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Table of Contents

About the ArcGIS Network Analyst tutorial	3
Exercise 1: Creating a network dataset	4
Exercise 2: Creating a multimodal network dataset	13
Exercise 3: Finding the best route using a network dataset	26
Exercise 4: Finding the closest fire stations	34
Exercise 5: Calculating service areas and creating an OD cost matrix	42
Exercise 6: Creating a model for route analysis	59
Exercise 7: Servicing a set of orders with a fleet of vehicles	69
Exercise 8: Finding best routes to service paired orders	89
Exercise 9: Choosing optimal store locations using location-allocation	05

About the ArcGIS Network Analyst tutorial

The ArcGIS Network Analyst extension allows you to build a network dataset and perform analyses on a network dataset. The best way to learn Network Analyst is to use it. In the exercises in this tutorial, you will do the following:

- Use ArcCatalog to create and build a network dataset from feature classes stored within a geodatabase.
- · Define connectivity rules and network attributes for the network dataset.
- Perform various network analyses in ArcMap using the Network Analyst toolbar.
- Learn how to use the Network Analyst geoprocessing tools to create models that automate analyses.

To use this tutorial, you need to have ArcGIS installed with the Network Analyst extension and have the tutorial data installed on a local or shared network drive on your system.

Tutorial data

Ask your system administrator for the correct path to the tutorial data if you do not find it at the default installation path (C:\ArcGIS\ArcTutor\Network Analyst\Tutorial).

In this tutorial

- Exercise 1: Creating a network dataset
- Exercise 2: Creating a multimodal network dataset
- Exercise 3: Finding the best route using a network dataset
- Exercise 4: Finding the closest fire stations
- Exercise 5: Calculating service area and creating an OD cost matrix
- Exercise 6: Creating a model for route analysis
- Exercise 7: Servicing a set of orders with a fleet of vehicles
- Exercise 8: Finding best routes to service a set of paired orders
- Exercise 9: Choosing optimal store sites using location-allocation

Exercise 1: Creating a network dataset

In this exercise, you will create a network dataset in a geodatabase using San Francisco street and turn features. You will also include historical traffic data so you can solve time-dependent routes.

Creating a network dataset

Steps:

- Start ArcCatalog by clicking Start > All Programs > ArcGIS > ArcCatalog 10.
- 2. Enable the Network Analyst extension.
 - a. Click Customize > Extensions. The *Extensions* dialog box opens.
 - b. Check Network Analyst.
 - c. Click Close.
- On the Standard toolbar, click the Connect To Folder button. The Connect to Folder dialog box opens.
- 4. Navigate to the folder with the ArcGIS Network Analyst tutorial data. The default location for the tutorial data is C:\ArcGIS\ArcTutor\Network Analyst\Tutorial
- 5. Click OK.

A shortcut to the folder is added to the Catalog Tree under Folder Connections.



- 6. In the *Catalog Tree*, expand ...\ArcTutor\Network Analyst\Tutorial > Exercise01 > SanFrancisco.gdb.
- Click the Transportation feature dataset.
 The feature classes the feature dataset contains are listed on the Contents tab of ArcCatalog.
- 8. Right-click the Transportation feature dataset and click New > Network Dataset.

Complexity: Beginner

Data Requirement: ArcGIS Tutorial Data Setup

Data Path: C:\ArcGIS\ArcTutor\Network Analyst\Tutorial\Exercise01

Goal:

To create a network dataset from a streets feature class in a geodatabase

Catalog Tree		Ψ×				
Folder Connections Carcgis/ArcTutor/Networ Carcgis/ArcTutor/Networ SaFrancisco.gdt Gargarancisco.gdt Gargarancisco.gdt)				1	
DailyProfiles	ii)	Copy Paste	Ctrl+C Ctrl+V			
 Streets_Dailyf Exercise02 Paris.gdb SanFrancisco.gdb Exercise03.mxd 	×	Delete Rename Refresh Analyze	F2			
Exercise04.mxd Exercise05.mxd Exercise06.mxd Exercise06.mxd		New Import		•	- 목	Feature Class Relationship Class
Exercise07.mxd		Export		,	-	Terrain
- 4 -			Geodatabase		끮	Network Dataset
		Uncompress Fi	ile Geodatabase al Reference		23 FI	Topology Parcel Fabric
		Add Global IDs.			đ	Geometric Network
	2	Properties		_		

The New Network Dataset wizard opens.

- Note: To open the New Network Dataset wizard in a geodatabase, you right-click the feature dataset that contains the source feature classes (Streets, for example) and choose New > Network Dataset. For a shapefile-based network dataset, you right-click the Streets shapefile itself—not the workspace that contains the shapefile—and choose New > Network Dataset. The reason for the difference is that geodatabase networks allow you to use multiple sources that are stored in the feature dataset to create a multimodal network, while shapefile-based network datasets are only capable of handling a single source feature class.
- 9. Type Streets ND for the name of the network dataset.

New Network Dataset	2 🔀
This wizard will help you build a network dataset. A network dataset is built from feature classes which act as network sources and have a connectivity policy and attributes associated with them.	
Enter a name for your network dataset:	
Streets_ND	
< Back Next >	Cancel

- 10. Click Next.
- 11. Check the **Streets** feature class to use it as a source for the network dataset.

- 12. Click Next.
- 13. Click Yes to model turns in the network.
- 14. Check **<Global Turns>**, which enables you to add default turn penalties, and check **RestrictedTurns** to select it as a turn feature source.

New Network Dataset	?
Do you want to model turns in this network?	
© N <u>e</u>	
● Yes	
Tum Sources:	
ସradional Turns> I RestrictedTurns	
< Back Next >	Cancel

- 15. Click Next.
- 16. Click Connectivity.

The Connectivity dialog box opens. Here you can set up the connectivity model for the network.

For this Streets feature class, all streets connect to each other at endpoints.

- 17. Make sure that the connectivity policy of **Streets** is set to **End Point**.
- 18. Click **OK** to return to the **New Network Dataset** wizard.
- 19. Click Next.
- 20. This dataset has elevation fields, so make sure that the **Using Elevation Fields** option is chosen.

Elevation settings in a network dataset further defines connectivity. To understand why, assume two edges have coincident endpoints in X and Y space but have different elevations (one endpoint is higher than the other). Furthermore, assume their connectivity policy is set to **Endpoint**. If elevation is ignored, the edges connect. However, if elevation is considered, they won't connect.

There are two ways to model elevations: using true elevation values from geometry or using logical elevation values from elevation fields.

The Streets feature class has logical elevation values stored as integers in the F_ELEV and T_ELEV fields. If two coincident endpoints have field elevation values of 1, for example, the edges will connect. However, if one endpoint has a value of 1, and the other coincident endpoint has a value of 0 (zero), the edges won't connect. ArcGIS Network Analyst recognizes the field names in this dataset and automatically maps them, as shown in the graphic below. (Only integer fields can serve as elevation fields.)

None Using Z Coordinate Value	s from Geometry		
Using Elevation Fields			
Source	End	Field	
Streets	From End	F_ELEV	
Streets	To End	T_ELEV	
Click in the Field column	o set elevation fields		

21. Click Next.

You can configure historical traffic data with this page of the wizard. Traffic data enables you to find the quickest routes based on time and day of the week. For example, the quickest route from point A to point B at 8:30 a.m. on Wednesday (during rush hour) could be different than the quickest route between the same points at 1:00 p.m. on Sunday. Even if the path of the route is the same, the time it takes to reach the destination could vary.

Learn more about historical traffic data

The SanFrancisco geodatabase contains two tables that store historical traffic data: DailyProfiles and Streets_DailyProfiles. The schemata of the tables were designed in such a way that Network Analyst could recognize the role of each table and configure historical traffic automatically.

No	
Yes Historical Traffic Tables:	
Traffic Profiles Table	
Table	DailyProfiles
First Time Slice Field	TimeFactor_0400
Last Time Slice Field	TimeFactor_2155
Minutes Per Time Slice	5
First Time Slice Start Time	4 AM
Last Time Slice Finish Time	10 PM
Streets - Traffic Profiles Join Te	able
Table	Streets_DailyProfiles
Base Travel Time Field	FreeflowMinutes
Base Travel Time Units	Minutes
Sunday ProfileID Field	PROFILE_1
Monday ProfileID Field	PROFILE_2
Tuesday ProfileID Field	PROFILE_3
Wednesday ProfileID Field	PROFILE_4
Thursday ProfileID Field	PROFILE_5
Friday ProfileID Field	PROFILE_6
Saturday ProfileID Field	PROFILE_7

22. Click Next.

0	Name	Usage	Units	Data Type	Add
0	HierarchyMultiNet Meters	Hierarchy Cost	Unknown Meters	Integer Double	Remove
0	Minutes Oneway	Cost Restriction	Minutes Unknown	Double Boolean	Remove All
	RoadClass	Descriptor	Unknown	Integer	Rename
0	WeekdayFallbac		Minutes Minutes	Double Double	Duplicate
	WeekendFallbac	Cost	Minutes	Double	Ranges
					Parameters
					E <u>v</u> aluators

The page for setting network attributes is displayed.

Network attributes are properties of the network that control navigation. Common examples are cost attributes that function as impedances over the network and restriction attributes that prohibit traversal in both directions or one direction, like one-way roads.

ArcGIS Network Analyst analyzes the source feature class (or classes) and looks for common fields like Meters, Minutes (FT_Minutes and TF_Minutes, one for each direction), and Oneway. If it finds these fields, it automatically creates the corresponding network attributes and assigns the respective fields to them. (This can be viewed by clicking **Evaluators**.)

Network Analyst automatically sets up eight attributes for this San Francisco data: HierarchyMultiNet, Meters, Minutes, Oneway, RoadClass, TravelTime,

WeekdayFallbackTravelTime, and WeekendFallbackTravelTime. It also assigns evaluators to the attributes.

23. Click the **Meters** row to select it, then click **Evaluators** to examine how the values of network attributes are determined.

Eva	luator	rs						? 🔀
Att	ribute:	Me	eters		•			
ſ		e Values: ce Values	Default Values					
	!	Source		Direction	Element	Туре	Value	
		Streets Streets Restrict		From-To To-From	Edge Edge Turn	Field Field	METERS METERS	
							OK Cancel	Apply

The *Evaluators* dialog box opens.

The table on the **Source Values** tab lists the source feature classes. Linear source feature classes, which become edge elements in the network dataset, are listed twice; once for the from–to direction and once for the to–from direction. (The directions are in relation to the digitized direction of the source line feature.) The **Type** column shows the type of evaluator used to calculate the network attribute values. The **Value** column holds information the evaluator needs to calculate attribute values.

- 24. From the **Attribute** drop-down list, click each type of attribute, one at a time, and inspect the evaluator types and values for the source feature classes.
- 25. Click OK to return to the New Network Dataset wizard.

In the next steps, you will add a new attribute to restrict movement over the turn elements created from the RestrictedTurns feature class.

- 26. Click Add. The Add New Attribute dialog box opens.
- 27. Type RestrictedTurns in the Name field.
- 28. For Usage Type, choose Restriction.

Note that **Use by Default** is checked. This restriction will be used by default when a new network analysis layer is created. If you want to ignore the restriction when performing an analysis, you can disable it in the settings of the analysis.

Add New Attrib	ute		2 💌
Name:	RestrictedTurns		ОК
Usage Type:	Restriction	-	Cancel
<u>U</u> nits:	Unknown	Ŧ	
Data Type:	Boolean	Ŧ	
	Vise by Default		

29. Click OK.

The new attribute, RestrictedTurns, is added to the list of attributes. The blue circle with the D in the middle indicates the attribute is enabled by default in new analyses.

- 30. Click Evaluators to assign values by source to the new attribute.
- Follow these substeps to set the type of evaluator for RestrictedTurns to Constant with a value of Restricted.
 - a. Click the Attribute drop-down list and choose RestrictedTurns.
 - b. For the **RestrictedTurns** row, click under the **Type** column and choose **Constant** from the drop-down list.
 - c. Click the **Value** column and choose **Restricted**. The result should look like the following graphic:

nbute \	Values:					
ource	Values Default Value	5				
! :	Source	Direction	Element	Туре	Value	
	Streets Streets	From-To To-From	Edge Edge			×
1 I I I	RestrictedTurns		Turn	Constant	Restricted	. 🖻

The evaluators for the street sources are empty, so they will remain traversable when this restriction is used.

- 32. Click OK to return to the New Network Dataset wizard.
- 33. Right-click the HierarchyMultiNet row and choose Use By Default. The blue symbol is removed from the attribute. This means the hierarchy won't be used by default when an analysis layer is created with this network dataset.
- 34. Click Next.
- 35. Click Yes to set up directions.

New Network Dataset	2 💌
Do you want to establish driving directions settings for this network dataset?	
© No	
Yes	
You can use the default Directions settings or you can click the Directions button below to specify the settings. You can change the direction settings now, or you can change them after the network dataset has been created.	
Directions	
< Back Next >	Cancel

36. Click Directions.

The Network Directions Properties dialog box opens.

Now you will specify the fields used to report directions for network analysis results.

37. On the **General** tab, make sure that the **Name** field for the **Primary** row automatically mapped to **NAME**.

The NAME field contains the San Francisco street names, which are needed to help generate driving directions.

The result should look like the following graphic:

Display	Length Units	Miles					
Length A	ttribute	Meters					=
Time Att	ribute	Minutes	3				-
Signpos	t Feature Class	Signpo	sts				
Signage	t Straate Tabla	Signo	ete Straate				-
Source:	Streets			•			
Source: Rank	Streets Prefix	Prefix Type	Name	▼ Suffix Type	Suffix	Hwy Dir	
_		Prefix Type	Name NAME	▼ Suffix Type	Suffix	Hwy Dir	

38. Click **OK** to return to the *New Network Dataset* wizard.

39. Click Next.

A summary of all the settings is displayed for your review.

40. Click Finish.

New Network Dataset	? 🗙
Summary:	
Name: Streets_ND Type: Geodatabase-Based Network Dataset Sources: Edge Sources: Streets	* III
Tums: <global tums=""> Restricted Tums</global>	
Connectivity: Group 1: Edge Connectivity: Streets (End Point)	
Elevation Model: Elevation Fields Edge Elevation Fields: (From End, To End): Streets: (F_ELEV, T_ELEV)	
Historical Traffic: Speed Profile Table:	•
< Back Finish C	Cancel

A progress bar opens showing you that Network Analyst is creating the network dataset.

New Network Dataset	E
Creating new network	lataset
	Cancel

Once the network is created, the system asks if you want to build it. The build process determines which network elements are connected and populates the attributes of the network dataset. You must build the network before you can perform any network analysis on it.

41. Click Yes.

The Build Network Dataset progress bar opens; it will disappear when the build process is finished.

Build Network Dataset	
Building the network dataset	
	Cancel

The new network dataset, Streets_ND, is added to ArcCatalog along with the system junctions feature class, Streets_ND_Junctions.

- 42. Preview the network dataset by clicking its name and clicking the **Preview** tab.
- 43. Close ArcCatalog.

Now you can add the network dataset to ArcMap and use it to create network analysis layers.

Exercise 2: Creating a multimodal network dataset

Exercise 1 shows how to create a network for a single mode of transportation; however, travelers and commuters frequently use several modes of transportation, such as walking on sidewalks, driving on road networks, and riding on trains. Goods also travel on many modes of transportation like trains, ships, trucks, and airplanes. In this exercise, you create a multimodal network dataset from multiple feature classes within a feature dataset.

Complexity: Beginner Data Requirement: ArcGIS Tutorial Data Setup Data Path: C:\ArcGIS\ArcTutor\Network Analyst\Tutorial\Exercise02 Goal: Create a multimodal network dataset

Starting the New Network Dataset wizard

Steps:

- 1. Start ArcCatalog by clicking Start > All Programs > ArcGIS > ArcCatalog 10.
- 2. Enable the Network Analyst extension.
 - a. Click **Customize** > **Extensions**. The **Extensions** dialog box opens.
 - b. Check Network Analyst.
 - c. Click Close.
- 3. If you don't already have a connection to the Network Analyst Tutorial folder, you need to create one by following the substeps below.
 - a. On the *Standard* toolbar, click the **Connect To Folder** button . The *Connect to Folder* dialog box opens.
 - Navigate to the folder with the ArcGIS Network Analyst tutorial data. The default location for the tutorial data is C:\ArcGIS\ArcTutor\Network Analyst\Tutorial
 - c. Click OK.

A shortcut to the folder is added to the *Catalog Tree* under Folder Connections.

Catalog Tree	Ψ×
Folder Connections	
C:\arcgis\ArcTutor\Network_A	nalyst\Tutorial
Toolboxes	
I Database Servers	
🗉 🛱 Database Connections	
Image: Barry Ba	

- 4. In the *Catalog Tree*, expand ...\ArcTutor\Network Analyst\Tutorial > Exercise02 > Paris.gdb.
- Click the Transportation feature dataset.
 The feature classes it contains are listed on the Contents tab of ArcCatalog.
- 6. Right-click the Transportation feature dataset and click New > Network Dataset.

-						
🐉 ArcCatalog						
File Edit View Go Geopre	oces	sing Custom	nize Windows	Help		
🚹 🖆 📾 📳 🖺 🗙 🔡 🔛		# Q 🗊	🗟 🖸 🐎 K	? ! €,	Q. 2	81 E
Location: C:\arcgis\ArcTutor\Netw	ork_A	nalyst\Tutorial\E	xercise02\Paris.gdl	b\Transpo	rtation	
: 📝 🗟 😫 🗟 😭						
Catalog Tree		ά×	Contents Previe	ew Desc	ription	
Folder Connections G:\arcgis\ArcTutor\Network	rk An	alvst/Tutorial	Name			3
Exercise01		alystinatonal	Metro_Entra	ances		
E Exercise02			Metro_Line			*
Paris Transportation			Metro_Stati	ons		3
Paris	Ð	Сору	(Ctrl+C		5
I D SanFrancisco	ß.	Paste	(Ctrl+V	ion	-
Exercise03	×	Delete				1
Exercise04		Rename		F2	i.	5
	2	Refresh			I~	
		Analyze			1	
		New		•		Feature Class
		Import		•	큡	Relationship Class
		Export		,	*	Terrain
		Compress Fil	le Geodatabase.		쁥	Network Dataset
		Uncompress	File Geodatabas	e	Щ	Topology
		Upgrade Spa	tial Reference		83	Parcel Fabric
		Add Global ID)s		đ	Geometric Network
	2	Properties				

The New Network Dataset wizard opens.

Naming the network and selecting source feature classes

Steps:

1. Type ParisMultimodal_ND as the name of your network dataset.

New Network Dataset	? 🔀
This wizard will help you build a network dataset. A network dataset is built from feature classes which act as network sources and have a connectivity policy and attributes associated with them.	
Enter a name for your network dataset:	
ParisMultimodal_ND	
< Back Next >	Cancel

2. Click Next.

The wizard page for choosing the feature classes that participate in the network dataset is displayed.

3. Click **Select All** to select all the feature classes to participate as sources in the network.

New Network Dataset	2 💌
Select the feature classes that will participate in the network dataset:	
🛛 🗁 Metro_Lines	Select All
V Streets	Clear All
✓	0.00171
V Metro_Entrances	
Metro_Stations	
< Back Ne	xt > Cancel

- 4. Click Next.
- 5. Click **Yes** to model turns in the network.

Although there are not any turn feature classes for this network, selecting **Yes** allows the network dataset to support global turns and gives you the option of adding turn features anytime after the network is created.

ew N	etwork Dataset 🔋 🗐
Dog	you want to model turns in this network?
0	No
۲	Yes
	Turn Sources:
	< Back Next > Cancel

6. Click Next.

The page for setting connectivity is displayed.

Setting the connectivity and elevation policies

Connectivity in ArcGIS Network Analyst begins with the definition of connectivity groups. Each edge source is assigned to exactly one connectivity group, and each junction source can be assigned to one or more connectivity groups. A connectivity group can contain any number of sources. How network elements connect depends on which connectivity groups the elements are in. For example, two edges created from two distinct source feature classes can connect if they are in the same connectivity group. If they are in separate connectivity groups, the edges won't connect unless they are joined by a junction that participates in both connectivity groups.

You will create connectivity groups in the following steps.

Steps:

- Click **Connectivity** to set up the connectivity model for the network. The **Connectivity** dialog box opens.
- 2. Click the **Group Columns** up-arrow once to increase the number of connectivity groups to **2**. A column for the second connectivity group is created in the **Connectivity Groups** table.

