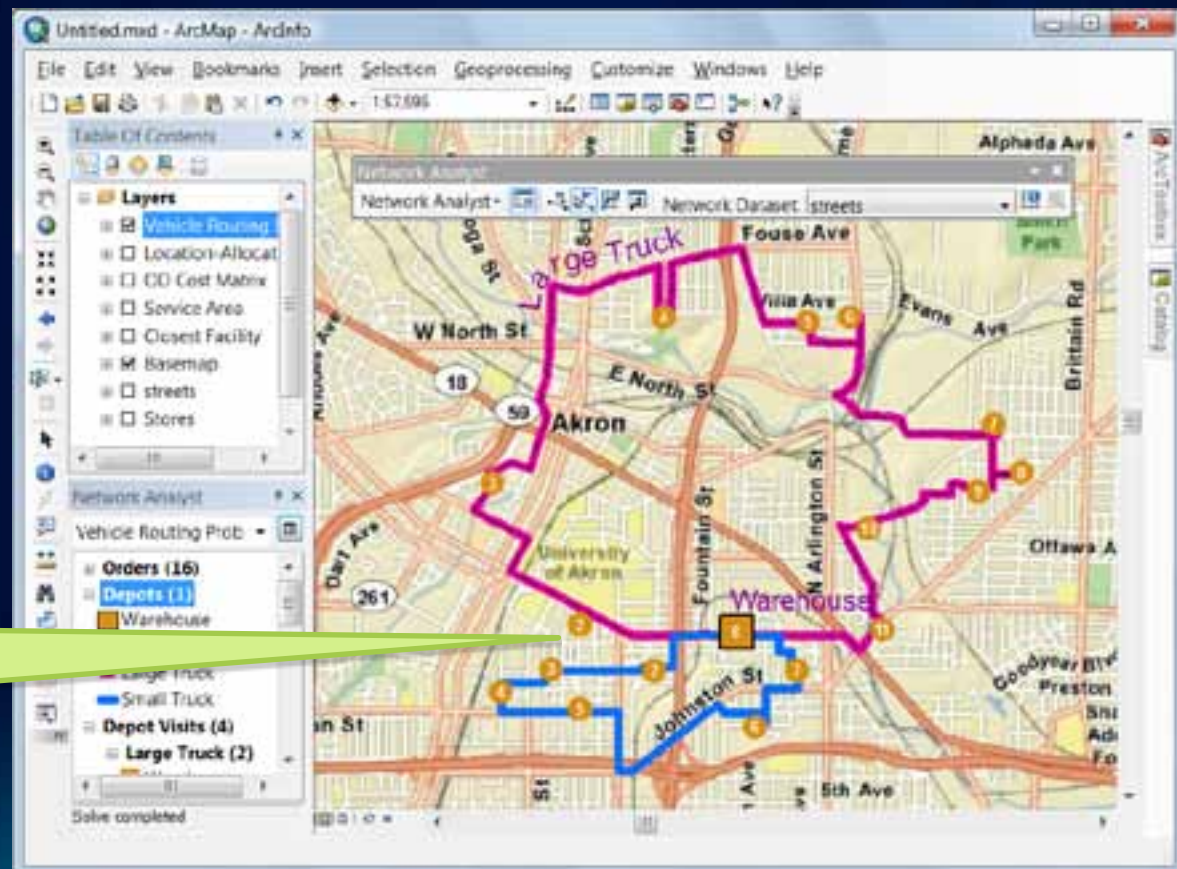
Location-Allocation

- Useful for locating
 - Warehouses
 - Retail Stores
 - Fire Stations



Location-Allocation

- Optimize warehouse location for VRP

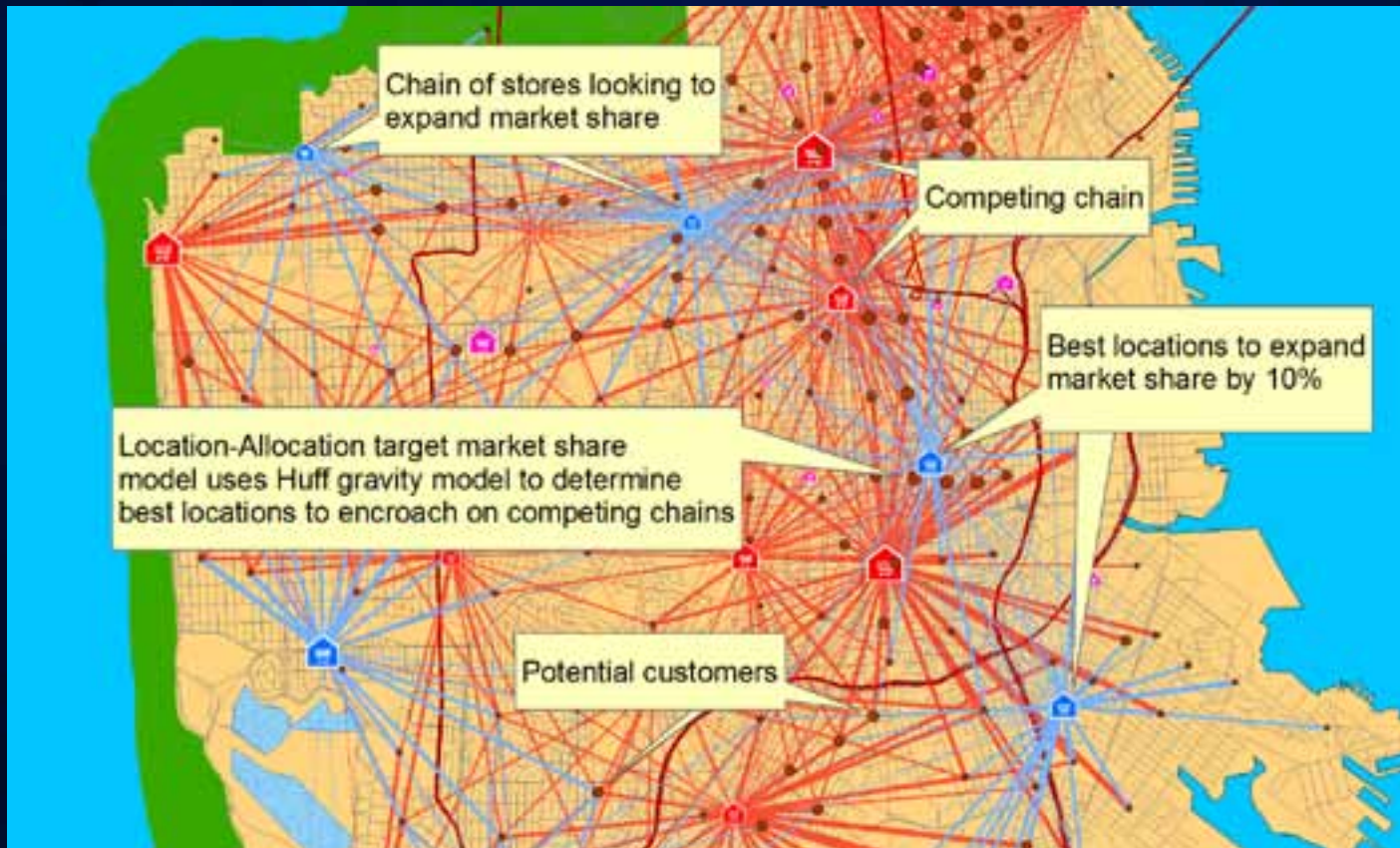


Re-locating Warehouse
Saves five percent fuel

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!**