Connectivity group 1 represents the metro system, and group 2 represents the street network.

- 3. Click the **Streets** row and check the check box under the column labeled **2** to move the Streets source to connectivity group 2.
- Click the Metro_Entrances row and check the check box under the column labeled 2 to include the source feature class in groups 1 and 2. Metro entrances are points of transfer between the streets and the walkways that lead to the metro stations.

Each feature of Metro_Entrances is coincident with a vertex of the streets feature class. However, the streets feature class has a policy of endpoint connectivity. Since the metro entrances need to be connected to the streets at the coincident vertex, you must set Metro_Entrances to override the default endpoint connectivity of the streets.

5. Change the **Connectivity Policy** of the **Metro_Entrances** row from **Honor** to **Override**.

Connectivity			2 💌
Connectivity Groups:			
Source	Connectivity Po	1	2
Transfer_Street_Station	End Point End Point End Point End Point Override Honor	¥	
Group Columns: 2	Subtypes		OK Cancel

- 6. Click **OK** to return to the *New Network Dataset* wizard.
- 7. Click Next.

Elevation settings in a network dataset further defines connectivity. To understand why, assume two edges have coincident endpoints in X and Y space but have different elevations (one endpoint is higher than the other). Furthermore, assume their connectivity policy is set to **Endpoint**. If elevation is ignored, the edges connect. However, if elevation is considered, they won't connect.

There are two ways to model elevations: using true elevation values from geometry or using logical elevation values from elevation fields.

8. No elevation data exists for this dataset; therefore, click None.

Using Z Coordinate Values from Ge	ometry		
Using Elevation Fields	End	Field	
Metro_Lines	From End		
Metro_Lines	To End		
Streets	From End		
Streets	To End		=
Transfer_Stations	From End		
Transfer_Stations	To End		
Transfer_Street_Station	From End		
Transfer_Street_Station	To End		
Metro_Entrances			-

9. Click Next.

The wizard displays the attributes of the network dataset.

0	Name	Usage	Units	Data Type	Add
•	HierarchyNavStr Meters	Hierarchy	Unknown Meters	Integer Double	Remove
▲ ▲ ⊖ ⊖	Minutes	Cost Cost	Minutes	Double	Remove All
	Oneway RoadClass	Restriction Descriptor	Unknown Unknown	Boolean Integer	Rename
					Duplicate
					Ranges
					Parameters
					Evaluators

Removing an attribute

Network attributes are properties of the network that control navigation. Common examples are cost attributes that function as impedances over the network and restriction attributes that prohibit traversal in both directions or one direction, like one-way roads.

ArcGIS Network Analyst analyzes the source feature class (or classes) and looks for common fields like Meters, Minutes (FT_Minutes and TF_Minutes, one for each direction), and Oneway. If it finds these fields, it automatically creates the corresponding network attributes and assigns the respective fields to them. (This can be viewed by clicking **Evaluators**.)

Network Analyst automatically configures five attributes for the Paris streets data: HierarchyNavStreets, Meters, Minutes, Oneway, and Road Class.

Although you could leave the hierarchy attribute on the network dataset, this short set of steps demonstrates how to remove a network attribute by removing HierarchyNavStreets.

Steps:

- 1. Click HierarchyNavStreets.
- 2. Click **Remove**. Now the network is left with four attributes.

Verifying and creating network attributes

One goal for this network dataset is to model both pedestrian times and drive times. When performing analyses on the network, this allows you to choose between the two time costs. For example, you can choose to answer a question like, What's the quickest route from point A to point B for a pedestrian who can walk along streets and ride the metro? or What's the quickest route for someone who's driving a car? To accomplish this, you must set up two time-cost attributes: PedestrianTime and DriveTime.

Steps:

The Minutes attribute that Network Analyst automatically detected in the source data represents drive times, so you can change the name to something more appropriate.

1. Select the Minutes row, click Rename, type DriveTime, and press ENTER.



Next, you will create the PedestrianTime attribute.

2. Click Add.

The Add New Attribute dialog box opens.

- 3. Type PedestrianTime in the Name text box.
- 4. Set the **Usage Type** to **Cost**.
- 5. Change **Units** to **Minutes**.
- 6. Set the **Data Type** to **Double**.

Add New Attribu	ite		? 💌
Name:	PedestrianTime		ОК
Usage Type:	Cost	•	Cancel
Units:	Minutes	•	
Data Type:	Double	-	
	Use by Default		

7. Click OK.

The *Add New Attribute* dialog box closes, and PedestrianTime is added to the list of attributes.

The three cost attributes—Meters, DriveTime, and PedestrianTime—have yellow warning symbols that alert you to potential problems with the evaluators, which specify how the values of network attributes are calculated.

In the next three sections, you will configure the evaluators.

Configuring the Meters evaluator

You will set up various evaluators in this section and the following sections. The Meters evaluator calculates the distance cost for edges in the network.

Steps:

1. Select Meters and click Evaluators.

0	Name	Usage	Units	Data Type	A <u>d</u> d
<u>^</u> 	DriveTime Meters	Cost Cost	Minutes Meters	Double Double	<u>R</u> emove
<u>.</u>	Oneway PedestrianTime	Restriction Cost	Unknown Minutes	Boolean Double	Remove Al
	RoadClass	Descriptor	Unknown	Integer	Rename
					Duplicate
					Range <u>s</u>
					Parameters
					Evaluators.

The *Evaluators* dialog box opens. Here you can view and edit the evaluator type and its value for each source in the network. You can see that junction and turn sources always have one associated evaluator, but edge sources have two: one for each direction of travel (the from-to and to-from directions).

ArcGIS Network Analyst inspects all source feature classes and tries to automatically assign evaluators for the Meters attribute. In this case, it discovered that the Metro_Lines and Streets sources had a field named Meters, so it set up evaluators to pull values from those fields. The same length values are assigned to the from-to and to-from directions of the edge sources.

Network Analyst was unable to find fields for meters in the Transfer_Stations and Transfer_Street_Station sources. Hence, a warning symbol is present to indicate there is a potential problem.

- While holding the SHIFT key, click the Transfer_Stations From-To row and click the Transfer_Street_Station To-From row. The four rows with the warning symbols are selected.
- 3. Right-click any of the selected rows and click Type > Field.

	e Values: Default Values						
!	Source	Direction	Element	Туре		Value	1
	Metro_Lines	From-To	Edge	Field		Meters	×
	Metro_Lines	To-From	Edge	Field		Meters	1
	Streets	From-To	Edge	Field		METERS	
	Streets	To-From	Edge	Field		METERS	_
4	Transfer_Stations						
4		To-From	Edge	Туре	•	Edge Traffic	
4			Edge	Value		Constant	
4	Transfer_Street_Stat	To-From	Edge	value			
	Metro_Entrances		Juncti	Delete	DEL	VB Script	
	Metro_Stations		Junction-			Global Turn Delay	
						Field	
						Function	

The warning symbols change to red error symbols, which indicate an incomplete assignment of values for the field evaluator.

4. With the four rows still selected, right-click any one of them and click Value > SHAPE_LENGTH.

	010010	1011011	Lugu	1 INTM	menervo.		
8	Transfer_Stations						
8							
8	Transfer_Street_Stat			Field	Туре	- F	
8	Transfer_Street_Stat	To-From	Edge	Field	Value	•	SHAPE
	Metro_Entrances		Junction				
	Metro Stations		Junction		Delete D	EL	SHAPE_LENGTH
	meno_oranona		Sancion				TRANSITTIM
					A		
1			~ ~	State of the second		-	Properties F12

This assigns values from the SHAPE_LENGTH field in the selected source feature classes to the Meters attribute for their associated network edge elements.

5. Click Apply.

The Meters network attribute is configured to get length values. For the network elements created from Metro_Lines, Streets, Transfer_Stations, and Transfer_Street_Station sources, the attribute values are respectively pulled from their Meters, METERS, Shape_Length, and SHAPE_LENGTH fields.

Configuring the DriveTime and Oneway evaluators

Since automobiles only travel on streets, the evaluators for the various sources should be set up accordingly.

Steps:

1. From the **Attribute** drop-down list, choose **DriveTime**.

The DriveTime values for the Streets source have been populated automatically by Network Analyst; however, the other edge sources display warning symbols because they don't have values assigned. These sources need to be marked as restricted. Also, metro stations need to be restricted so that new network analysis objects can be prevented from locating there.

- Make sure that all the rows with a warning symbol (Metro_Lines, Transfer_Stations, and Transfer_Street_Station) are selected.
 If they aren't selected, select them by clicking one row and holding the CTRL key while clicking the other rows.
- 3. Hold the CTRL key and click Metro_Stations to add it to the selection.
- 4. Right-click any one of the selected rows and click **Type > Constant**.

bute:	DriveTime		-				
tribute Value							
Source Valu	Default Values						_
t Sour	ce	Direction	Element	Туре	Value		
🛕 Metro	_Lines	From-To	Edge				\mathbf{X}
🛕 Metro	_Lines	To-From	Edge				
Stree	ts	From-To	Edge	Field	FT_MIN	IUTES	
Stree	ts	To-From	Edge	Field	TF_MIN	IUTES	
🛕 Tran	sfer_Stations	From-To					
🛕 Tran	sfer_Stations			Туре	•	Edge Traffic	
🛕 Tran	sfer_Street_Stat			Value	•	Constant	
🛕 Tran	sfer_Street_Stat	To-From	Edge	value			
Metro	_Entrances		Junction	Delete	DEL	VB Script	
Metro	_Stations		Junction			Global Turn	Delay
						Field	

The same rows remain selected, and their evaluator type changes to Constant.

- 5. Again, right-click one of the selected rows, but this time click **Value > Properties.** The **Constant Value** input box appears.
- 6. Type -1 and press ENTER.



The values for all the selected rows change to -1. Network Analyst treats any elements that have a cost value of -1 as restricted. So whenever the DriveTime attribute is used as impedance in network analyses, these sources are not traversable.

:	Source	Direction	Element	Туре	Value
	Metro_Lines	From-To	Edge	Constant	-1
	Metro_Lines	To-From	Edge	Constant	-1 🍙
	Streets	From-To	Edge	Field	FT_MINUTES
	Streets	To-From	Edge	Field	TF_MINUTES
	Transfer_Stations	From-To	Edge	Constant	-1 2
	Transfer_Stations	To-From	Edge	Constant	-1 🔍
	Transfer_Street_Stat	From-To	Edge	Constant	-1 🐳
	Transfer_Street_Stat	To-From	Edge	Constant	-1 🥔
	Metro_Entrances		Junction		- E
	Metro_Stations		Junction		-1
					in march

7. Click Apply.

The Oneway attribute is loosely associated with the DriveTime attribute because it models the one-way traffic restrictions that drivers are required to follow. Later, when you perform an analysis using DriveTime as the cost, you should enable the Oneway restriction so the resulting

routes respect one-way streets. Alternatively, when modeling the movement of a pedestrian, you shouldn't use the Oneway restriction, since pedestrians are free to walk in the direction they choose.

8. From the **Attribute** drop-down list at the top of the **Evaluators** dialog box, choose **Oneway**. The **Attribute Values** frame now displays the evaluators for the Oneway network attribute, which has automatically been assigned values for the Streets source.

The sources related to the metro system don't need one-way restrictions.

- 9. Click either one of the **Streets** rows and click the **Evaluator Properties** button . You can see the expression used to determine whether a street is one-way.
- 10. Click **Cancel** to return to the *Evaluators* dialog box.

Configuring the PedestrianTime evaluator

The PedestrianTime network attribute represents the time it takes a pedestrian to travel on the network. In this set of steps, you will assign appropriate travel times for a pedestrian who can ride the metro system or walk along streets.

Steps:

1. From the **Attribute** drop-down list at the top of the **Evaluators** dialog box, choose **PedestrianTime**.

The rows for the following sources should already be selected: Metro_Lines, Transfer_Stations, and Transfer_Street_Station.

- 2. Right-click one of the selected rows and click **Type > Field.**
- Again, right-click one of the selected rows, but this time click Value > TRANSITTIM. The TRANSITTIM fields store the time costs for a pedestrian to use the transit system. The streets also need pedestrian time values, but you calculate them differently.

luator	rs					? 💌
tribute:	PedestrianTime		-			
Attribute	te Values:					
Sourc	ce Values Default Values					
:	Source	Direction	Element	Туре	Value	
	Metro_Lines	From-To	Edge	Field	TransitTim	×
	Metro_Lines	To-From			TransitTim	
	Streets	From-To	Edge	Field	FT_MINUTES	
	Streets	To-From	Edge	Field	TF_MINUTES	
	Transfer_Stations	From-To	Edge	Field	Transittim	
	Transfer_Stations				Transittim	
	Transfer_Street_Stat				Transittim	
	Transfer_Street_Stat	To-From			Transittim	
	Metro_Entrances Metro_Stations		Junction Junction			
					OK Cancel	Apply

4. Click the **Streets From-To** row to select it. Hold the CTRL key and click the **Streets To-From** row to select both rows.

 Right-click one of the selected rows and click Value > Properties. The *Field Evaluators* dialog box opens.

For the Streets source, the value of PedestrianTime is the walk time. Assuming a pedestrian can walk at 3 km/hour, walk time in minutes would be [Meters] * 60 / 3000 where [Meters] is the attribute containing the length of the edge in meters.

- 6. Double-click the field **METERS** to move it into the **Value** = text box and finish typing the expression as [METERS] * 60 / 3000 in the *Field Evaluators* dialog box, as shown below.
- 7. Click Verify to ensure that the expression is correct and fix it if necessary.

Field Evaluators		? 🗙
Fields CFCC DISP_CODE FT_MINUTES FULL_NAME FUNC_CLASS METERS NA_Herarc	Type Number String Date	Functions Abs () A Abn () Cos () Exp () E Int () Log () Sin () Sar ()
Pre-Logic VB Script Code	~	• / & + • = Load
Value =		
[METERS]*60/3000	ОК	Cancel

8. Click **OK** to return to the *Evaluators* dialog box.

	0	Discritica	Florent	T	Makua	
!	Source	Direction	Element	Туре	Value	
	Metro_Lines	From-To	Edge	Field	TransitTim	\times
	Metro_Lines	To-From	Edge	Field	TransitTim	
	Streets	From-To	Edge	Field	<expression></expression>	
	Streets	To-From	Edge	Field	<expression></expression>	
	Transfer_Stations	From-To	Edge	Field	Transittim	
	Transfer_Stations	To-From	Edge	Field	Transittim	
	Transfer_Street_Stat	From-To	Edge	Field	Transittim	
	Transfer_Street_Stat	To-From	Edge	Field	Transittim	
	Metro_Entrances		Junction			
	Metro_Stations		Junction			

- 9. Click OK to return to the New Network Dataset wizard.
- 10. Click Next.

Configuring directions

When routes are calculated on your network dataset, you have the ability to produce driving directions to accompany the results. A network dataset is required to have at least one edge source with a text attribute (for street name information) and a distance attribute to show how far it will be before the next relevant maneuver is required.

Steps:

- 1. Click **Yes** to set up directions.
- 2. Click Directions.

The Network Directions Properties dialog box opens.

Now you will specify the fields used to report directions for network analysis results.

3. On the General tab, click the Source drop-down list and choose Streets.

neral Shield	s Road Detail					
Display L Length At Time Attri	ength Units tribute bute	Miles Meters DriveTime				•
	Feature Class					-
Source: Rank Primary	Streets Metro_Lines Streets Transfer_Station Transfer_Street	ns 💫 Station	rpe S	uffix	Hwy Dir	
Number of A	Iternate Names:	0				

- 4. In the Street Name Fields list, click Primary to select it.
- 5. Click in the **Name** column and choose **FULL NAME**.

ource:	Street	ts			•			
Rank	Prefix	Prefix Type	Name	Suffix Type	Suffix	Full Name	Hwy	Lang
Primary <			FULL_NAM - <none> CFCC FULL_NAME FUNC_CLASS Oneway</none>			FULL_NA		,

6. Click OK to return to the New Network Dataset wizard.

7. Click Next.

A summary of all the settings is displayed for your review.

Creating and building the network dataset

After setting up how you want the network dataset to function, you need to create and build it. The creation process is quick and essentially creates a container for the logical network.

Steps:

1. Click Finish.

A progress bar opens showing you that Network Analyst is creating the network dataset.

Cancel

Once the network is created, the system asks if you want to build it. The build process determines which network elements are connected and populates the attributes of the network dataset. You must build the network before you can perform any network analysis on it.

2. Click Yes.

The Build Network Dataset progress bar opens; it will disappear when the build process is finished.

Build Network Dataset	X
Building the network dataset	
	Cancel

The new network dataset, ParisMultimodal_ND, is added to ArcCatalog along with the system junctions feature class, ParisMultimodal_ND_Junctions.

- 3. Preview the network dataset by clicking its name and clicking the **Preview** tab.
- 4. Close ArcCatalog.

Exercise 3: Finding the best route using a network dataset

In this exercise, you will find the quickest route to visit a set of stops in a predetermined order.

Preparing your display

Steps:

- 1. If you have Exercise03.mxd open in ArcMap, skip to step 6.
- Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.
- On the ArcMap Getting Started dialog box, click Existing Maps > Browse for more. The Open ArcMap Document dialog box appears.
- 4. Browse to C:\ArcGIS\ArcTutor\Network Analyst\Tutorial. This is the default installation location for the tutorial data.
- 5. Double-click **Exercise03.mxd**. The map document opens in ArcMap.
- 6. Enable the Network Analyst extension.
 - a. Click **Customize > Extensions**.
 - The *Extensions* dialog box opens.
 - b. Check Network Analyst.
 - c. Click Close.

If the Network Analyst toolbar is not displayed, you need to add it.

 Click Customize > Toolbars > Network Analyst. The Network Analyst toolbar is added to ArcMap.

Network Analyst × III III - 長次 III III Network Dataset Streets_ND ・ 部 認

If the Network Analyst window is not displayed, you need to add it.

On the Network Analyst toolbar, click the Show/Hide Network Analyst Window button .
 The dockable Network Analyst window opens.

Network Analyst	
	- 🗉

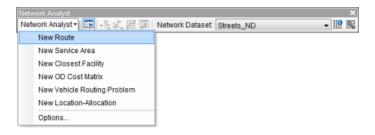
You can dock or undock the *Network Analyst* window. In this exercise, it is docked below the *Table Of Contents* window.

Complexity: Beginner Data Requirement: ArcGIS Tutorial Data Setup Data Path: C:VarcGIS\ArcTutor\Network Analyst\Tutorial Goal: Find the quickest route (shortest path) between stops.

Creating a route analysis layer

Steps:

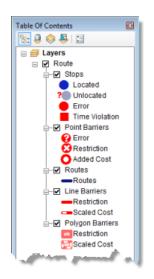
1. Click Network Analyst on the Network Analyst toolbar and click New Route.



The route analysis layer is added to the *Network Analyst* window. The network analysis classes (Stops, Routes, Point Barriers, Line Barriers, and Polygon Barriers) are empty.

Route	- 🔳
Stops (0)	
Routes (0)	
Point Barriers (0)	
Restriction (0)	
Added Cost (0)	
Line Barriers (0)	
Restriction (0)	
Scaled Cost (0)	
Polygon Barriers (0)	
Restriction (0)	
Scaled Cost (0)	

The analysis layer is also added to the Table Of Contents window.



Adding a stop

Next, you will add the stops to be visited by a route.

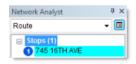
Steps:

- In the *Network Analyst* window, click **Stops (0)**.
 Stops is selected, which means it is the active network analysis class.
- On the *Network Analyst* toolbar, click the Create Network Location Tool .
 By clicking on the map with the Create Network Location Tool, you can add network analysis objects to the active network analysis class.
- 3. Click anywhere on the street network to define a new stop location.



ArcGIS Network Analyst calculates the nearest network location and symbolizes the stop with the Located symbol. The stop remains selected until another stop is placed or you clear the selection.

The located stop also displays the number 1. All stops have a unique number, which represents the order in which the stop will be visited by the route. Also notice that the **Stops** class in the **Network Analyst** window now lists one stop.



4. Add two more stops anywhere on or near the streets.



The new stops are numbered 2 and 3.

The first stop is treated as the origin, and the last as the destination.

Network Analyst	Ψ×
Route	- 🗉
 Stops (3) 745 16TH AVE 139 2ND AVE 1652 MCALLIST 	ER ST

The sequence of the stops can be changed by clicking a stop in the **Network Analyst** window and dragging it to another position in the list.

If a stop is not located on the network, it appears with an unlocated symbol. (However, using the default settings, you would need to place a stop more than 5 kilometers from the nearest street segment for it to not locate.)

?

You can move an unlocated stop closer to the network to locate it. If a stop is located on the network but in the wrong location, you can move the stop to the correct position.

- 5. To move a stop, follow these substeps:
 - a. Click the Select/Move Network Locations Tool 💦 on the Network Analyst toolbar.
 - b. Click a stop to select it.
 - c. Click the stop again and drag it to a new location.



Setting up the parameters for the analysis

Next, you will specify that your route will be calculated based on travel time (minutes), that U-turns are allowed anywhere, and that one-way and turn restrictions must be followed.

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.



The Layer Properties dialog box opens.

- 2. Click the Analysis Settings tab.
- 3. Make sure that Impedance is set to TravelTime (Minutes).

This network dataset has historical traffic data associated with the TravelTime (Minutes) attribute. If you choose to enter a start time by checking **Use Start Time** and filling out the three fields below it, Network Analyst will find the quickest route based on that time of day and historical traffic speeds. Alternatively, it will find the quickest route based on a function of street lengths and speed limits.

- 4. Check **Use Start Time**, enter a specific time and date or day of the week.
 - a. For Time of Day, enter the time you want to leave the first stop.
 - b. Click either Day of Week or Specific Date.
 If you choose Day of Week, specify any day between Sunday and Saturday; optionally, choose Today to use your system's current day setting.

If you choose **Specific Date**, either type a date in the text box or click the down-arrow to open a calendar that allows you to choose a date.

5. Leave Use Time Windows unchecked.

You can specify time windows for stops and have ArcGIS Network Analyst try to find a route that honors those time ranges in which a stop should be visited.

6. Leave Reorder Stops To Find Optimal Route unchecked.

By leaving this property unchecked, Network Analyst discovers the best route given the stop sequence you specify. This is commonly known as the traveling salesman problem (TSP). If checked, it finds the best route and best sequence to visit the stops.

- 7. Click the U-Turns at Junctions drop-down arrow and choose Allowed.
- 8. Click the Output Shape Type drop-down arrow and choose True Shape with Measures.
- 9. Make sure that the Use Hierarchy and Ignore Invalid Locations boxes are checked.
- 10. In the **Restrictions** frame, make sure that **RestrictedTurns** and **Oneway** are checked.
- 11. In the **Directions** frame, make sure that **Distance Units** is set to **Miles**, **Use Time Attribute** is checked, and the time attribute is set to **TravelTime (Minutes)**.

The **Analysis Settings** tab should look like the following graphic; however, your **Use Start Time** properties may be different:

General Layers Source An	halysis Settings A	ccumulation	Network Locations
Settings Impedance: ✓ Use Start Time: Ime of Day: © Day of Week: © Specific Date: ✓ Use Time Windows	TravelTime (Minu 8:30 AM Today 4/14/2010	rtes) 🔹	RestrictedTurns
Reorder Stops To Find Q Preserve Eirst Stop Preserve Last Stop	ptimal Route:		Directions Distance Units:
Ù-Turns at Junctions: Output Shape Type: ☑ Use Hjerarchy	Allowed True Shape with	▼ Measures ▼	Miles Vilse Time Attribute: TravelTime (Minutes) V
☑ Ignore In <u>v</u> alid Locations			Ogen Directions window automatically

12. Click OK.

Computing the best route

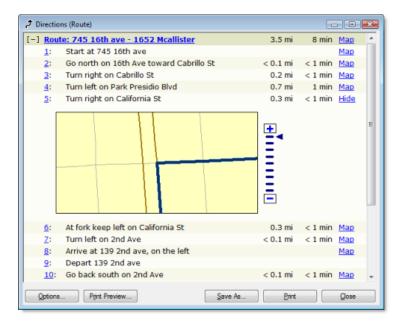
Steps:

Click the Solve button in on the Network Analyst toolbar.
 A route feature appears in the map display and in the Network Analyst window under the Routes class.



If a warning message appears, a stop may be located on a restricted edge. Try moving one or more stops using the **Select/Move Network Locations Tool** *k*, which is on the **Network Analyst** toolbar.

- Click the Directions Window button in on the Network Analyst toolbar. The Directions dialog box opens.
- 3. On the rightmost column of the *Directions* dialog box, click one of the links named **Map**. An inset map of the maneuver is displayed.



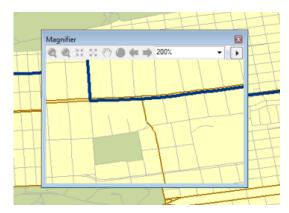
4. Click Close.

Adding a barrier

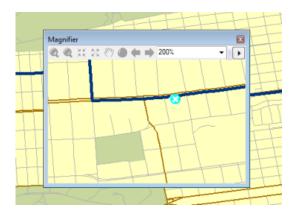
In this section, you will add a barrier on the route to represent a roadblock, and you will find an alternate route to your destination.

Steps:

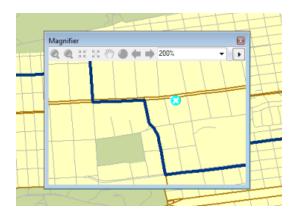
- Click Windows > Magnifier. The Magnifier window opens.
- 2. Click the title bar of the *Magnifier* window and drag the window to reposition it over the route.



- 3. In the Network Analyst window under Point Barriers (0), click Restriction (0).
- 4. Click the Create Network Location Tool . A on the Network Analyst toolbar.
- 5. In the *Magnifier* window, click anywhere on the route to place one or more barriers.
 - **Tip:** To see where a barrier will be placed, hold down the 1 key before clicking on the map with the Create Network Location Tool.



Click the Solve button # on the Network Analyst toolbar.
 A new, alternative route is computed that avoids the barrier.



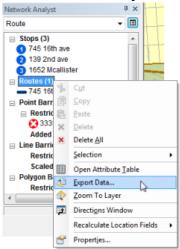
7. Close the *Magnifier* window.

Saving the route

The route analysis layer is currently stored in memory, so if you exit ArcMap without saving, the analysis is lost. However, if you save the map document, the analysis layer is saved with it. You can also export data. One option is to export the entire analysis layer to an LYR file. The analysis properties and objects are stored within the LYR file. Another option is to save the sublayers of the analysis as feature classes using the **Export Data** command. The next set of steps show how to export the Routes sublayer to a feature class.

Steps:

1. On the *Network Analyst* window, right-click **Routes (1)** and click **Export Data**.



The Export Data dialog box opens.

- 2. In the Output feature class text box, type or browse to a location to save the results in, such as C:\ArcGIS\ArcTutor\Network Analyst\Tutorial\SanFrancisco.gdb\Exercise3 Route.
- 3. Click OK.

The route's feature is saved to the specified workspace.

- 4. Click No when prompted to add the exported data to the map as a layer.
- 5. If you don't plan to work on any other exercise, exit ArcMap. Click No to discard any changes.
- 6. If you plan to work on another exercise, follow the substeps below.
 - a. Click File > New. The *New Document* dialog box opens.
 - b. Click OK.
 - c. Click No when prompted to save changes.

Exercise 4: Finding the closest fire stations

In this exercise, you will find the four fire stations that can provide the quickest response to a fire at a given address. You will also generate routes and driving directions for the firefighters to follow.

Preparing your display

Steps:

- 1. If you have Exercise04.mxd open in ArcMap, skip to step 6.
- 2. Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.
- 3. On the ArcMap Getting Started dialog box, click Existing Maps > Browse for more.
- 4. Browse to C:\ArcGIS\ArcTutor\Network Analyst\Tutorial. This is the default installation location for the tutorial data.
- 5. Double-click **Exercise04.mxd**. The map document opens in ArcMap.
- 6. Enable the Network Analyst extension.
 - a. Click **Customize** > **Extensions**. The **Extensions** dialog box opens.
 - b. Check **Network Analyst**.
 - c. Click Close.

If the Network Analyst toolbar is not displayed, you need to add it.

 Click Customize > Toolbars > Network Analyst. The Network Analyst toolbar is added to ArcMap.



If the Network Analyst window is not displayed, you need to add it.

On the Network Analyst toolbar, click the Show/Hide Network Analyst Window button .
 The dockable Network Analyst window opens.

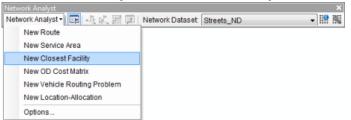
Network Analyst	8
	- 🗉

You can dock or undock the *Network Analyst* window. In this exercise, it is docked below the *Table Of Contents* window.

Complexity: Beginner Data Requirement: ArcGIS Tutorial Data Setup Data Path: C:\ArcGIS\ArcTutor\Network Analyst\Tutorial Goal: Create, set up, and solve a closest facility analysis. Creating the closest facility analysis layer

Steps:

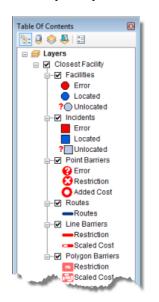
1. Click Network Analyst on the Network Analyst toolbar and click New Closest Facility.



The closest facility analysis layer is added to the **Network Analyst** window. The network analysis classes (Facilities, Incidents, Routes, Point Barriers, Line Barriers, and Polygon Barriers) are empty.

Network Analyst
Closest Facility 👻 🔳
Facilities (0)
Incidents (0)
Routes (0)
Point Barriers (0)
Restriction (0)
Added Cost (0)
Line Barriers (0)
Restriction (0)
Scaled Cost (0)
Polygon Barriers (0)
Restriction (0)
Scaled Cost (0)

The analysis layer is also added to the Table Of Contents window.

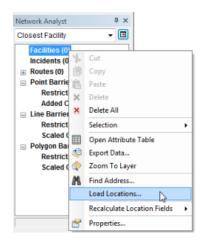


Adding facilities

Next, you will load facilities from a point feature layer that represents fire stations.

Steps:

1. In the *Network Analyst* window, right-click **Facilities (0)** and click **Load Locations**.



The Load Locations dialog box opens.

2. Choose FireStations from the Load From drop-down list.

d Locations				- ? -
ad From: Fires	Stations how point layers			•
Only load selected rows				
rt Field:				
rt Heid:		•		
Location Analysis Properti	es			
Property	Field		Default Value	*
Name	NAME			
CurbApproach			Either side of vehicle	=
Attr_Minutes			0	
Attr_Meters			0	
Attr_WeekdayFallback			0	
Attr_WeekendFallback			0	
Attr_TravelTime			0	
Cutoff Mauton				-
Ocation Position Use Geometry Search Tolerance:	5000	Meters	•	
O Use Network Location				
Property	Fields			-
Property SourceID				
Property SourceID SourceOID				•
Property SourceID SourceOID PosAlong				
Property SourceID SourceOID				
Property SourceID SourceOID PosAlong			OK	

3. Click OK.

Forty-three fire stations are displayed in the map as facilities and listed in the **Network Analyst** window.

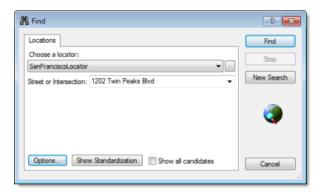


Adding an incident

Next, you will add an incident by geocoding an address received from an emergency call.

Steps:

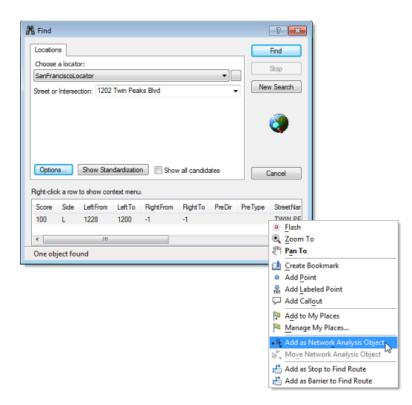
- 1. In the *Network Analyst* window, right-click **Incidents (0)** and choose **Find Address**. The *Find* dialog box opens.
- 2. Make sure that SanFranciscoLocator is chosen in the Choose a locator drop-down list.
- 3. In the Street or Intersection text box, enter 1202 Twin Peaks Blvd.



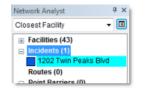
4. Click Find.

One location is found with that street address and is listed as a row in the table at the bottom of the *Find* dialog box.

5. Right-click the row and choose Add as Network Analysis Object.



This adds the located address as an incident, which you can see on the map and in the *Network Analyst* window.



6. Close the *Find* dialog box.

Setting up parameters for the analysis

Next, you will specify the parameters for your closest facility analysis.

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.

Network Analyst	ά×
Closest Facility	- R
Second Strength address	- hr

The Layer Properties dialog box opens.

- 2. Click the Analysis Settings tab.
- 3. Make sure that Impedance is set to TravelTime (Minutes).
- 4. Enter 3 in the Default Cutoff Value text box.

ArcGIS will search for fire stations that are within three minutes of the fire on Twin Peaks Boulevard. Any fire stations outside the cutoff time are ignored.

5. Increase Facilities to Find to 4.

ArcGIS will search for a maximum of four fire stations from the fire site. However, the threeminute cutoff still applies; therefore, if only three fire stations are within the three-minute cutoff, then a fourth fire station will not be found.

- Choose Facility to Incident for the Travel From direction. The search results emanate out from the fire stations, which are loaded as facilities. This mimics the fire engines traveling from the stations to the fire (incident).
- 7. Click the U-Turns at Junctions drop-down arrow and choose Allowed.
- 8. Click the Output Shape Type drop-down arrow and choose True Shape with Measures.
- 9. Uncheck Use Hierarchy.
- 10. Check Ignore Invalid Locations.
- In the Restrictions frame, uncheck RestrictedTurns.
 Fire engines don't need to obey this traffic rule in emergencies.
- 12. In the **Directions** frame, make sure that **Distance Units** is set to **Miles**, **Use Time Attribute** is checked, and the time attribute is set to **TravelTime (Minutes)**.

Your Analysis Settings tab should look like the following graphic:

eneral Layers Source An	alysis Settings Accumulation	Network Locations	8	
Settings		Restrictions		
Impedance:	TravelTime (Minutes)	Restrict Onewar	tedTurns	
Default <u>C</u> utoff Value:	3	✓ Onewa	Ŷ	
Eaclities To Find:	4			
Iravel From: Incident to Facility				
Facility to Incident		Directions		
		Distance Unit	:	
U-Turns at Junctions:	Allowed	Miles		-
Output Shape Type:	True Shape with Measures	V Use Ti <u>m</u> e	Attribute	
Use Hierarchy		TravelTin	ne (Minutes)	•
Ignore Invalid Locations		📃 Ogen Dire	ections window auto	matically

13. Click **OK**.

Identifying the closest facilities

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.



Routes appear in the map display and in the **Route** class in the **Network Analyst** window.

Note that you configured the analysis to find four facilities within a three-minute cutoff; however, only three facilities are within the cutoff.

t Di	irectio	ns (Closest Facility)		
[-]	Rou	te: Station 39 - 1202 Twin Peaks Blvd	0.6 mi	1 min Map
	1:	Start at Station 39		Map
	<u>2</u> :	Go northeast on Portola Dr toward Rex Ave	0.5 mi	1 min <u>Map</u>
	<u>3</u> :	At fork keep left on Twin Peaks Blvd	0.1 mi	< 1 min <u>Map</u>
	<u>4</u> :	Turn left on Panorama Dr	< 0.1 mi	< 1 min <u>Map</u>
	<u>5</u> :	Finish at 1202 Twin Peaks Blvd		Map
		Total time: 1 min Total distance: 0.6 mi		
[-]	Rou	<u>te: Station 20 - 1202 Twin Peaks Blvd</u>	0.6 mi	1 min Map
	1:	Start at Station 20		Map
	<u>2</u> :	Go east on Olympia Way toward Dellbrook Ave	0.2 mi	< 1 min Map
	<u>3</u> :	Turn right on Panorama Dr	0.4 mi	< 1 min Map
	<u>4</u> :	Finish at 1202 Twin Peaks Blvd		Map
		Total time: 1 min Total distance: 0.6 mi		
[-]	Rou	<u>te: Station 24 - 1202 Twin Peaks Blvd</u>	1.1 mi	3 min Map
	1:	Start at Station 24		Map
	<u>2</u> :	Go west on Alvarado St toward Grand View Ave	< 0.1 mi	< 1 min Map
	<u>3</u> :	Turn left on Grand View Ave	0.4 mi	1 min Map
	<u>4</u> :	Turn right on Clipper St	0.1 mi	< 1 min Map
	<u>5</u> :	Continue on Diamond Heights Blvd	< 0.1 mi	< 1 min Map
	<u>6</u> :	Turn left on Portola Dr	0.3 mi	< 1 min Map
	Z:	Turn right on Twin Peaks Blvd	0.1 mi	< 1 min Map
	<u>8</u> :	Turn left on Panorama Dr	< 0.1 mi	< 1 min Map
	<u>9</u> :	Finish at 1202 Twin Peaks Blvd		Map
		Total time: 3 min Total distance: 1.1 mi		
)ptions		Print	Qose

Driving directions from each fire station are listed in the window.

- 3. If you don't plan to work on any other exercise, exit ArcMap. Click **No** to discard any changes.
- 4. If you plan to work on another exercise, follow the substeps below.
 - a. Click File > New.

The New Document dialog box opens.

- b. Click OK.
- c. Click **No** when prompted to save changes.

Exercise 5: Calculating service areas and creating an OD cost matrix

In this exercise, you will create a series of polygons that represent the distance that can be reached from a facility within a specified amount of time. These polygons are known as service area polygons. You will calculate 3-, 5-, and 10-minute service areas for six warehouses in Paris.

You will also find how many stores are within each of these service areas. You will identify one warehouse that should be relocated to better service the stores. Additionally, you will create an origin–destination cost matrix for delivery of goods from the warehouses to all stores within a 10-minute drive time. Such a matrix is used as an input for logistics, delivery, and routing analyses.

Complexity: Beginner Data Requirement: ArcGIS Tutorial Data Setup Data Path: C:\ArcGIS\ArcTutor\Network Analyst\Tutorial Goal: Create service area polygons and create an OD cost matrix.

Preparing your display

Steps:

- 1. If you have Exercise05.mxd open in ArcMap, skip to step 6.
- 2. Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.
- 3. On the ArcMap Getting Started dialog box, click Existing Maps > Browse for more.
- Browse to C:\ArcGIS\ArcTutor\Network Analyst\Tutorial. This is the default installation location for the tutorial data.
- 5. Double-click **Exercise05.mxd**. The map document opens in ArcMap.
- 6. Enable the Network Analyst extension.
 - a. Click **Customize** > **Extensions.** The **Extensions** dialog box opens.
 - b. Check Network Analyst.
 - c. Click Close.

If the Network Analyst toolbar is not displayed, you need to add it.

 Click Customize > Toolbars > Network Analyst. The *Network Analyst* toolbar is added to ArcMap.

INELWORK Analyst					~
Network Analyst -	P	上に 開日	Network Dataset	Streets_ND	- 19 🕅

If the Network Analyst window is not displayed, you need to add it.

8. On the *Network Analyst* toolbar, click the **Show/Hide Network Analyst Window** button **E**. The dockable *Network Analyst* window opens.

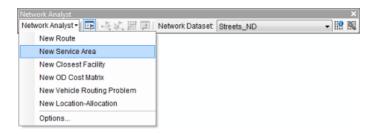


You can dock or undock the *Network Analyst* window. In this exercise, it is docked below the *Table Of Contents* window.

Creating the service area analysis layer

Steps:

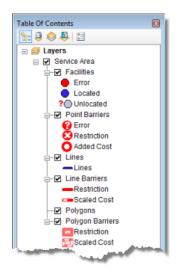
1. Click Network Analyst on the Network Analyst toolbar and click New Service Area.



The service area analysis layer is added to the **Network Analyst** window. The network analysis classes (Facilities, Polygons, Lines, Point Barriers, Line Barriers, and Polygon Barriers) are empty.

Network Analyst
Service Area 👻 🔳
Facilities (0)
Polygons (0)
Lines (0)
Point Barriers (0)
Restriction (0)
Added Cost (0)
Line Barriers (0)
Restriction (0)
Scaled Cost (0)
Polygon Barriers (0)
Restriction (0)
Scaled Cost (0)
P

The analysis layer is also added to the Table Of Contents window.



Adding facilities

Next, you will add warehouses as facilities for which the service area polygons will be generated.