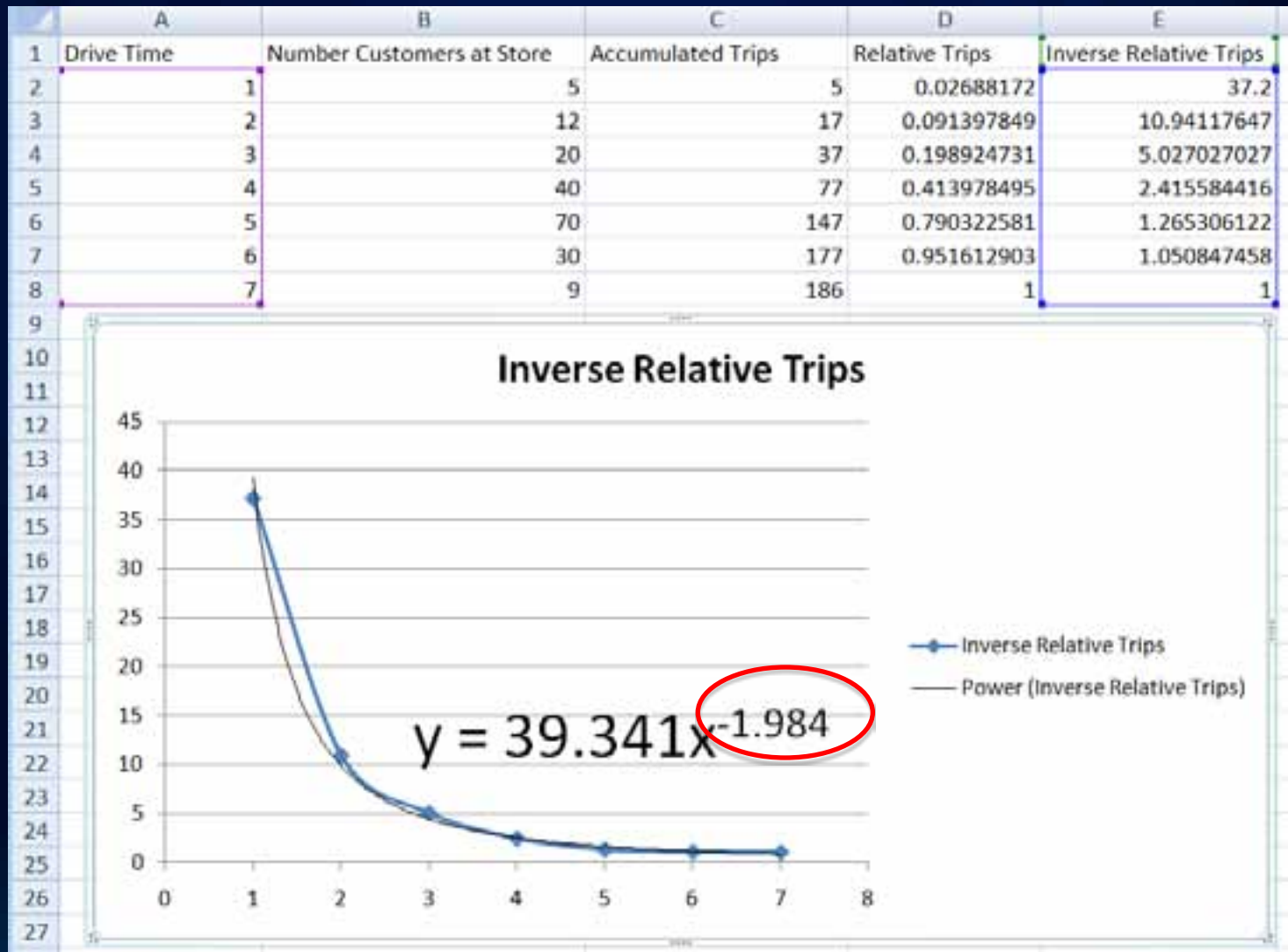
Location-Allocation Gravity Models example



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

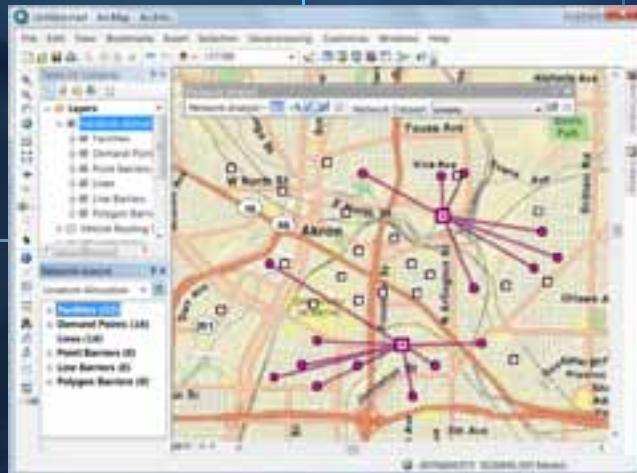


Location-Allocation

- **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**

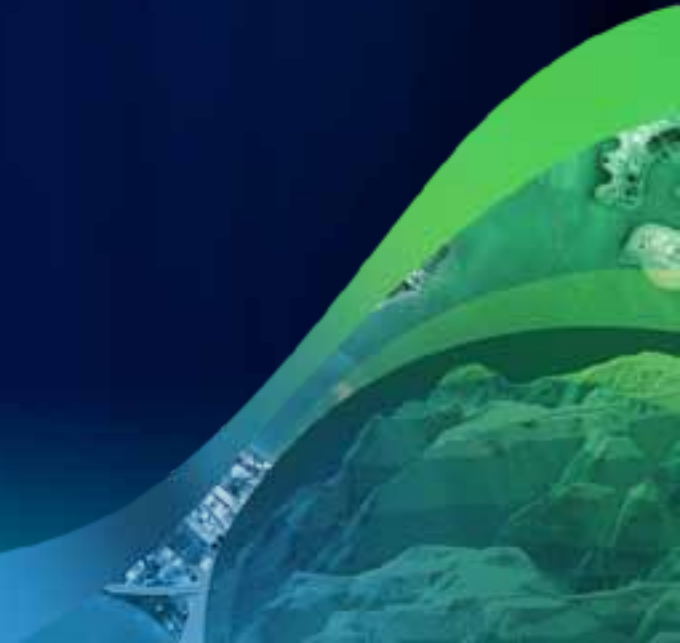
Summary

- **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	
4 pm		What is Network Analyst?	ArcGIS Network Analyst – Location-Allocation in site selection		Spatial Analyst Island Demo Theater	
					Mapping and Visualization Island Demo Theater	

Online Survey

- www.esri.com/sessionevals

Questions?