Steps:

1. On the *Network Analyst* window, right-click **Facilities (0)** and choose **Load Locations**.

Network Analyst	₽×
Service Area	- 🗉
Facilities (0)	~
Polygons (0 🤌	Cut
Lines (0) 📳	Сору
Point Barrie	Paste
Restrict ×	Delete
Added C	Delete All
😑 Line Barrier °	
Restrict	Selection >
Scaled (Open Attribute Table
Polygon Ba	Export Data
Restrict	
Scaled (📿	Zoom To Layer
8	Find Address
	Load Locations
	Recalculate Location Fields
2	Properties

The Load Locations dialog box opens.

2. In the Load From drop-down list, choose Warehouses.

Load Locations		2	X
Load From:	🍄 Warehouses ⊡-ጭ Service Area	•	2
Only load select			
Location Analysi Property Name	Image: Warehouses Image: Wetro_Stations Image: Wetro_Entrances Image: Baseness days		

3. Click OK.

The six facilities are displayed in the map.

4. In the *Network Analyst* window, click the plus (+) sign next to **Facilities (6)** to see a list of the loaded facilities.



Setting up the parameters for the analysis

Next, you will specify that your service area will be calculated based on drive time (using minutes). Three service area polygons will be calculated for each facility, one at 3 minutes, one at 5 minutes, and another at 10 minutes. You will specify that the direction of travel will be from the facility—not toward the facility, that no U-turns are allowed, and that one-way restrictions must be followed.

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.

Network Analyst	Ψ×
Service Area	- 🖳
In Eaching the last	للوحدان

The Layer Properties dialog box opens.

- 2. Click the Analysis Settings tab.
- 3. Make sure that Impedance is set to use DriveTime (Minutes).
- 4. Type 3 5 10 in the Default Breaks text box.
- 5. Under Direction, click Away From Facility.
- 6. Choose Not Allowed from the U-Turns at Junctions drop-down list.
- 7. Leave Ignore Invalid Locations checked.
- 8. Check Oneway in the Restrictions list.

The Analysis Settings tab should now look like this:

Line Gene	eration	Accum	lation	Network Locations
General	Layers	Source	Analysis Settings	Polygon Generation
ettings			Restrictions	
mpedance:	Drive	Time (Minutes)	▼ Oneway	(
efault <u>B</u> reaks:	3 5 3	10		
irection:				
-Turns at Juncti	ons: Not A	Allowed	•	
Ignore In <u>v</u> alid	Locations			

- 9. Click the **Polygon Generation** tab.
- 10. Make sure that Generate Polygons is checked.
- For **Polygon Type**, click **Generalized**.
 Detailed polygons are more accurate but need more time to be generated.
- Uncheck the Trim Polygon option.
 This is a postprocess that trims the outside polygon to remove spikes but takes a little longer to run.
- Click Overlapping for the Multiple Facilities Options. This results in individual polygons for each facility. A polygon from one facility might overlap with a polygon from another, nearby facility.
- Click **Rings** for the **Overlap** type.
 This excludes areas of smaller breaks from the polygons of a bigger break.
- 15. Click **Apply** to save the settings.
- 16. Click the Line Generation tab.
- 17. Leave Generate Lines unchecked.
- 18. Click OK.

Run the process to compute the service area

Steps:

 Click the Solve button # on the Network Analyst toolbar. The service area polygons appear on the map and on the Network Analyst window.

The polygons are transparent, which allow you to see the underlying streets. However, instead of color coding the breaks from dark to light with increasing distance, you will change them to go from light to dark.

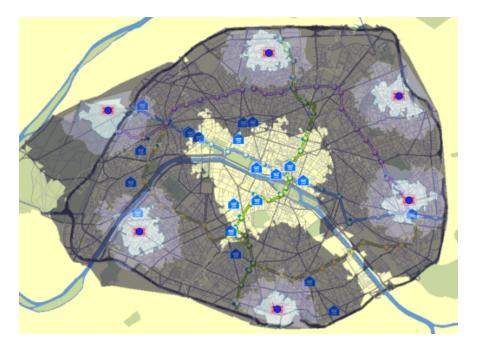
2. In the Table Of Contents window, right-click the Polygons sublayer and choose Properties.

- 3. Click the **Symbology** tab.
- 4. Click the **Symbol** field name and choose **Flip Symbols**. (Make sure you click—not rightclick—**Symbol**; otherwise, you get a different context menu.)

iyer Properties General Source Selectio	on Display Symbology	Fields Definition Query Labels	loins & Relates	Time HTML Popup
Show: Features Categories		g unique values of one field.		nport
Unique values Unique values, many Match to symbols in a	ToBreak			•
Quantities	Symbol Value	Label	Count	
Charts	Flip Symb	ols		
Multiple Attributes	Properties	for Selected Symbol(s)	?	
	Properties	for All Symbols	?	1
	القدمة فليري المسيم	and the second second	The second	

5. Click OK.

The outer and inner service area breaks switch colors, making it clearer what areas the 10-minute breaks cover.



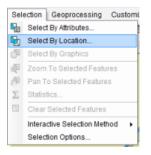
Identifying stores that are outside all service areas

Steps:

1. In the *Table Of Contents* window, click and drag **Stores** to the top of the **Layers** list to improve visibility.



2. Click Selection > Select By Location.



3. Create the selection query on the *Select By Location* dialog box to select features from stores that are completely within polygons, as shown below.

Select By Location	×
Select features from one or more target layers based on their location in relation to the features in the source layer.	
Selection method:	
select features from	•
Target layer(s):	
Stores S	A HI
Polygons	-
Use selected features (0 features selected)	
Spatial selection method:	
Target layer(s) features are within the Source layer feature	•
Apply a search gistance 2000.000000 Meters	
Hgb OK Apply Glos	æ

4. Click OK.

The stores that are within the polygons are selected; however, you want to select the stores that are outside the service area polygons.

5. In the *Table Of Contents* window, right-click Stores and click **Selection > Switch Selection**.

Table Of Contents	a x				
E dyers	Â				
	🗊 Сору				
= >	Remove				0
Service A	Open Attribute Table				No.
En En	Joins and Relates	•			
📥 Lo 🔙	Zoom To Layer			- Cotoko	5
? Ur 🗧	Zoom To Make Visible			TATA .	
E- Point	Visible Scale Range	•	1		Nº V
Re	Use Symbol Levels				1
O Ad	Selection	•	⊕ ∎	Zoom To Selected Features	H
È-♥ Lines	Label Features		A	Pan To Selected Features	2
e- ✓ Line	Edit Features	•		Clear Selected Features	1
-Re Sc	Convert Labels to Annotation		2	Switch Selection	-
%	Convert Features to Graphics			Select All	1
Network Analyst	Convert Symbology to Representation			Make This The Only Selectable Layer	ſ
Service Area	Data	•		Copy Records For Selected Features	ő
E Facilities (6)	Save As Layer File			Annotate Selected Features	3
Warehouse	Create Layer Package			Create Layer From Selected Features	20
Warehouse	Properties			Open Table Showing Selected Features	SX

The selection now shows the distribution of stores not contained in any service area polygons. Use this selection to identify the area in which you will relocate a warehouse. The best area appears to be in the center of the map.



6. On the Tools toolbar, click the Clear Selected Features button .

Relocating the least accessible warehouse

Look at the service area polygons of Warehouse #2. There are not any stores within the 3-, 5-, or 10-minute service areas around Warehouse #2; hence, you will relocate that warehouse to better service the stores.

Steps:

1. On the Network Analyst window, select Warehouse #2 under Facilities (6).



2. Click the Select/Move Network Location Tool k on the Network Analyst toolbar.

3. On the map display, drag Warehouse #2 to the center of the map as shown below.



Run the process to compute the service area

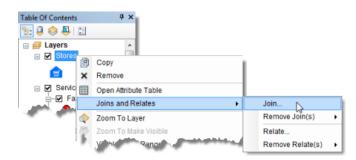
Steps:

 Click the Solve button if on the Network Analyst toolbar. The service area polygons appear on the map and the Network Analyst window.

Identifying the service area polygon that each store is within

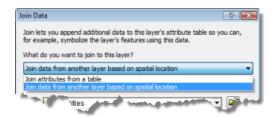
Steps:

1. In the *Table Of Contents* window, right-click Stores and click Joins and Relates > Join.

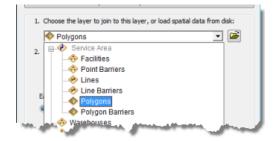


The Join Data dialog box opens.

2. Choose Join data from another layer based on spatial location.



3. Choose **Polygons** as the layer to join to this layer.

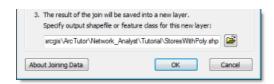


4. Click the it falls inside button.

Ea	ch point will be given all the attributes of the polygon that:
۲	it falls inside.
	If a point falls inside more than one polygon (for example, because the layer being joined contains overlapping polygons) the attributes of the first polygon found will be joined.
0	is dosest to it.
	A distance field is added showing how close the polygon is (in the units of the target layer). A polygon that the point falls inside is treated as being closest to the point (i.e. a distance of 0).

This adds the attributes of the polygon to all points that fall inside the polygon.

5. Specify an output shapefile or feature class to save the join results to and name it StoresWithPoly.



6. Click OK.

ArcGIS performs the join and adds the new layer to the map document.

7. In the *Table Of Contents* window, right-click the new **StoresWithPoly** feature layer and choose **Open Attribute Table**.

Each row in the table displays the name of the store and polygon it falls under. You can use this table to generate other useful categories, such as the number of stores within 0-to 3-minute service areas.

8. Close the attribute table.

You can optionally export your facilities (including the one you moved) as a feature class.

- 9. In the *Network Analyst* window, right-click **Facilities (6)** and choose **Export Data**. The *Export Data* dialog box opens.
- 10. In the Export drop-down list, choose All features.
- 11. Choose an output location and type (shapefile or feature class). You might choose to store a feature class in the Paris geodatabase: C:\arcgis\ArcTutor\Network Analyst\Tutorial\Paris.gdb\New Warehouses

Export Dat	a 🔋 🔀
Export:	All features
Use the sa	ame coordinate system as:
O this lay	ver's source data
🗇 the da	ta frame
	sture dataset you export the data into pplies if you export to a feature dataset in a geodatabase)
Output fe	ature class:
;gis\Arc`	Tutor/Network_Analyst/Tutorial/Paris.gdb/New_Warehouses 🗃
	OK Cancel

12. Click OK.

A message appears asking if you want to add the exported data to the map.

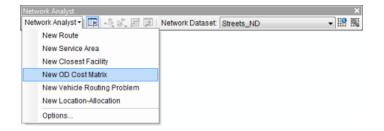
 Click No. You won't need the data for the rest of this exercise.

Creating an OD cost matrix analysis layer

Optionally, you can create an origin–destination cost matrix for deliveries from the new warehouses to each store. The results of this matrix can be used to identify stores that will be serviced by each warehouse within a 10-minute drive time. Also, you can find the total drive time from each warehouse to its stores.

Steps:

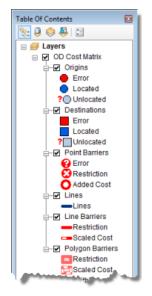
- 1. In the *Table Of Contents* window, uncheck the **Service Area** analysis layer and the **StoresWithPoly** feature layer to improve readability of the map.
- 2. Click Network Analyst on the Network Analyst toolbar and click New OD Cost Matrix.



The OD cost matrix analysis layer is added to the *Network Analyst* window. The network analysis classes (Origins, Destinations, Lines, Point Barriers, Line Barriers, and Polygon Barriers) are empty.

Netv	vork Analyst 🛛 🖻
OD	Cost Matrix 👻 🔳
	Origins (0)
	Destinations (0)
	Lines (0)
	Point Barriers (0)
	Restriction (0)
	Added Cost (0)
	Line Barriers (0)
	Restriction (0)
	Scaled Cost (0)
	Polygon Barriers (0)
	Restriction (0)
	Scaled Cost (0)

The analysis layer is also added to the Table Of Contents window.



Adding origins

You can use the facilities from the service area analysis (in the previous sections) as origins. If you have not completed the section on service areas, you can use the Warehouses feature layer instead.

Steps:

- 1. In the *Network Analyst* window, right-click **Origins (0)** and choose **Load Locations**. The *Load Locations* dialog box opens.
- 2. Click **ServiceArea/Facilities** in the **Load From** drop-down list. (If you did not complete the previous sections on service area analysis, you can choose **Warehouses** instead.)
- 3. Uncheck Only load selected rows.
- 4. Under Location Position, click Use Network Location Fields. (If you are loading Warehouses, click Use Geometry.) Using network location fields allows ArcGIS to use the already-located position of service area facilities to locate them again as origins. This is much faster than using a spatial search to locate them again.

d From: 🔅 Facili	lies	•
Only sh	ow point layers	
Only load gelected rows		
Field:		
Heid:		•
cation Analysis Propertie	s	
Property	Field	Default Value
Name	Name	
largetDestinationCount	THEFT.	
CurbApproach	CurbApproach	Either side of vehicle
Outoff_Drivetime		
Cutoff_Meters		
Cutoff_PedestrianTime		
cation Position		
Use Geometry		
_		
	5000 Mete	47S
Search <u>T</u> olerance:		
	ields	
Search <u>I</u> olerance:	ields	
	ields Field	
Use Network Location F		
Use Network Location F	Field	
Use Network Location P Property SourceID SourceOID PosAlong	Field SourceID SourceOID PosAlong	
Use Network Location F Property SourceID SourceOID	Field SourceID SourceOID	

5. Click OK.

The six new origins are displayed on the map and listed in the *Network Analyst* window under **Origins**.



Adding destinations

Steps:

- 1. In the *Network Analyst* window, right-click **Destinations (0)** and choose **Load Locations**.
- 2. Choose Stores in the Load From drop-down list.
- 3. Under Location Analysis Properties, for the property name, choose NOM from the Field drop-down list.

Since the French field name NOM is not configured in the NASolverConfiguration.xml file, ArcGIS is unable to map the field name automatically.

Lond London			2 2
Load Locations			8 💌
	Stores hly show point layers		• 🖻
Only load selected n	ows		
Sort Field:		•	
Location Analysis Prop	perties		
Property	Field	Default Value	
Name		-	
CurbApproach	OBJECTID	Either side of vehide	
	POI NOM		
Location Position			
Ose Geometry			
Search Tolerance	: 5000	Meters	
O Use Network Loca	the Table		
O USE NEtwork Loca	oon rielos		
Property	Field		~
SourceID			=
SourceOID			
PosAlong			-
_CideO4Edea			
Advanced		ок	Cancel
Advanced		<u>OK</u>	Cancel

4. Click OK.

The Network Analyst window now lists 21 destinations.



These destinations are also displayed on the map.



Setting up the parameters for the analysis

Next, you will specify that your OD cost matrix will be calculated based on drive time. You will set a default cutoff value of 10 minutes and ensure that all destinations are found within the specified cutoff. Additionally, you will specify that U-turns are allowed everywhere and the output Shape type should be a straight line. Since all these trips are on roads, one-way restrictions must be followed. All invalid locations (locations not found) will be ignored.

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.

Network Analyst	Ψ×
OD Cost Matrix	- 🖻
in the second	hr.

- 2. Click the Analysis Settings tab.
- 3. Make sure that the Impedance drop-down list is set to DriveTime (Minutes).
- Type 10 in the Default Cutoff Value text box. This will create origin-destination paths from each warehouse to all stores that can be reached within 10 minutes.
- 5. Make sure that **Destinations To Find** is set to **<All>**.
- 6. Click the U-Turns at Junctions drop-down arrow and choose Allowed.
- 7. Make sure that **Output Shape Type** is set to **Straight Line**.
- 8. Make sure that Ignore Invalid Locations is checked.
- 9. Check Oneway in the Restrictions list.

Layer Properties			
General Layers Source Ar	alysis Settings	Accumulation	on Network Locations
Settings			Restrictions
Impedance:	DriveTime (Min	utes) 🔻	▼ V Oneway
Default <u>C</u> utoff Value:	10		
Destinations To Find:	<al></al>		×
U-Turns at Junctions:	Allowed	•	•
Output Shape Type:	Straight Line	•	•
Use Hierarchy			
☑ Ignore Invalid Locations			
			OK Cancel Apply

10. Click OK.

The parameter settings are saved.

Run the process to create the OD cost matrix

Steps:

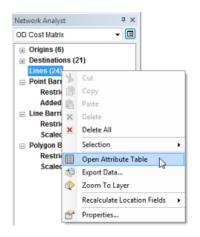
- Click the Solve button ## on the Network Analyst toolbar. The OD lines appear on the map. There are 24 lines in this example. This number may be different for you, depending on where you relocated Warehouse #2.
- 2. If the Service Area layer is not displayed, turn it on to show the OD Cost Matrix layer on top of the service areas of the warehouses.

Allocating stores to warehouses

Based on the OD cost matrix, you can now identify the stores that would be served by each warehouse.

Steps:





The Lines table opens.

The Lines table represents the origin–destination cost matrix from each warehouse to the stores within a 10-minute drive time. The OriginID column contains IDs of warehouses. The DestinationID column contains IDs of stores. The DestinationRank is a rank assigned to each destination that is served by a store based on the total drive time. For example, in the table below, for Warehouse #1, DestinationID 2 has a rank of 1, and DestinationID 3 has a rank of 2. This is because it takes less time to go from Warehouse #1 to DestinationID 2. (This may be different for you, as your analysis results are dependent on the source feature class of the origins and destinations.)

Objec	tID Shape	Name	OriginID	DestinationID	DestinationRank	Total Drivetime
	1 Polyline	Warehouse #1 - AU PRINTEMPS HAUSSMANN	1	2	1	8.502172
	2 Polyline	Warehouse #1 - GALERIES LAFAYETTE HAUSSMANN	1	3	2	8.816077
	3 Polyline	Warehouse #2 - SAMARITAINE	2	11	1	2.335185
	4 Polyline	Warehouse #2 - ESPACE EXPANSION FORUM DES HALLES	2	9	2	2.67174
	5 Polyline	Warehouse #2 - BAZAR DE L'HOTEL-DE-VILLE	2	12	3	3.568851
	6 Polyline	Warehouse #2 - GALERIE CARROUSEL DU LOUVRE	2	10	4	4.466903
	7 Polyline	Warehouse #2 - LE MARCHE SAINT GERMAIN	2	14	5	7.042571
	8 Polyline	Warehouse #2 - GALERIE DES TROIS QUARTERS	2	7	6	7.441952
	9 Polyline	Warehouse #2 - GALERIES LAFAYETTE HAUSSMANN	2	3	7	8.504664
	10 Polyline	Warehouse #2 - LE BON MARCHE	2	15	8	8.627457
	11 Polyline	Warehouse #2 - AU PRINTEMPS HAUSSMANN	2	2	9	9.274025
	12 Polyline	Warehouse #2 - MAINE-MONTPARNASSE	2	18	10	9.974127
	13 Polyline	Warehouse #3 - PRINTEMPS NATION	3	16	1	4.442888
	14 Polyline	Warehouse #4 - ITALIE 2	4	20	1	5.628731
	15 Polyline	Warehouse #4 - CENTRE COMMERCIAL MASSENA 13	4	21	2	6.300414
	16 Polyline	Warehouse #4 - GAITE	4	19	3	8.578204
	17 Polyline	Warehouse #5 - S.C.I. BEAUGRENELLE	5	17	1	2,428298
	18 Polyline	Warehouse #5 - GALERIE COMMERCIALE PASSY PLAZA	5	13	2	7.046085
	19 Polyline	Warehouse #6 - LES BOUTIQUES DU PALAIS DES CONGRES	6	1	1	3.868477
	20 Polyline	Warehouse #6 - GALERIE SAINT DIDIER	6	8	2	6.098853
	21 Polyline	Warehouse #6 - ARCADES DU LIDO	6	4	3	8.649859
	22 Polyline	Warehouse #6 - GALERIE DU CLARIDGE	6	5	4	8.793694
	23 Polyline	Warehouse #6 - GALERIE COMMERCIALE PASSY PLAZA	6	13	5	8.857523
	24 Polyline	Warehouse #6 - ELYSEE 26	6	6	6	9.773601

The OD cost matrix displays the stores serviced by each warehouse along with the total drive time for each route. Some stores are within a 10-minute accessibility zone of more than one warehouse and can be served by any one of them. The OD cost matrix can also be used as an input in logistics routing models that use origin–destination matrices to allocate goods and services.

- 2. If you don't plan to work on any other exercise, exit ArcMap. Click **No** to discard any changes.
- 3. If you plan to work on another exercise, follow the substeps below.
 - a. Click File > New. The *New Document* dialog box opens.
 - b. Click OK.
 - c. Click **No** when prompted to save changes.

Exercise 6: Creating a model for route analysis

In this exercise, you will create a model for finding the fastest delivery route connecting 21 stores in Paris.

Preparing your display

Steps:

- 1. If you have Exercise06.mxd open in ArcMap, skip to step 6.
- Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.
- 3. On the ArcMap Getting Started dialog box, click Existing Maps > Browse for more.
- 4. Browse to C:\ArcGIS\ArcTutor\Network Analyst\Tutorial. This is the default installation location for the tutorial data.
- 5. Double-click **Exercise06.mxd**. The map document opens in ArcMap.
- 6. Enable the Network Analyst extension.
 - a. Click **Customize** > **Extensions**. The **Extensions** dialog box opens.
 - b. Check Network Analyst.
 - c. Click Close.

If the Network Analyst toolbar is not displayed, you need to add it.

 Click Customize > Toolbars > Network Analyst. The Network Analyst toolbar is added to ArcMap.



If the Network Analyst window is not displayed, you need to add it.

On the Network Analyst toolbar, click the Show/Hide Network Analyst Window button .
 The dockable Network Analyst window opens.

Network Analyst	
	- 🗉

You can dock or undock the *Network Analyst* window. In this exercise, it is docked below the *Table Of Contents* window.

Complexity: Beginner Data Requirement: ArcGIS Tutorial Data Setup Data Path: C:\ArcGIS\ArcTutor\Network Analyst\Tutorial Goal:

Create a geoprocessing model using ModelBuilder and ArcGIS Network Analyst tools.

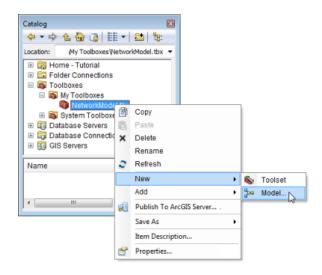
Creating the model

Steps:

- Click the Catalog window button in on the Standard toolbar. The dockable Catalog window opens.
- 2. In the *Catalog* window, expand Toolboxes.
- 3. Right-click **My Toolboxes** and choose **New > Toolbox.**

Catalog			
🗢 🕈 🚖 🗟	1 - 1	18:	
Location: Toolboxes	Wy Toolboxes	•	
 ■ □ Home - Tutorial ■ □ Folder Connect ■ □ FolderXes 			
 Image: Big System Image: Big System	Paste Refresh		
 Image: Database Image: GIS Serve 	New >	🖏 То	olbox 🔓
Name	T	ype	

- 4. Type NetworkModel and press ENTER to name the newly added toolbox.
- 5. Right-click the NetworkModel toolbox and click New > Model.



A new model appears in the toolbox, and the *Model* dialog box opens.



Pa Model
Model Edit Insert View Windows Help
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Creating a route layer in the model

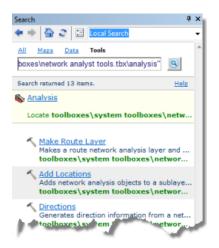
Next, you will create the route layer within the model. The workflow for using Network Analyst in a model is the same as the workflow for using Network Analyst in ArcMap. First, you create a route layer and set properties. Next, you add the network locations (stops) to be used as inputs. Last, you solve and display the results.

Steps:

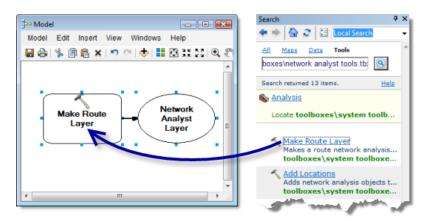
 On the menu bar, click Geoprocessing > Search For Tools. The dockable Search window opens with the Tools category selected.



- Click Network Analyst Tools in the list of toolboxes in the Search window.
 A list of toolsets and tools related to the ArcGIS Network Analyst extension are listed.
- Click Analysis in the Search window.
 Only tools related to network analysis are displayed in the Search window.



4. Drag the Make Route Layer link onto the Model dialog box.



- On the *Model* dialog box, double-click Make Route Layer.
 The *Make Route Layer* dialog box opens so you can set its properties.
- 6. Click the Input analysis network drop-down arrow and choose ParisMultimodal_ND.
- 7. In the Impedance attribute drop-down list, click DriveTime.
- 8. Check the Reorder stops to find optimal route check box.
- 9. In the **Preserve ordering of stops** drop-down list, click **PRESERVE_BOTH**.

The tool dialog box should look like the one in the graphic below.

🔨 Make Route Layer	×
Input analysis network	^
ParisMultimodal_ND 🗾 🖆	
Output layer name	
Route	
Impedance attribute	
Drivetime	
Reorder stops to find optimal route (optional)	
Preserve ordering of stops (optional)	
PRESERVE_BOTH -	
Use time windows (optional)	
Start Time (optional)	
* Accumulators	
* Hierarchy	
	÷
OK Cancel Apply Show Help >>	

10. Click OK.

The input analysis layer is now added to the model. The Make Route Layer tool turns yellow, and the output turns green.

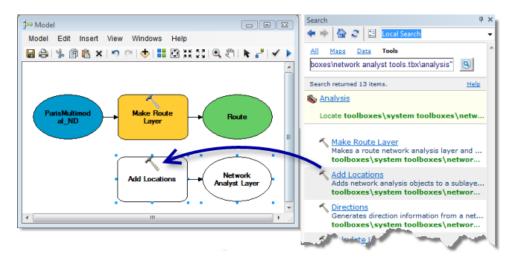
11. Click the **Full View** button . The entire model is displayed.

Adding stops to the route layer

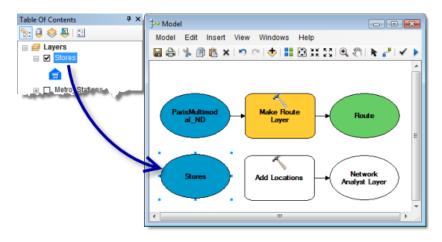
Next, you will add the stores as stops by using the Add Locations tool.

Steps:

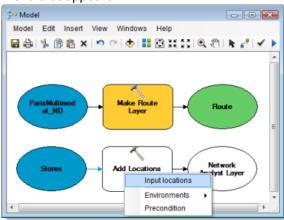
1. Drag the Add Locations tool from the Search window onto the Model dialog box.



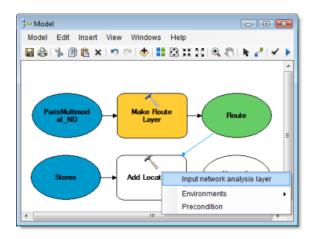
2. Select the **Stores** feature layer in the **Table Of Contents** window and drag it onto the model to the left of **Add Locations**.



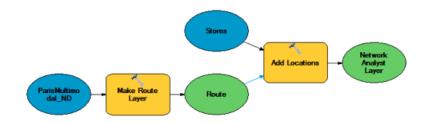
- 3. On the *Model* dialog box, click the Connect tool.
- 4. Click **Stores** and click **Add Locations** to connect them. Click **Input locations** on the context menu that appears.



5. Using the **Connect** tool, connect **Route** to **Add Locations**. Click **Input network analysis layer** on the context menu that appears.



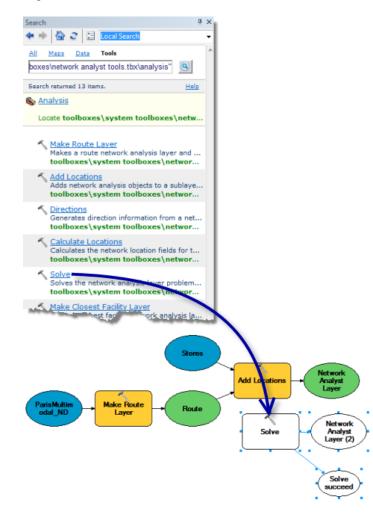
 Click the Auto Layout button . The model is arranged in a logical order. 7. Click the Full View button .



Adding the Solve tool

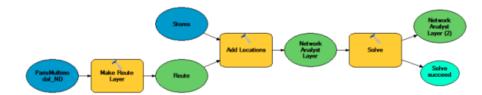
Steps:

1. Drag the Solve tool from the Search window onto the Model dialog box.



- Using the Connect tool, connect the output layer, Network Analyst Layer, to Solve. Click Input network analysis layer on the context menu that appears. The Solve tool turns yellow, the output layer turns green, and Solve succeeded turns cyan.
- 3. Click the Auto Layout button .

4. Click the Full View button .



- 5. Click the Select tool .
- 6. Right-click the output layer of the **Solve** tool, which is labeled **Network Analyst Layer (2)**, and click **Add To Display**.



This tells the model to add the final output to the map display.

Running the model to find the best route

Steps:

- 1. Click the **Save** button \blacksquare to save the model.
- Click the Run button .
 A status window appears while ArcGIS performs the route analysis.
- 3. When completed, close the status window and close the *Model* dialog box so you can inspect the results.

A message appears prompting you to save the model.

4. Click Yes.

A new route layer is added to the **Table Of Contents** window. The **Network Analyst** window has all the stops and the resultant route. The map displays the stops that were loaded and the resultant route.



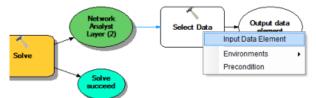
Configuring the model to save the results to disk

Steps:

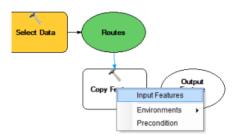
1. In the *Catalog* window, expand the **NetworkModel** toolbox, right-click **Model**, then choose **Edit**.

To access the shortest path feature class for further analysis, you will need to copy features from memory onto disk.

- 2. Type Select Data in the Search window text box and press ENTER.
- 3. Drag the Select Data tool from the search results and drop it in the Model window.
- 4. Using the **Connect** tool, connect the final output layer to **Select Data**. Click **Input Data Element** on the context menu that appears.



- 5. In the *Model* window, double-click **Select Data**. The **Select Data** dialog box opens.
- 6. Choose Routes from the Child Data Element drop-down list.
- 7. Click **OK**. The dialog box closes.
- Type Copy Features in the Search window text box and press ENTER.
- 9. Drag the **Copy Features** tool from the search results onto the **Model** dialog box.
- 10. Using the **Connect** tool , connect the final output layer to **Copy Features**. Click **Input Features** on the context menu that appears.



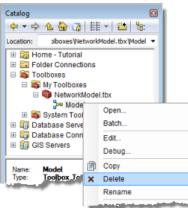
- 11. On the *Model* dialog box, double-click **Copy Features**. The **Copy Features** dialog box opens.
- 12. Enter an output location for saving the route as a feature class or shapefile. For example, you might type C:\arcgis\ArcTutor\Network Analyst\Tutorial\Paris.gdb\path.
- 13. Click OK.

Now running the model will solve the best route, select the route sublayer, and export it to a feature class. You can run the model by clicking the **Run** button .

Deleting the model

Steps:

1. In the *Catalog* window, navigate to the **NetworkModel** toolbox, right-click **Model**, then choose **Delete**.



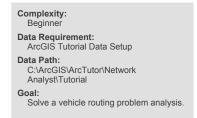
A message appears prompting you to confirm deletion.

If you ran the model, you may also want to navigate to the location that you specified for the output of the Copy Features tool and delete the feature class that was created.

- 2. Click Yes.
- 3. Exit ArcMap and do not save any changes to Exercise06.mxd.

Exercise 7: Servicing a set of orders with a fleet of vehicles

In this exercise, you will find the best routes for a fleet of vehicles, operated by a distribution company, to deliver goods from a distribution center to a set of 25 grocery stores. Each store has a specific quantity of demand for the goods, and each truck has a limited capacity for carrying the goods. The main objective is to assign trucks in the fleet a subset of the stores to service and to sequence the deliveries in a way that minimizes the overall transportation costs.



This can be achieved by solving a vehicle routing problem (VRP). Once the delivery sequence is determined, you will generate the turn-by-turn directions for the resulting routes, which can be electronically distributed or printed and given to the drivers to make the deliveries.

Preparing your display

Steps:

- 1. If you have Exercise07.mxd open in ArcMap, skip to step 6.
- 2. Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.
- On the ArcMap Getting Started dialog box, click Existing Maps > Browse for more. The Open ArcMap Document dialog box appears.
- 4. Browse to C:\ArcGIS\ArcTutor\Network Analyst\Tutorial. This is the default installation location for the tutorial data.
- 5. Double-click **Exercise07.mxd**. The map document opens in ArcMap.
- 6. Enable the Network Analyst extension.
 - a. Click **Customize > Extensions.**

The *Extensions* dialog box opens.

- b. Check Network Analyst.
- c. Click Close.

If the Network Analyst toolbar is not displayed, you need to add it.

 Click Customize > Toolbars > Network Analyst. The Network Analyst toolbar is added to ArcMap.

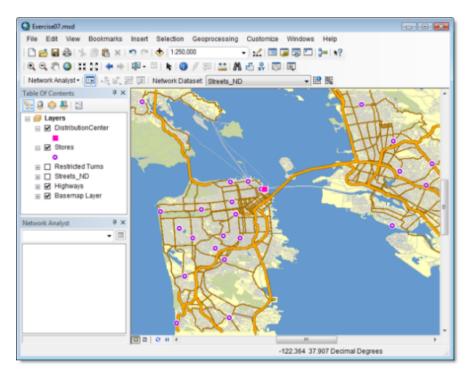


If the Network Analyst window is not displayed, you need to add it.

On the Network Analyst toolbar, click the Show/Hide Network Analyst Window button .
 The dockable Network Analyst window opens.

Network Analyst	
	- 🗉

You can dock or undock the *Network Analyst* window. In this exercise, it is docked below the *Table Of Contents* window.



Creating the vehicle routing problem analysis layer

Steps:

1. Click **Network Analyst** on the **Network Analyst** toolbar and click **New Vehicle Routing Problem**.

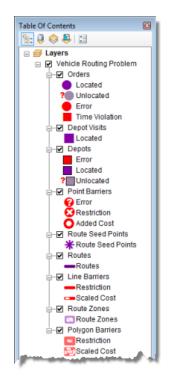


The vehicle routing problem analysis layer is added to the *Network Analyst* window. The network analysis classes (Orders, Depots, Routes, Depot Visits, Breaks, Route Zones, Route

Seed Points, Route Renewals, Specialties, Order Pairs, Point Barriers, Line Barriers, and Polygon Barriers) are empty.



The analysis layer is also added to the *Table Of Contents* window.



Adding orders

You will add the grocery store locations to the Orders network analysis class. You can think of orders as orders to be filled, since each grocery store has requested goods to be delivered to it from the distribution center. Members of the Orders class will eventually become stops along the vehicle's routes.

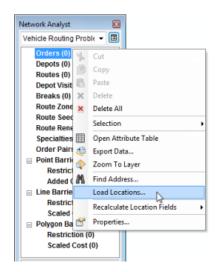
The grocery store locations are already added as a feature layer, Stores, in the map document. The attributes of Stores contain information about the total weight of goods (in pounds) required at each store, the time window during which the delivery has to be made, and the service time (in minutes) incurred while visiting a particular store. The service time is the time required to unload the goods.

Table pounds) of good					the store accepts deliveries		Ē	
Sto	res				1	1)
	OBJECTID *	SHAPE *	NAME	Demand	ServiceTime	Time Start1	TimeEnd1	
E	1	Point	Store_1	1706	25	9:00:00 AM	5:00:00 PM	1
	2	Point	Store_2	1533	23	9:00:00 AM	5:00:00 PM	=
Π	3	Point	Store_3	1580	24	9:00:00 AM	5:00:00 PM	
	4	Point	Store_4	1289	20	9:00:00 AM	5:00:00 PM	
	5	Point	Store_5	1302	21	9:00:00 AM	5:00:00 PM	
	6	Point	Store_6	1775	26	9:00:00 AM	5:00:00 PM	
	7	Point	Store_7	1014	17	9:00:00 AM	5:00:00 PM	
	8	Point	Store_8	1761	26	9:00:00 AM	5:00:00 PM	
	9	Point	Store_9	1815	27	9:00:00 AM	5:00:00 PM	-
ŀ		1 н н	, (0 out of 25 s	Selected)			

You will add these point features of stores as orders in the analysis layer.

Steps:

1. In the *Network Analyst* window, right-click **Orders (0)** and choose Load Locations.



The Load Locations dialog box opens

2. Select Stores from the Load Locations drop-down list.

The **Location Analysis Properties** section on the *Load Locations* dialog box lets you specify which attributes of the Stores feature class contain the values that ArcGIS Network Analyst will use to help solve this vehicle routing problem.

 In the Location Analysis Properties section, make sure that the Name property is automatically matched to the NAME field, and the ServiceTime property is matched to the ServiceTime field. Network Analyst tries to match location analysis properties automatically for a newly created vehicle routing problem layer based on a configuration file (located in the ArcGIS installation directory within [...]\NetworkAnalyst\NetworkConfiguration\NASolverConfiguration.xml).

Load Locations					8
Load From:	i Stor i Only s	es how point layers			• 🖻
Only load se	lected rows				
Sort Field:			•]	
Location Analy	ysis Propert	es		,	
Property		Field		Default Value	~
Name		NAME			-
Description					E
ServiceTime		ServiceTime			
TimeWindow	/Start1			-	
TimeWindow	/End1				
TimeWindow	/Start2	OBJECTID			
TimeWindow	/End2	NAME Demand			
Maultalation	Time 1	ServiceTime			
Location Posit	ion	TimeStart1 TimeEnd1			
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O Use Netwo	ork Location	Fields			
Propert	у	Field			-
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Advanced.				ОК	Cancel

4. Set the Field value of TimeWindowStart1 to TimeStart1.

- 5. Set the Field value of TimeWindowEnd1 to TimeEnd1.
- 6. Set the Field value of DeliveryQuantities to Demand.
- Type 0 under Default Value for the MaxViolationTime1 property. Setting this property to zero specifies that the time window should not be violated.

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Only load sele	cted rows						
t Field:					•		
cation Analys	is Propert	line					
-	is Propert						
Property		Field			Default Va	lue	
Name		NAME					
Description							=
ServiceTime		Service					
TimeWindowS		TimeSt					
TimeWindowE		TimeEn	d1				
TimeWindowS							
TimeWindowE							
MaxViolationT					0		
MaxViolationT		-					
DeliveryQuan		Deman	d				
PickupQuantit	es						
Revenue							
SpecialtyName					C. set de		
AssignmentRu RouteName	le				Override		
Sequence							
CurbApproact					Fither side	ofushida	
curowpproact	1				Either side	or venue	-
Use Geomet Search Tole	гу		5000	Meters		•	
Use Network	Location	Fields					
Property			Field				*
SourceID							Е
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PosAlong							
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Twenty-five stores are listed in the *Network Analyst* window under **Orders** and are displayed as orders on the map.

Adding depots

The goods are delivered from a single distribution center whose location is shown in the DistributionCenter feature layer in ArcMap. The distribution center operates between 8:00 a.m. and 5:00 p.m. You will add this point feature to the Depots network analysis class.

Steps:

- In the *Network Analyst* window, right-click **Depots (0)** and choose Load Locations. The *Load Locations* dialog box opens.
- 2. Select DistributionCenter from the Load Locations drop-down list.
- 3. In the Location Analysis Properties section, make sure that the Name property is automatically matched to the NAME field.
- 4. Type 8 AM under Default Value for the TimeWindowStart1 property.
- 5. Type 5 PM under Default Value for the TimeWindowEnd1 property.

			- 8	
ad From: 🤫 Di	stributionCenter		-	
Only	show point layers			
Only load selected row	VS			
· · ·				
rt Field:		•		
and the Analysis Deser	-Fee			
Location Analysis Prope	rties			_
Location Analysis Prope Property	Field	Default Value		1
		Default Value		
Property	Field	Default Value		
Property Name	Field	Default Value 8:00:00 AM		
Property Name Description	Field			
Property Name Description TimeWindowStart1	Field	8:00:00 AM		
Property Name Description TimeWindowStart1 TimeWindowEnd1	Field	8:00:00 AM		

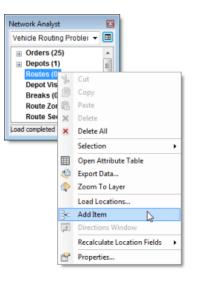
One distribution center is listed in the *Network Analyst* window under **Depots** and displayed as a depot on the map.

Adding Routes

The distribution center has three trucks, each with a maximum capacity to carry 15,000 pounds of goods. You will add three routes (one for each vehicle) and set the properties for the routes based on the center's operational procedures.

Steps:

1. In the Network Analyst window, right-click Routes (0) and choose Add Item.



A new route, **Item 1**, is added under the **Routes** class in the *Network Analyst* window, and the *Properties* window for the route opens.

2. In the *Properties* window, specify the attributes for the route as shown in the table below. The description column of the table explains the use of particular values. Leave default values for attributes not in the table.

Attribute	Value	Description	
-----------	-------	-------------	--

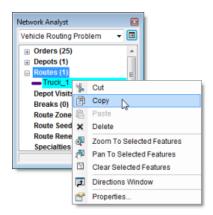
Name	Truck_1	Name of the vehicle.
StartDepotName	San Francisco	The truck starts at the distribution center.
EndDepotName	San Francisco	The truck returns to the distribution center at the end of the route.
StartDepotServiceTime	60	Time (in this case, minutes) required to fully load the truck with goods.
EarliestStartTime	8 AM	The truck can start operation as soon as the distribution center opens at 8:00 a.m.
LatestStartTime	8 AM	The truck must start operation as soon as possible.
Capacities	15000	The truck can carry a maximum of 15,000 pounds of goods.
CostPerUnitTime	0.20	The truck driver is paid 12 dollars per hour, so the wage is: \$12.00/60 minutes = \$0.20 per minute.
CostPerUnitDistance	1.5	The average dollar amount spent per mile on fuel consumption, truck depreciation, and maintenance.
MaxOrderCount	10	The maximum number of stores that can be serviced by a truck.
MaxTotalTime	360	Due to workday constraints, drivers can't have a work shift of more than six hours (360 minutes).
MaxTotalTravelTime	120	To satisfy the workday constraints and still be able to serve a reasonable number of stores—while taking into account the service time needed at a store—the truck should not spend more than two hours (120 minutes) driving on the streets.
MaxTotalDistance	80	To balance daily fuel and maintenance costs among the fleet, any one truck should not travel more than 80 miles on its route.

Properties	X
Attribute	Value
ObjectID	1
Name	Truck_1
Description	<nul></nul>
StartDepotName	San Francisco
EndDepotName	San Francisco
StartDepotServiceTime	60
EndDepotServiceTime	<nul></nul>
EarliestStartTime	8:00:00 AM
LatestStartTime	8:00:00 AM
ArriveDepartDelay	<nul></nul>
Capacities	15000
FixedCost	<nul></nul>
CostPerUnitTime	0.2
CostPerUnitDistance	1.5
OvertimeStartTime	<nul></nul>
CostPerUnitOvertime	<nul></nul>
MaxOrderCount	10
MaxTotalTime	360
MaxTotalTravelTime	120
MaxTotalDistance	80
SpecialtyNames	<nul></nul>
AssignmentRule	Include
ViolatedConstraints	<nul></nul>
OrderCount	<nul></nul>
TotalCost	<null></null>
RegularTimeCost	<nul></nul>
OvertimeCost	<nul></nul>
DistanceCost	<nul></nul>
TotalTime	<null></null>
TotalOrderServiceTime	<null></null>
TotalBreakServiceTime	<nul></nul>
TotalTravelTime	<null></null>
TotalDistance	<nul></nul>
StartTime	<nul></nul>
EndTime	<null></null>
TotalWaitTime	<nul></nul>
TotalViolationTime	<null></null>
RenewalCount	<nul></nul>
TotalRenewalServiceTime	<nul></nul>
0	K Cancel

A new route, **Truck_1**, is added to the routes class in the **Network Analyst** window.

Since the three trucks at the distribution center are the same, you can make two copies of the first truck you entered and rename them.

4. Right-click the Truck_1 route object in the Network Analyst window and choose Copy.

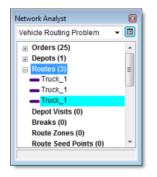


5. Right-click the Route (1) class in the Network Analyst window and choose Paste.



The Routes class contains two identical route objects.

6. Repeat the last step to create a third route object.



- Double-click the second Truck_1 object in the list. The *Properties* window opens.
- 8. Click the Name property and type Truck 2.
- 9. Press ENTER twice.

The route is given a unique name, and the window closes.

10. Use the same procedure to change the name of the last route to Truck_3.

Vehicle Routing Problem	- 🗉
Orders (25)	*
Depots (1)	
Routes (3)	E
Truck_1	
Truck_2	
Truck_3	
Depot Visits (0)	
Breaks (0)	
Route Zones (0)	
Route Seed Points (0)	*

Setting up the properties for the vehicle routing problem analysis

Steps:

1. Click the Analysis Layer Properties button on the *Network Analyst* window.

	· ·			_
Vehicle	Routing Pro	oblem	-	R

The Layer Properties dialog box opens.

- 2. Click the Analysis Settings tab.
- Make sure that the Time Attribute drop-down list is set to TravelTime (Minutes). The VRP solver will use this attribute to calculate time-based costs between orders and the depot.
- 4. Click the **Distance Attribute** drop-down list and choose **Meters**. This attribute is used to determine travel distances between orders and the depot for constraint purposes and creating directions; however, the VRP solver's objective is to minimize time costs.
- 5. Set the Default Date to Day of Week. Choose Monday in the Day of Week drop-down list.
- 6. Make sure that Capacity Count is set to 1. This setting indicates that the goods being delivered have only one measurement. In this case, that measurement is weight (pounds). If the capacities were specified in terms of two measurements, such as weight and volume, then the capacity count would be set to 2.
- Make sure that Minutes is selected for Time Field Units. This specifies that all time-based attributes, such as ServiceTime and MaxViolationTime1 for Orders and MaxTotalTime, MaxTotalTravelTime, and CostPerUnitTime for Route, are in minutes.
- Make sure that **Distance Field Units** is set to **Miles**.
 This specifies that all distance-based attributes, such as MaxTotalDistance and CostPerUnitDistance for Routes, are in miles.
- 9. Since it is difficult for these delivery trucks to make U-turns, set U-Turns at Junctions to Not Allowed.
- Select Straight Line in the Output Shape Type drop-down list. You could select either the True Shape with Measures or True Shape option if you wanted the routes to follow the streets. Note that this option only affects the display of the routes, not the results determined by the VRP solver.
- 11. Make sure that Use Hierarchy is checked.
- 12. In the Restrictions frame, make sure that RestrictedTurns and Oneway are checked.
- 13. Leave the options that are in the **Directions** frame set to their default values.

ettings		Restrictions
lime Attribute:	TravelTime (Minutes)	RestrictedTurns Oneway
Sistance Attribute:	Meters (Meters)	• Oneway
Default Date:		
Day of Week:	Monday	•
Specific Date:	9/15/2009	
apacity Count:	1	
ime Field Units:	Minutes	Directions
Vistance Field Units:	Miles	Distance Units:
-Turns at Junctions:	Not Allowed	▼ Use Time Attribute
Output Shape Type:	Straight Line	TravelTime (Minutes)
Use Hierarchy		Open Directions window automatically

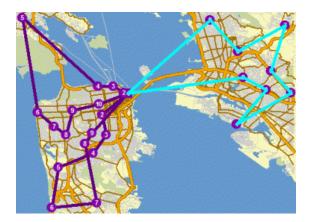
Run the process to determine the best route assignment and order sequence

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.

The VRP solver calculates the three routes required to service the orders and draws lines connecting the orders. Each route begins and ends at the distribution center and serves a set of orders along the way.

If you receive any error messages, make sure that the value of the **Capacities** attribute for the routes is set to 15000 instead of 15,000 and each route has a unique name.



Determine turn-by-turn directions for the routes

Steps:

- 1. Right-click Routes (3) in the *Network Analyst* window and click Selection > Clear Selected Features.
- Click the Directions Window button in on the Network Analyst toolbar. The Directions dialog box opens.
- Optionally, you can export the Vehicle Routing Problem layer as a layer file (<filename>.lyr) by right-clicking Vehicle Routing Problem in the *Table Of Contents* window and choosing Save As Layer File. This saves the analysis on disk so that you can add it to a different map document and reuse it later.
- 4. If you want to continue on to the following advanced sections of this tutorial exercise, close the *Directions* window. Otherwise, exit ArcMap and do not save any changes to Exercise 07.mxd.

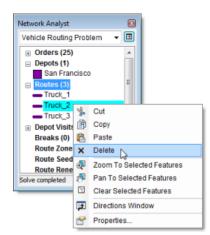
Make changes to the existing solution to solve a different scenario

The vehicle routing problem solution obtained earlier worked well for the company. After a few weeks, however, the driver assigned to Truck_2 went on vacation. So now the distribution company has to service the same stores but with just two trucks. To accommodate the extra workload, the company decided to pay overtime to the other two drivers and provide them with one paid break during the day. The distribution company also acquired two additional satellite distribution centers. These centers can be used by the trucks to renew their truckload while making their deliveries instead of returning to the main distribution center for renewal. You will modify the solution obtained from the previous step to accommodate these changes.

Deleting an existing route from a solution

Steps:

1. In the *Network Analyst* window, right-click the **Truck_2** object in the **Routes** class and click **Delete**.



Adding route renewals

The two satellite distribution centers that the company acquired are at 800 Brush Street and 100 Old County Road, and they can act as renewal locations for the trucks. The trucks can refill their cargo by visiting these renewal locations and thus save time by not returning to the starting depots. You will add the

renewal locations to the Depots network analysis class by geocoding their addresses. The routes that can renew at a renewal location and the service time for the renewal are specified in the Route Renewals network analysis class.

Steps:

- 1. In the *Network Analyst* window, right-click **Depots (1)** and choose **Find Address**. The **Find** dialog box opens.
- 2. Choose SanFranciscoLocator from the Choose an address locator drop-down list.
- 3. In the Street or Intersection box, type 800 Brush St.

🏦 Find	? 🗙
Locations	End
Choose a locator:	Stop
SanFranciscoLocator	Zoob
Street or Intersection: 800 Brush St 🗸	New Search
	۲
Options Show Standardization Show all candidates	<u>C</u> ancel

4. Click Find.

The SanFranciscoLocator, which is an address locator that was already added to the Exercise07.mxd, finds the address and shows the result at the bottom of the *Find* dialog box.

- Right-click the result on the *Find* dialog box and choose Add as Network Analysis Object. The located address is added as a depot in the *Network Analyst* window and the map display.
- 6. In the Street or Intersection box of the Find dialog box, type 100 Old County Rd.
- 7. Click Find.
- 8. Right-click the new result at the bottom of the *Find* dialog box and choose **Add as Network Analysis Object**.

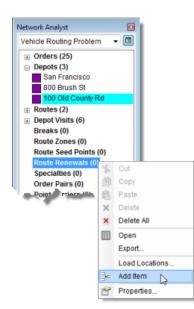
A third depot is added to the Depots network analysis class.

letwork Analyst	
Vehicle Routing Problem	- 🗉
Orders (25)	
Depots (3)	
San Francisco	
800 Brush St	
100 Old County Rd	
Routes (2)	
(Demotification)	للغمي

9. Close the *Find* dialog box.

Since both trucks are allowed to renew their loads at the 800 Brush Street and 100 Old County Road locations, you will associate each truck with the two renewal locations. The VRP solver will figure out the best renewal location for the trucks.

10. In the *Network Analyst* window, right-click Route Renewals (0) and click Add Item.



A new route renewal object, Item1, is added under the Route Renewals class in the **Network Analyst** window, and the **Properties** window for Item1 opens.

11. In the *Properties* window, specify the attributes for the route renewal as shown below.

Attribute	Value	Description
DepotName	800 Brush St	The truck can use this depot location for renewal.
RouteName	Truck_1	Name of the vehicle.
ServiceTime	30	Time in minutes required to load the truck.

Properties	. 💌
Attribute	Value
ObjectID	1
DepotName	800 Brush St
RouteName	Truck_1
ServiceTime	30
Sequences	<nul></nul>
ОК	Cancel

12. Click OK.

A new route renewal object, **800 Brush St**, is listed within the **Truck_1** item in the **Network Analyst** window.

 Follow the last three steps to add three more route renewal objects such that each truck (Truck_1 and Truck_3) can reload at both the renewal locations (800 Brush St, 100 Old County Rd).

The *Network Analyst* window should now have two route renewal objects listed within the **Truck_1** and **Truck_3** items, respectively.



Modifying routes to include overtime

To accommodate the extra workload, the company wants to remove the maximum time, maximum travel time, and maximum distance constraints for the routes. Since the drivers have to work longer than before, they are provided with overtime pay at the rate of \$18 per hour after completing six hours of work. In this step, you will make these changes to the routes.

Steps:

 In the *Network Analyst* window, under the **Routes** network analysis class, double-click Truck_1.

The Properties window opens.

2. Make changes to the attributes of Truck_1 so they match the values in the table below.

Attribute	Value	Description
OvertimeStartTime	360	The driver is paid overtime if he or she works for more than six hours (360 minutes).
CostPerUnitOvertime	0.3	The truck driver is paid \$18 per hour for the overtime. So the wage in dollars per minute is: \$18.00/60 minutes = \$0.30 per minute.
MaxOrderCount	20	Since the driver is paid overtime, he or she is expected to service more stores.
MaxTotalTime	<null></null>	There are no restrictions on the total duration of the work shift for the driver.
MaxTotalTravelTime	<null></null>	There are no restrictions on the time spent driving on the streets.
MaxTotalDistance	<null></null>	There are no restrictions on the total distance traveled by a truck.

Attribute	Value	-			
ObjectID	1	1			
Name	Truck 1	1			
Description	<null></null>	1			
StartDepotName	San Francisco	1			
EndDepotName	San Francisco				
StartDepotServiceTime	60				
EndDepotServiceTime	<null></null>	Ξ			
EarliestStartTime	8:00:00 AM				
atestStartTime	8:00:00 AM				
ArriveDepartDelay	<null></null>				
Capacities	15000				
FixedCost	<null></null>				
CostPerUnitTime	0.2				
CostPerUnitDistance	1.5				
OvertimeStartTime	360				
CostPerUnitOvertime	0.3				
MaxOrderCount	20				
MaxTotalTime	<null></null>				
MaxTotalTravelTime	<null></null>				
MaxTotalDistance	<null></null>				
SpecialtyNames	<null></null>				
AssignmentRule	Indude				
ViolatedConstraints	<null></null>	-			
(m	•				
П	Cance				

- 3. Click OK.
- 4. Repeat the last three steps for **Truck_3**.

Adding breaks

Since the drivers have to work longer, they will require one half hour break during their work shift. In this step, you will specify the breaks for each route.

Steps:

- 1. In the *Network Analyst* window, right-click **Breaks (0)** and choose **Add Item**. The *Properties* window opens.
- 2. Specify the attribute values for the new break as shown in the table below.

Attribute	Value	Description
TimeWindowStart	12:30 PM	The break has to start sometime after 12:30 p.m.
TimeWindowEnd	1:30 PM	The break has to start sometime before 1:30 p.m.
RouteName	Truck_1	The name of the route to which this break applies.
ServiceTime	30	The break duration in minutes.
MaxViolationTime	0	The break has to start between 12:30 p.m. and 1:30 p.m. The zero value indicates that the break can't start after 1:30 p.m. (that is, the break time-window is rigid).
IsPaid	True	It is a paid break, so the cost is included in the total cost of the route.

Attribute	Value	1		
ObjectID	1			
TimeWindowStart	12:30:00 PM			
TimeWindowEnd	1:30:00 PM	=		
MaxTravelTimeBetweenBreaks	<null></null>			
MaxCumulWorkTime	<nul></nul>			
RouteName	Truck_1			
Precedence	1			
Sequence	<null></null>			
ServiceTime	30			
MaxViolationTime	0			
IsPaid	True			
DelativeDecition	ALL	-		

- 3. Click OK.
- Repeat the last three steps, entering Truck_3 for the RouteName property. The *Network Analyst* window now has two objects listed under the Breaks class: Truck_1 and Truck_3.

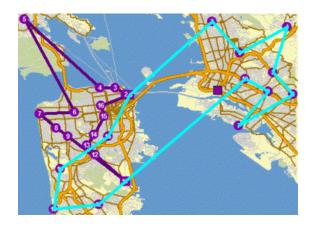
Network Analyst	
Vehicle Routing Problem 🔹	
Orders (25)	*
Depots (3)	
Routes (2)	
Depot Visits (6)	
Breaks (2)	
<unassigned> (0)</unassigned>	
Truck_1 (1)	E
12:30:00 PM - 1:30:00 PM	
Truck_3 (1)	
12:30:00 PM - 1:30:00 PM	
Route Zones (0)	
Route Seed Points (0)	-

Determining the solution

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.

The VRP solver calculates the two routes that can be used to service the orders and draws straight lines connecting the orders. Each route begins and ends at the distribution center, serves a set of orders along the way, visits a renewal location to load the truck again, continues to service the remaining orders, and finally returns to the distribution center.



This solution meets all the constraints specified by the distribution company. However, after giving the route itinerary to the two drivers, the company discovered that the driver of Truck_1 prefers driving in the downtown area and the driver of Truck_3 prefers driving in the East Bay area. The company would like to determine a new solution in which the routes service the orders that are in the areas their drivers prefer. In the next steps, you will add route seed points to incorporate these driver preferences.

Adding route seed points

Steps:

1. In the *Network Analyst* window, right-click **Route Seed Points (0)** and choose **Find Address**.

The *Find* dialog box opens.

2. In the Street or Intersection combo box, type 278 Dorantes Ave.

🏦 Find	? 🔀
Locations	Eind
Choose a locator:	Stop
SanFranciscoLocator	
Street or Intersection: 278 Dorantes Ave	New Search
	٢
Options Show Standardization Show all candidates	Cancel

3. Click Find.

The SanFranciscoLocator finds the address and shows the result at the bottom of the dialog box.

4. Right-click the result and choose Add as Network Analysis Object.

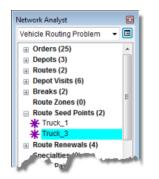
The location of the address is added as a route seed point. It is shown in the **Network Analyst** window and the map display.

- 5. Close the *Find* dialog box.
- 6. In the *Network Analyst* window, double click the new route seed point, **278 Dorantes Ave**. The *Properties* dialog box opens.
- 7. Specify the attribute values for the route seed point as shown in the table below.

Attribute	Value	Description
RouteName	Truck_1	The name of the route to which this seed point applies.
SeedPointType	Static	This makes it more likely that the orders near the specified seed point will be assigned to Truck_1.

Properties	×
Attribute	Value
ObjectID	1
RouteName	Truck_1
SeedPointType	Static
ОК	Cancel

- 8. Repeat steps 1-5 in this section to add another route seed point at 1888 Peralta St.
- Repeat steps 6 and 7 to change the RouteName attribute of the second seed point to Truck_3.



Determine the solution

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.

The VRP solver calculates the two routes that can be used to service the orders and draws straight lines connecting the orders. The route for Truck_1 includes orders in the downtown region only.

2. Exit ArcMap without saving any changes.

Exercise 8: Finding best routes to service paired orders

In this exercise, your goal is to find the best routes for a fleet of vans to transport people who would otherwise not have access to transportation from their homes to different hospitals for medical appointments. You will accomplish this by solving a vehicle routing problem (VRP) analysis using order pairs, which relate and sequence two orders (stops) so that the vans will pick up riders and take them to their proper destinations. Using other features of the VRP analysis layer, you'll also make sure that additional requirements are met. For instance, you will enter a max transit time for

Complexity: Beginner Data Requirement: ArcGIS Tutorial Data Setup Data Path: C:\ArcGIS\ArcTutor\Network Analyst\Tutorial Goal: Solve a vehicle routing problem analysis with order pairs.

order pairs so that riders don't spend too much time in transit. You'll use time windows on orders so that riders are not late for their appointments. Some riders require wheelchairs; you'll use specialties to match those riders with vans that have wheelchair lifts. Once the routes are determined, you will generate turn-by-turn directions of the resulting routes, which can be electronically distributed or printed and given to the drivers.

Preparing your display

Steps:

- 1. If you have Exercise08.mxd open in ArcMap, skip to step 6.
- 2. Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.
- On the ArcMap Getting Started dialog box, click Existing Maps > Browse for more. The Open ArcMap Document dialog box appears.
- 4. Browse to C:\ArcGIS\ArcTutor\Network Analyst\Tutorial. This is the default installation location for the tutorial data.
- 5. Double-click **Exercise08.mxd**. The map document opens in ArcMap.
- 6. Enable the Network Analyst extension.
 - a. Click **Customize** > **Extensions**. The **Extensions** dialog box opens.
 - b. Check Network Analyst.
 - c. Click Close.

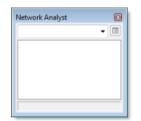
If the Network Analyst toolbar is not displayed, you need to add it.

 Click Customize > Toolbars > Network Analyst. The Network Analyst toolbar is added to ArcMap.



If the Network Analyst window is not displayed, you need to add it.

On the Network Analyst toolbar, click the Show/Hide Network Analyst Window button .
 The dockable Network Analyst window opens.

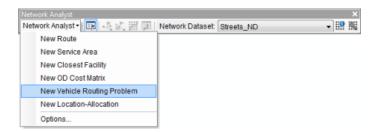


You can dock or undock the *Network Analyst* window. In this exercise, it is docked below the *Table Of Contents* window.

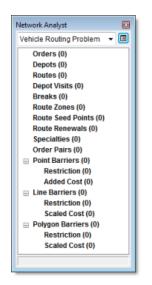
Creating the vehicle routing problem analysis layer

Steps:

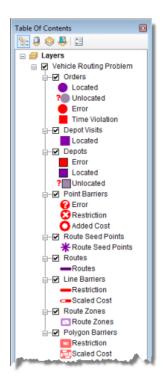
1. Click **Network Analyst** on the **Network Analyst** toolbar and click **New Vehicle Routing Problem**.



The vehicle routing problem analysis layer is added to the *Network Analyst* window. The network analysis classes (Orders, Depots, Routes, Depot Visits, Breaks, Route Zones, Route Seed Points, Route Renewals, Specialties, Order Pairs, Point Barriers, Line Barriers, and Polygon Barriers) are empty.



The analysis layer is also added to the Table Of Contents window.

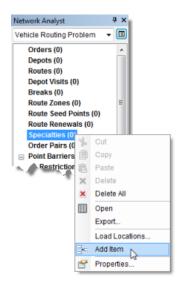


Adding specialties

The logistics company has three vans. One of the vans that operates in the downtown area is equipped to provide access for wheelchairs. You will add Wheelchair as a specialty so that the orders that require this specialty can be assigned to the route that has a wheelchair lift.

Steps:

1. In the Network Analyst window, right-click Specialties (0) and click Add Item.



A new specialty, Item 1, is added under the **Specialties** class in the **Network Analyst** window. The **Properties** window for the new specialty opens. 2. In the *Properties* window, enter Wheelchair as the value of Name.



3. Click OK.

Adding orders

A spreadsheet is provided with the tutorial data. It contains information about each patient, including their name and home address; the name and the address of the hospital they must be taken to; the time window within which the patient has to be picked up; and so on. The following table describes the fields in the spreadsheet:

Attribute	Description			
OrderName1	The name of the patient needing transportation			
PatientAddress	The location where the patient will be picked up			
OrderName2	A unique name for the destination			
HospitalAddress	The location where the patient has the appointment			
PickFrom	The earliest time the patient may be picked up from PatientAddress			
PickTo	The latest time the patient may be picked up from PatientAddress			
TotalPassengers	The total number of passengers to be picked up			
MaxTransitTime	The maximum time the patient can spend in the van			
SpecialtyNames	Specifies the special needs that are required by the passenger, for example, a wheelchair			

In this case, the passengers and hospital visits are related to each other since each passenger has to visit a predetermined hospital. You can model this situation with order pairs—by loading both patient and hospital locations into the Orders network analysis class and relating them with new order pair objects.

In the following steps, you will geocode the patient and hospital addresses and load the resulting points as orders.

Steps:

1. Click File > Add Data > Geocoding > Geocode Addresses.

(Exercise08.mxd								
	File	Edit View Bookmarks	Insert	Sele	ction Geoply				
l		New	Ctrl+N	÷ i	1:150,000				
I	8	Open	Ctrl+O		: I 🕕 🖉 📖				
ł		Save	Ctrl+S	-	1 2 2 2 2				
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		Add Data	÷	•	Add Data				
		Page and Print Setup			Add Data From ArcGIS Online		1		
		Print Preview		***	Add XY Data		1		
	۵	Print			Geocoging	•	P	Geocode Addresses 📡	
	67	Create Map Package		#,	Add Route Events			Review/Rematch Addresses	•
ľ				2	Add Query Layer			Address Locator Manager	- 1

The Choose an Address Locator to use dialog box opens.

- Click SanFranciscoLocator. The SanFranciscoLocator is included with Exercise08.mxd.
- Click OK.
 The Geocode Addresses: SanFranciscoLocator dialog box opens.
- Click the browse button next to the Address table drop-down list. The Choose a table containing addresses dialog box opens.
- Click the Look in drop-down list and choose Home Tutorial. The table that you will add is stored in an Excel spreadsheet that is included in the ArcGIS Network Analyst tutorial data.
- 6. Double-click OrderPairs.xls.
- Double-click Patients\$.
 The Patients worksheet is added to the Address table drop-down list.
- 8. In the Street or Intersection drop-down list, choose PatientAddress.
- Click the browse button next to the Output shapefile or feature class text box. The Saving Data dialog box opens at the home location for Exercise08.mxd.
- 10. Click the Look in drop-down list and choose Home Tutorial.
- 11. Click the Save as type drop-down list and choose File and Personal Geodatabase feature classes.

The list of files and workspaces is updated.

- 12. Double-click SanFrancisco.gdb.
- 13. Delete the name in the Name text box and type Patients. Patients will be the name of the output feature class.
- 14. Click Save.

The **Output shapefile or feature class** text box on the **Geocode Addresses: SanFranciscoLocator** dialog box is updated to show the new output path.

Geocode Addresses: SanFra	nciscoLocator				
Address table:					
Patients\$					
Address Input Fields					
Street or Intersection:	PatientAddress				
)				
Output					
Create static snapshot of	table inside new feature dass				
Create dynamic feature d	lass related to table				
Output shapefile or feature of	lass:				
	kAnalyst\Tutorial\SanFrancisco.gdb\P				
Config Keyword: DEFA	NULTS 👻				
Advanced Geometry Options					
Geocoding Options					
Help	OK Cancel				

The *Geocoding Addresses* dialog box opens and indicates that all 15 addresses were matched.

16. Click Close.

The geocoded addresses are added to the map document as a point feature layer, **Geocoding Result: Patients**.

- 17. Repeat steps 1–16 to load the patients' destination hospitals, but make the following changes:
 - a. In step 8, set Street or Intersection to HospitalAddress.
 - b. In step 13, type DestinationHospitals in the Name text box.

atients\$	•
Address Input Fields	
Street or Intersection:	HospitalAddress 🔹
Output	
	of table inside new feature class
Create static snapshot o Create dynamic feature Output shapefile or feature	class related to table
Create static snapshot o Create dynamic feature Output shapefile or feature	class related to table
Create static snapshot o Create dynamic feature Output shapefile or feature C:\ArcGIS\ArcTutor\Netw	class related to table
Create static snapshot o Create dynamic feature Output shapefile or feature C:\ArcGIS\ArcTutor\Netw	dass related to table e dass: orkAnalyst\Tutorial\SanFrancisco.gdb\C) FAULTS

The *Table of Contents* window should now have two feature layers, **Geocoding Results: DestinationHospitals** and **Geocoding Results: Patients**.

18. In the *Table Of Contents* window, uncheck the two geocoding results layers so that they are not visible in the map display.

In the next steps, you will load these layers into the Orders network analysis class.

- 19. In the *Network Analyst* window, right-click **Orders (0)** and choose **Load Locations**. The *Load Locations* dialog box opens.
- 20. Choose Geocoding Results: Patients from the Load From drop-down list.

The **Location Analysis Properties** section on the **Load Locations** dialog box lets you specify which attributes of the Geocoding Results: Patients layer contain the values that Network Analyst will reference in this vehicle routing problem.

- 21. Configure the properties that are listed in the **Location Analysis Properties** section so that they copy field values from the Geocoding Results: Patients layer in the way specified by the substeps below. (The next graphic highlights these changes.)
 - a. Map the **Name** property to the **OrderName1** field.
 - b. Map the **Description** property to the **PatientAddress** field.
 - c. Map the TimeWindowStart1 property to the PickFrom field.
 - d. Map the TimeWindowEnd1 property to the PickTo field.
 - e. Map the PickupQuantities property to the TotalPassengers field.
 - f. Make sure that the **SpecialtyNames** property is automatically matched to the **SpecialtyNames** field.
- 22. Type 2 under Default Value for the ServiceTime property.All patient address locations that are loaded will have a ServiceTime value of 2 to account for the average time (in minutes) that is taken for passengers to board the van.
- Type 0 under Default Value for the MaxViolationTime1 property. By setting all the MaxViolationTime1 properties to zero, the VRP solver will only search for routes that visit the orders within their time windows.

Load Location	ns					? X
Load From:		coding Result Patient	S			I 🖻
	Only st	how point layers				
Only load	selected rows					
Sort Field:			-	1		
agree lea.				J		
Location An	alysis Properti	es				
Property		Field		Default Value		*
Name		OrderName 1				
Descriptio	n	PatientAddress				
ServiceTin	ne			2		
TimeWind	owStart1	PickFrom				
TimeWind	owEnd1	PickTo				
TimeWind	owStart2					
TimeWind	owEnd2					
MaxViolati	ionTime1			0		
MaxViolati	ionTime2					
DeliveryQ	uantities					
PickupQua	antities	TotaPassengers				
Revenue						
Specialty		SpecialtyNames				
Assignmen	ntRule			Override		
RouteNam	ne					
Sequence						
CurbAppro	oach			Either side of	vehide	-
Location Po	sition					
Use Geo	una bru					
Search	Tolerance:	5000	Meters		-	
O Use Net	work Location I	Fields				
Prope	erty	Field				<u>^</u>
Source	eID					E
Source	eOID					
PosA	long					
Cidao	Alden					•
Advance					ок	Cancel

Fifteen orders are loaded. You can see them in the map display and in the **Network Analyst** window.

In the next steps, you will load the destination hospitals as orders too.

- 25. In the *Network Analyst* window, right-click **Orders (15)** and choose **Load Locations**. The *Load Locations* dialog box opens.
- 26. Choose Geocoding Results: DestinationHospitals from the Load From drop-down list.
- 27. Configure the properties that are listed in the **Location Analysis Properties** section so that they copy field values from the Geocoding Results: DestinationHospitals layer in the way specified by the substeps below. (The next graphic highlights these changes.)
 - a. Map the Name property to the OrderName2 field. Note that the value for the Name attribute has to be unique in the Orders network analysis class. In this case, there are many patients who need to visit the same hospital. So if the hospital addresses were used to derive the value of the Name attribute for Orders, then the VRP solver would return error messages as there would be duplicate Name values.
 - b. Map the **Description** property to the **HospitalAddress** field.
 - c. Map the **DeliveryQuantities** property to the **TotalPassengers** field.

d. Make sure that the **SpecialtyNames** property is automatically matched to the **SpecialtyNames** field.

28.	Type 2 under	Default Val	ue for the S	ServiceTime	property.
-----	--------------	-------------	--------------	-------------	-----------

ad From: 🧔 Geo	ocoding Result DestinationHosp	itals	-
Only	show point layers		
Only load selected rows	5		
rt Field:		•	
Location Analysis Proper	ties		
Property	Field	Default Value	^
Name	OrderName2		
Description	HospitalAddress		
ServiceTime		2	
TimeWindowStart1			
TimeWindowEnd1			
TimeWindowStart2			
TimeWindowEnd2			
MaxViolationTime1			
MaxViolationTime2			
DeliveryQuantities	TotalPassengers		_
PickupQuantities			_
Revenue			_
SpecialtyNames	SpecialtyNames		_
AssignmentRule		Override	
RouteName			=
Sequence			-
CurbApproach		Either side of vehicle	

29. Click OK.

Thirty orders are listed in the *Network Analyst* window under the Orders network analysis class and are displayed as orders on the map in the Vehicle Routing Problem layer.

Adding order pairs

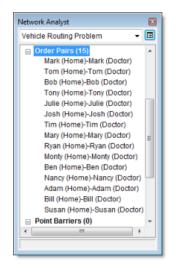
The passengers have to be taken to a predetermined hospital. By adding objects to the Order Pairs network analysis class, you can add the information that specifies which hospital the patients have to be taken to and the maximum time the patients can sit in the van during a one-way trip.

Steps:

- 1. In the *Network Analyst* window, right-click **Order Pairs (0)** and choose **Load Locations**. The *Load Locations* dialog box opens.
- 2. Click the browse button next to the Load From drop-down list.
- Click the Look in drop-down list and choose Home Tutorial. The table that you will add is stored in an Excel spreadsheet that is included in the Network Analyst tutorial data.
- 4. Double-click OrderPairs.xls.
- Double-click Patients\$.
 The Patients table is added to the Load From drop-down list on the Load Locations dialog box.
- 6. Configure the properties that are listed in the **Location Analysis Properties** section so that they pull field values from the Patients\$ table in the way specified by the substeps below.

- a. Map the FirstOrderName property to the OrderName1 field.
- b. Map the SecondOrderName property to the OrderName2 field.
- c. Make sure that the **MaxTransitTime** property is automatically matched to the **MaxTransitTime** field.
- 7. Click OK.

Fifteen order pairs are listed in the *Network Analyst* window under the **Order Pairs** network analysis class.



Adding depots

The logistics company operates vans from three depots whose locations are shown in the **CentralDepots** feature layer in ArcMap. You will now add these point features to the Depots network analysis class.

Steps:

- In the *Network Analyst* window, right-click **Depots (0)** and choose Load Locations. The *Load Locations* dialog box opens.
- 2. Select CentralDepots from the Load From drop-down list.
- 3. In the Location Analysis Properties section, make sure that the Name property is automatically matched to the Name field.

Load Locations				- 8	×
Load From:	CentralDepots			•	2
Only load sel	ected rows				
Sort Field:		•			
Location Analy Property	sis Properties Field		Default Value		
Name	Name				
Description					
TimeWindow					
TimeWindow	End 1				
TimeWindow					
ndow	End2	and the state of the	ai		
road			Sector Sector Sector		

Three depots are listed in the *Network Analyst* window under the **Depots** network analysis class and are displayed on the map in the Vehicle Routing Problem layer.

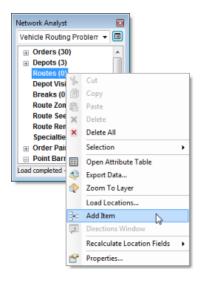
Adding routes

The logistics company has three vans, each with a maximum capacity of six passengers. The vans start and return to the depots after completing all the trips. One of the vans that operates within the downtown area has a lift to provide easy access for wheelchairs.

You will add three routes (one for each van) and set the property for the downtown van to include Wheelchair as a specialty.

Steps:

1. In the *Network Analyst* window, right-click **Routes (0)** and choose **Add Item**.



A new route, **Item1**, is added under the Routes network analysis class, and the route's *Properties* window opens.

 In the *Properties* window, specify the attributes for the route as shown in the table below, leaving the default values for the other attributes. The Description column in the table explains the use of particular values.

Attribute	Value	Description
Name	Downtown	Name of the route.
StartDepotName	Downtown Depot	The van starts at the depot in the downtown area.
EndDepotName	Downtown Depot	The van returns to the depot in the downtown area at the end of the route.
Capacities	6	The van can carry a maximum of six passengers at a time.
SpecialtyNames	Wheelchair (Check Wheelchair to set it as the value.)	The van is equipped to provide access for wheelchairs.

Attribute	Value	1
ObjectID	1	1
Name	Downtown	
Description	<null></null>	
StartDepotName	Downtown Depot	
EndDepotName	Downtown Depot	
StartDepotServiceTime	<null></null>	÷
EndDepotServiceTime	<null></null>	
EarliestStartTime	8:00:00 AM	
LatestStartTime	10:00:00 AM	
ArriveDepartDelay	<null></null>	
Capacities	6	
FixedCost	<null></null>	
CostPerUnitTime	1	1
CostPerUnitDistance	<null></null>	
OvertimeStartTime	<null></null>	
CostPerUnitOvertime	<nul></nul>	
MaxOrderCount	30	
MaxTotalTime	<null></null>	
MaxTotalTravelTime	<null></null>	
MaxTotalDistance	<null></null>	
SpecialtyNames	Wheelchair	
AssignmentRule	Indude	
ViolatedConstraints	ZMalls	

A new route, **Downtown**, is listed in the *Network Analyst* window.

4. Repeat steps 1–3 to add two more routes representing the vans that operate in the North Bay and East Bay areas. Use the following tables for these new routes instead of the properties listed in step 2.

Attribute	Value
Name	North Bay
StartDepotName	North Bay Depot
EndDepotName	North Bay Depot
Capacities	6
Attribute	Value
Name	East Bay
StartDepotName	East Bay Depot
EndDepotName	East Bay Depot
Capacities	6

Note that these vans are not equipped to allow access for wheelchairs.

The *Network Analyst* window displays three route objects listed within the **Routes** network analysis class.

letwork Analyst	2
Vehicle Routing Problem	r 🕶 🔳
Depots (3)	*
Routes (3)	
Downtown	
North Bay	=
 East Bay 	
Depot Visite (0)	
and and a second s	· · ·

Adding route zones

The three vans used by the company are only licensed to service orders in a predetermined area. You will add route zones and associate them with the vans/routes.

Steps:

- 1. In the *Network Analyst* window, select Route Zones (0).
- 2. Click the Create Network Location Tool . to the Network Analyst toolbar.
- 3. On the map display, digitize a polygon that roughly covers the downtown area as shown below.

Click to add vertices; double-click to complete the polygon.



A new route zone, **Graphic Pick 1**, is added to the route zones class in the *Network Analyst* window.

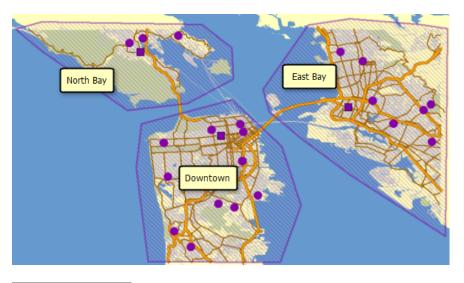
- 4. In the *Network Analyst* window, double-click the new route zone object, **Graphic Pick 1**. The route zone's *Properties* window opens.
- 5. Set the properties of the route zone as shown in the table below.

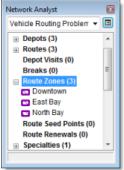
Attribute	Value	Description
RouteName	Downtown	The name of the route that this route zone is associated with.
IsHardZone	True	The van can't service orders that are outside the route zone. Setting this value to True ensures that the van is only assigned orders that are within the route zone.

Attribute	Value
ObjectID	1
RouteName	Downtown
IsHardZone	True

6. Repeat steps 1–6 to add two more route zones: one for the North Bay and one for the East Bay.

The map and the *Network Analyst* window should contain three route zone objects.





Setting up the properties for analysis

Next you will specify the properties for your vehicle routing problem analysis.

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.

Network Analyst	
Vehicle Routing Problem	R
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The Layer Properties dialog box opens.

2. Click the Analysis Settings tab.

- Make sure that the Time Attribute drop-down list is set to TravelTime (Minutes). The VRP solver will use this attribute to calculate time-based costs between orders and depots.
- Make sure that nothing is selected in the **Distance Attribute** drop-down list. Since you are not using any distance-based cost parameters, such as CostPerUnitDistance or MaxTotalDistance, setting the distance attribute is not required.
- 5. Set the **Default Date** to **Day of Week**. In the **Day of Week** drop-down list, choose **Monday**.
- Since the van capacity is measured only by the total number of passengers that can be accommodated, make sure that Capacity Count is set to 1.
 If the capacity had been measured by the total number of passengers and the maximum number of wheelchairs that can be accommodated in the van, the capacity count would be 2.
- 7. Leave the default options for the other properties.

ieneral Layers Source	Analysis Settings Advance	d Settings	Network Locations
Settings			Restrictions
Time Attribute:	TravelTime (Minutes)	-	RestrictedTurns
Distance Attribute:		•	Oneway
Default Date:			
Day of Week:	Monday	-	
Specific Date:	9/16/2009		
Capacity Count:	1		
Time Field Units:	Minutes	•	Directions
Distance Field Units:	Miles	•	Distance Units:
U-Turns at Junctions:	Allowed	-	Use Time Attribute
Output Shape Type:	True Shape with Measur	es 🔻	TravelTime (Minutes)
Use Hierarchy			Open Directions window automatically

Run the process to determine the solution

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.

The VRP solver calculates the routes for each van. Each route begins at a depot, picks up one or more people if the time they spend on the van is less than the MaxTransitTime specified in the order pair, drops them at their hospital locations, continues to pick up and drop off other people, and returns to the depot at the end. The routes only service orders in their assigned route zones.



Determine turn-by-turn directions for the routes

Steps:

- Click the Directions Window button and the Network Analyst toolbar. The Directions dialog box opens.
- 2. You can optionally export the vehicle routing problem as a layer file (<filename>.lyr) on disk so that you can load it in a different map document.
- 3. Exit ArcMap without saving any changes.

Exercise 9: Choosing optimal store locations using location-allocation

In this exercise, you will choose the store locations that would generate the most business for a retail chain. The main objective is to locate stores close to population centers, which provide demand for the stores. This objective is based on the premise that people tend to shop more at nearby stores than at those that are farther away. You will perform the location-allocation analysis using three different problem types: maximize attendance, maximize market share, and target market share. The differences among these problem types will become apparent as you work through the exercise.

Complexity: Beginner Data Requirement: ArcGIS Tutorial Data Setup Data Path: C:\ArcGIS\ArcTutor\Network Analyst\Tutorial Goal: Choose store locations using a locationallocation analysis.

Preparing your display

Steps:

- 1. If you have Exercise09.mxd open in ArcMap, skip to step 6.
- 2. Start ArcMap by clicking Start > All Programs > ArcGIS > ArcMap 10.
- 3. On the *ArcMap Getting Started* dialog box, click **Existing Maps** > **Browse for more.**
- Browse to C:\ArcGIS\ArcTutor\Network Analyst\Tutorial. This is the default installation location for the tutorial data.
- 5. Double-click **Exercise09.mxd**. The map document opens in ArcMap.
- 6. Enable the Network Analyst extension.
 - a. Click **Customize** > **Extensions**. The **Extensions** dialog box opens.
 - b. Check Network Analyst.
 - c. Click Close.

If the Network Analyst toolbar is not displayed, you need to add it.

 Click Customize > Toolbars > Network Analyst. The Network Analyst toolbar is added to ArcMap.

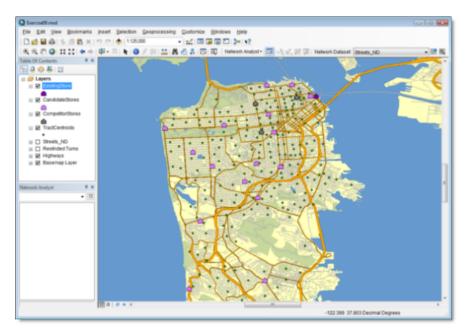


If the Network Analyst window is not displayed, you need to add it.

On the *Network Analyst* toolbar, click the Show/Hide Network Analyst Window button .
 The dockable *Network Analyst* window opens.



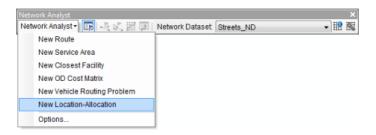
You can dock or undock the *Network Analyst* window. In this exercise, it is docked below the *Table Of Contents* window.



Creating the location-allocation analysis layer

Steps:

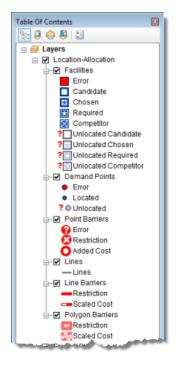
1. Click Network Analyst on the Network Analyst toolbar and click New Location-Allocation.



The location-allocation analysis layer is added to the *Network Analyst* window. The network analysis classes (Facilities, Demand Points, Lines, Point Barriers, Line Barriers, and Polygon Barriers) are empty.

Vetwork	: Analyst			
Locatio	on-Allocation	ı	•	
Fa	cilities (0)			
De	mand Point	s (0)		
Lin	ies (0)			
😑 Po	int Barriers	(0)		
	Restriction	ı (0)		
	Added Cos	t (0)		
😑 Lin	e Barriers	(0)		
	Restriction	ı (0)		
	Scaled Co	st (0)		
🗆 Po	lygon Barri	ers (0)		
	Restriction	ı (0)		
	Scaled Cos	st (0)		

The analysis layer is also added to the Table Of Contents window.



Adding candidate facilities

You will add the candidate store locations to the network analysis class Facilities. These are the potential places where you can open a store. The solution from the location-allocation process will include a subset of these stores.

The candidate store locations are already added as a layer (CandidateStores) in the map document. The names of the stores are contained in the layer's attribute table. You will load the point features from CandidateStores into the Facilities class of the location-allocation layer.

Steps:

1. In the *Network Analyst* window, right-click Facilities (0) and choose Load Locations.

Network Analyst	ά ×
Location-Allocation	- 🔲
Facilities (0)	
Demand Po	Cut
Lines (0)	Сору
😑 Point Barri	Paste
Restric	Delete
Added	Delete All
😑 Line Barrie 🐣	
Restric	Selection •
Scaled Polygon Ba	Open Attribute Table
Polygon Ba Restric	Export Data
Scaled 🔷	Zoom To Layer
28	Find Address
	Load Locations
	Recalculate Location Fields
e	Properties

The Load Locations dialog box opens.

2. Select CandidateStores from the Load Locations drop-down list.

Load Locations				? 💌
-			×	
Property	Field		Default Value	
Name	NAME			
FacilityType	THE REAL		Candidate	
Weight			1	
CurbApproach	1		Either side of	fvehide
Location Position	гу	00 Meters		•
© Use <u>N</u> etwork	Location Fields			
Property		Field		<u>^</u>
SourceID SourceOI PosAlong SideOfEd				
Advanced			0	OK Cancel

The **Location Analysis Properties** section of the **Load Locations** dialog box lets you specify which attributes of the CandidateStores feature class contain the values that Network Analyst will use to solve this location-allocation problem.

3. In the Location Analysis Properties section, make sure the Name property is automatically mapped to the NAME field.

Network Analyst tries to match location analysis properties automatically for a newly created location-allocation layer based on a configuration file (usually located in C:\Program Files\ArcGIS\Desktop10.0\NetworkAnalyst\NetworkConfigurations\NASolverConfiguration.xml).

4. Click OK.



Sixteen candidate stores are loaded into the Facilities network analysis class. The new facilities are listed in the **Network Analyst** window and displayed on the map.

Adding Demand Points

The stores need to be located to best service the existing populations. A point layer of census tract centroids is already added to ArcMap. Now you will load these centroids into the demand points network analysis class.

Steps:

- 1. In the *Network Analyst* window, right-click **Demand Points (0)** and choose Load Locations.
- 2. Select TractCentroids from the Load Locations drop-down list.
- 3. In the Location Analysis Properties section, make sure the Name property is automatically mapped to the NAME field.
- Click the Field column for the Weight property and choose POP2000.
 Each demand point will be weighted by the population from the 2000 census.
- 5. Click OK.

The 208 census tract centroids are loaded into the Demand Points class. The new demand points are listed in the *Network Analyst* window and displayed on the map.



Setting up the properties of the location-allocation analysis

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.

Network Analyst	ų ×
Location-Allocation	- 🖳
Internet de la carde	L h

The Layer Properties dialog box opens.

- 2. Click the Analysis Settings tab.
- 3. Make sure that Impedance is set to TravelTime (Minutes).
- 4. Set Travel From to Demand to Facility.

The default option, **Facility to Demand**, is a good choice for the classic minimize impedance and maximize coverage problem types. However, for maximize attendance, maximize market share, and target market share, the demand tends to travel to the facilities, thus **Demand to Facility** is often a good choice for them.

- 5. Click the U-Turns at Junctions drop-down arrow and choose Allowed.
- Set Output Shape Type to Straight Line. Although the output will be displayed with straight lines, the travel costs are still measured along the network.
- 7. Make sure that the Use Hierarchy and Ignore Invalid Locations boxes are checked.
- 8. In the **Restrictions** frame, make sure that **RestrictedTurns** and **Oneway** are checked.

Your Analysis Settings tab should look like the following graphic:

Layer Properties					? X
	alysis Settings TravelTime (M Allowed Straight Line	Advanced Settings inutes)	Accumulation Restrictions V Restricted Oneway	Network Locations	
			ОК	Cancel	Apply

- 9. Click the Advanced Settings tab.
- Click the Problem Type drop-down list and choose Maximize Attendance.
 These problem types are often referred to as models. Maximize attendance is a good problem type for choosing retail store locations, since it assumes that all stores are equally attractive

Layer Properties	
ieneral Layers Source	Analysis Settings Advanced Settings
Advanced Settings	- Pi
Problem Type:	Maximize Attendance
Facilities To Choose:	Minimize Impedance Maximize Coverage Minimize Facilities
Impedance Cutoff:	Maximize Attendance Maximize Market Share Target Market Share

and people are more likely to shop at nearby stores.

- 11. Increase Facilities To Choose to 3. ArcGIS will try to choose 3 facilities out of the 16 to optimally serve the 208 demand points.
- 12. Increase Impedance Cutoff to 5.

This setting implies that people are not willing to travel more than five minutes to shop at these stores. The units for this value are determined by the units of the impedance attribute. Therefore, since TravelTime uses minutes, this value is also in minutes.

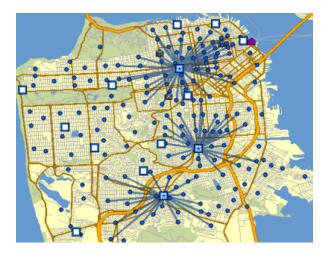
- 13. Make sure that **Impedance Transformation** is set to **Linear**. ArcGIS will use a linear decay in calculating people's propensity to visit a store. That is, with a five-minute impedance cutoff and a linear impedance transformation, the probability of visiting a store decays at 1/5, or 20 percent; therefore, a store one minute away from a demand point has an 80 percent probability of a visit compared to a store four minutes away, which only has a 20 percent probability.
- 14. Click OK.

Run the process to determine the best store locations

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.

Once the solve process is completed, lines in the map display connect chosen stores to their associated demand points. The lines also appear in the Lines class in the **Network Analyst** window.



Now you will inspect the results in more detail.

2. In the **Table Of Contents**, right-click the **Facilities** sublayer and choose **Open Attribute Table**.



Examine the attributes of the Facilities table. Three of the features have their FacilityType field values set to Chosen instead of the default status, Candidate.

The DemandCount column lists the number of demand points assigned to each of the chosen facilities. Note that out of the 208 demand points, only 113 were allocated to the chosen facilities because some of the points were farther than the five-minute cutoff.

The DemandWeight column lists the demand that is allocated to each facility. In this case, the value represents the number of people that are likely to shop at the store.

- 3. Close the *Facilities* table.
- 4. In the Table Of Contents, right-click the Demand Points sublayer and choose Open Attribute Table.

Table Of Contents	4	×
🏡 📮 📚 🦊 🖾		
🗆 😅 Layers		A
Location-Allocation	on	
Facilities		
🖨 🗹 🖸 Demand Poin	nte	
Error		Сору
Let ed.	×	Remove
E		Open Attribute Table
		Joins and Relates
	h.,	Zoom Text ayer

Examine the attributes of the Demand Points table. The Facility ID column has a value of <Null> if the demand point was outside the five-minute cutoff, but if a numeric value is present, it represents the ID of the chosen facility the demand point was allocated to.

The Weight column contains the population count that was loaded from the census tract feature class. The AllocatedWeight column contains the amount of demand that was apportioned to the associated facility. The amount of weight allocated is based on the linear distance decay and the five-minute cutoff parameters you set in the *Layer Properties* dialog box.

5. In the **Table Of Contents**, right-click the **Lines** sublayer and choose **Open Attribute Table**.

This table contains one record for each demand point allocated to a facility. It also lists the shortest path impedance between the two locations and the weight captured by the facility.

Adding a required facility

In the previous section, you generated results for where to locate three new stores. In this section, you will use location-allocation to solve a store-expansion scenario, in which you will start with an existing store and optimally locate two additional stores.

Steps:

- 1. In the *Network Analyst* window, right-click **Facilities (16)** and choose **Load Locations**. The *Load Locations* dialog box opens.
- 2. Select ExistingStore from the Load From drop-down list.
- 3. In the **Location Analysis Properties** section, make sure that the **Name** property is automatically matched to the **NAME** field.
- 4. In the **Default Value** column for **Facility Type**, change **Candidate** to **Required**. This ensures that when the store is loaded as a facility, it will have a status of Required. Required facilities must always be part of the solution.

Network Analyst Tutorial

	ExistingStore Only show point layers	<u>.</u>	·
Only load selected	rows		
t Field:		-	
ocation Analysis Pr	operties		
Property	Field	Default Value	
Name	NAME		
FacilityType		Required	
Weight		Candidate	
CurbApproach		Required	
		Competitor 48 Chosen	

5. Click OK.

Setting up the properties of the analysis (maximize attendance with required facility)

You will use the same properties from the previous solution to solve this problem.

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.



The Layer Properties dialog box opens.

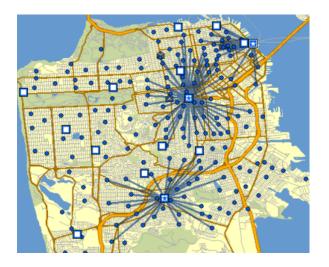
- 2. Make sure that the problem type is set to **Maximize Attendance**, the facilities to find is **3**, the impedance cutoff is **5**, and the impedance transformation is **Linear**.
- 3. Click OK.

Run the process to determine the best store locations (maximize attendance with required facility)

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.

When the solve process is complete, lines connect chosen stores to demand points. Note that the original solution changed, and the ExistingStore location is now part of the solution. The other two chosen facility locations are now at different places.



Adding competing facilities

Location-allocation can locate new stores to maximize market share in light of competing stores. The market share is computed using a Huff, or gravity, model. A Huff model assumes that demand points have a probability of visiting stores based on some properties of the store as well as the distance away from that store.

Steps:

- 1. In the *Network Analyst* window, right-click Facilities (17) and choose Load Locations.
- 2. Choose CompetitorStores in the Load From drop-down list.
- 3. In the Location Analysis Properties section, make sure that the Name property is automatically matched to the NAME field.
- 4. In the **Default Value** column for **Facility Type**, change **Candidate** to **Competitor**.

d From:	CompetitorStores	<u>•</u>
Only load <u>s</u> e	elected rows	
t Field:		•
ocation Ana	lysis Properties	
Property	Field	Default Value
Name	NAME	
FacilityType	2	Competitor -
Weight		Candidate
	ach	Required
CurbApproa		Competitor N

5. Click OK.

Setting up the properties of the analysis (maximize market share)

You will change the properties of the location-allocation analysis layer so that it solves using the maximize market share problem type.

Steps:

1. Click the Analysis Layer Properties button on the *Network Analyst* window.

Network Analyst	ţ	×
Location-Allocation	-	R
Contraction of American State	<u>.</u>	-63

The Layer Properties dialog box opens.

- 2. Click the Advanced Settings tab.
- 3. Click the **Problem Type** drop-down list and choose **Maximize Market Share**.

General	Layers	Source	Analysis Settings	Advanced Settings
Advan	ced Settir	ngs		
Proble	m Type:		Maximize Mark	ket Share 💌
Eaclities To Choose:		Minimize Impe Maximize Covi Minimize Facili Maximize Atte	erage ties	
Impedance <u>O</u> utoff:		Maximize Mari Target Market		

- Click the Impedance Transformation drop-down list and choose Power.
 ArcGIS will use a power distance decay in determining people's propensity to visit a store.
 Notice that Impedance Parameter becomes available for you to edit.
- 5. Change the **Impedance Parameter** value to **2**.

An impedance parameter of 2 on a power impedance transformation means the probability of visiting a store decays with the square of the distance between a demand point and a facility location. Usually, an accurate value of the impedance parameter is computed from other analyses, such as those provided by using ArcGIS Business Analyst.

The Advanced Settings tab should look like the following graphic:

Layer Properties							
General Laye	rs Source	Analysis Settings	Advanced Settings	Accumulation	Network Locations		
-Advanced Se	ttings		Problem Type Description				
Problem Type:		Maximize Mark	Maximize Market Share 🔹		Maximize Market Share		
Eaclities To Choose:		3	3				
Impedance <u>O</u> utoff:		5	5				
Impedance Transformation:		Power	Power 🔻				
Impedance Parameter:		2	2				
Target Market Share (%):		: 10	10 *		This option solves the competitive ta location problem. It chooses facilities maximize market share in the presen competitive facilities. Gravity model concepts are used to determine the proportion of demand allocated to e facility. The set of facilities that max the total allocated demand is chosen		
				ОК	Cancel	Apply	

Run the process to determine the best store locations (maximize market share)

Steps:

- 1. Click **Network Analyst** on the **Network Analyst** toolbar and click **Options**. The **Network Analyst Options** dialog box opens.
- 2. Click the General tab.
- 3. Click All Messages.

By choosing **All Messages** with a market share problem, the market share you capture will be reported in a dialog box once the solve process is completed.

- 4. Click OK.
- Click the Solve button # on the Network Analyst toolbar. When the solve process is completed, a message indicates how much of the market share you captured.
- 6. Close the message box.

Lines in the map connect demand points to chosen and competitor stores. Notice the chosen stores have changed to maximize the amount of demand given the presence of the three competitors.

The lines overlap more than in the previous solutions, since each demand point in the maximize market share problem can interact with all the facilities that are within the impedance cutoff.

7. In the *Table Of Contents*, right click the **Facilities** sublayer and choose **Open Attribute Table**.

Three facilities have a FacilityType value of Competitor, one has a value of Required, and two have a value of Chosen, which indicates the solver chose them as the best facilities to open.

The DemandCount column lists the number of demand points assigned to each of the facilities. Note that some demand points were not assigned, since they were outside the five-minute cutoff.

The DemandWeight column lists the sum of the demand weight assigned to each of the chosen facilities. The weight assigned to your stores versus that assigned to the competitor stores can be used to figure out the market share that was reported after the solve process finished.

Achieving a target market share

In the last section, the three stores chosen accounted for 33.79 percent of the market share. Say, however, you want to capture 70 percent of the market share. You need to know the minimum number of stores that would be needed, and where they should be located, to accomplish that goal. The target market share problem type can help you find the answer.

Steps:

1. Click the Analysis Layer Properties button on the Network Analyst window.

Network Analyst	4 ×
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The Layer Properties dialog box opens.

- 2. Click the Advanced Settings tab.
- Click the Problem Type drop-down list and choose Target Market Share. Notice that when you change the problem type to Target Market Share, the Target Market Share (%) property becomes available for you to edit.
- 4. Change Target Market Share (%) to 70.

The Advanced Settings tab should look like the following graphic:

Layer Properties								
		Analysis Settings	Advanced Settings	Accumulation	Network Locations			
Advanced Settings		Anayao Joungo	Problem Type Description					
Problem Type:		Target Market Share 🔻		rel to				
Fadities To Choose:		3						
Impedance Cutoff:		5						
Impedance Transformation:		Power	Power 💌					
Impedance Parameter:			2		Target Market Share			
Target Market Share (%):		: 70	×	This option solves the competitive facility location problem. It chooses facilities to reach a specified target market share in the presence of competitive facilities. Gravity model concepts are used to determine the proportion of demand allocated to each facility. The minimum number of facilities needed to reach the specified target market share is chosen.				
				ОК	Cancel Acoly			

Run the process to determine the best store locations (target market share)

Steps:

1. Click the **Solve** button **#** on the **Network Analyst** toolbar.

When the solve process is complete, a message indicates how much of the market share you captured and the total number of facilities required to capture that share. The percentage is more than the 70 percent you had indicated, because opening any fewer facilities would result in a market share below your target of 70 percent.

2. Close the message box.

Once again, lines connect the solution facilities to demand points in the map display.

3. In the *Table Of Contents*, right-click the **Facilities** sublayer and choose **Open Attribute Table**.

In addition to the three competitor facilities and the one required facility, nine facilities now have a FacilityType value of Chosen. This means nine additional stores are needed to achieve the 70 percent market share.

- 4. If you don't plan to work on any other exercise, exit ArcMap. Click **No** to discard any changes.
- 5. If you plan to work on another exercise, follow the substeps below.
 - a. Click **File** > **New.** The **New Document** dialog box opens.
 - b. Click OK.
 - c. Click **No** when prompted to save changes.