Introductions

• Who are we?
  - Network Analyst Product Engineers

• Who are you?
  - Current Network Analyst users?
  - Current geoprocessing users?
  - Have made geoprocessing models?
  - Experience with Python?
  - Have made geoprocessing python scripts?
Topics

• ArcGIS Network Analyst extension concepts
• Geoprocessing framework for network analysis
• Building geoprocessing models
• Writing Python scripts and building script tools
• Support and resources
• Network Analyst at the User’s Conference
• Questions
Network Analyst Extension Concepts

More Information:
What is Network Analyst in ArcGIS Desktop help
ArcGIS Network Analyst Extension

Solving transportation problems

- Route
- Closest Facility
- Service Area
- Location-Allocation
- Vehicle Routing Problem
- Origin-Destination Cost Matrix
Network Dataset

Transportation Network

Data Model

Network Dataset

Geodatabase

Shapefile Streetmap
Where do you get street data?

- **Free data**
  - Data and Maps DVD
  - TIGER

- **Community data**
  - OpenStreetMap

- **Your data**

- **Vendor data**
Network Analysis Layer

- Composite layer configured for a specific solver.
- Stores analysis properties, inputs, and outputs from the solver.
- Contains **Network Analysis Classes** that store Network Analysis Objects.
Geoprocessing Framework

More Information:

The geoprocessing framework in ArcGIS Desktop help
Geoprocessing Framework

What is Geoprocessing?

- **Compute**
- **Visualize**
- **Manage**
- **Automate GIS Tasks**
- **Modeling & Analysis**

Geoprocessing Framework
Using Geoprocessing – How?

- Accessed through ArcToolbox

- Network Analyst Tools
  - Performing Network Analysis
  - Building networks
  - Managing turns
Using Geoprocessing – How?

- Geoprocessing Framework
- Single tool execution
- Tool dialog
- Python window
- Chain tools
- Model
- Script

Using Geoprocessing – How?
Using Geoprocessing – Where?

Geoprocessing Framework

Server

Mobile

Desktop/Engine

Geoprocessing Tools

Model tools

Script tools

System (built-in) tools

- Allocation Problems
- Determine Optimum Allocation
- School Allocation Problem Model
- Transportation Problem Model

- Closest Facilities Service
- Apply Style Sheet
- Find Closest Facilities to Incidents

- Gravity Modeling Tools
- Determine Accessibility
- Determine Spatial Interaction
- Network Central Feature

- Network Analyst Tools
- Analysis
- Network Dataset
- Turn Feature Class
- Service Area Tools
- Find Service Area
Building Geoprocessing Models

More Information:

Geoprocessing with Model Builder in ArcGIS Desktop help
Network Analysis Workflow

1. Make Network Analysis Layer
2. Add locations to one or more Network Analysis Classes
3. Solve
4. Use the results
Demo: Geoprocessing Models

Authoring a simple route model
Demo: Geoprocessing models - takeaways

- You can easily share models as tools

- If running models as tools, make the output network analysis layer as model parameter so that it is added to the ArcMap Table of contents

- Network analysis layer is the derived output from most of the tools (Add Locations, Solve)
Geoprocessing Models

- Chain geoprocessing tools to perform a workflow
- Authored using the Model Builder application
- Models behave like any other tools within ArcToolbox
  - Can use a model within another model
- All Model Builder techniques apply when authoring models for network analysis
Example Model to perform Service Area Analysis

- Numbers refer to steps in Network Analysis workflow
Adding analysis results to ArcMap

- If running models as tools, make the output network analysis layer a model parameter. This will add the layer to the ArcMap Table of Contents.
Post-processing your analysis

- Use **Select Data** tool to access individual sublayers from an analysis layer
Demo: Geoprocessing Models

Authoring a model to determine multiple routes from a text file containing start and end addresses
Demo: Geoprocessing models - takeaways

- Use the **Select Data** tool to access sublayers of a network analysis layer

- Incorporate external data (csv in this example) into your analysis

- Automate your workflows without code

- Model tools can be added as buttons on any toolbar

- If network analysis layer is intermediate data, explicitly delete it as a last step
Writing Python Scripts

More Information:

Geoprocessing with Python in ArcGIS Desktop help
Python Scripts

- **Used for**
  - Conditional logic
  - Looping
  - Cursors, creating geometry
  - Accessing built-in and third party python modules

- **ArcPy site package**
  - Access any geoprocessing tool (including network analyst tools)
  - Other useful functions and classes such as Describe

- Python scripts can be run cross platform
# Import arcpy and other system modules

```python
import arcpy
from arcpy import env
import traceback
import sys
```

# Set environment settings
```python
temp_data_folder = r'C:\data\SanFrancisco.gdb'
temp_out_datasets = True
```

# Set local variables
```python
inNetworkDataset = "Transportation/Streets_NO"
outNALayer = "StoreRoute"
impedanceAttribute = "TravelTime"
startLocation = "Analysis/distributionCenter"
storeLocations = "Analysis/Stores"
fieldMappings = "Name Name #; Attr_TravelTime ServiceTime #"
outLayerFile = "C:\data\output" + "/" + outNALayer + ".lyr"
```

# Create a new route layer. The route starts at the distribution center and
# takes the best sequence to visit the store locations.
```python
arcpy.MakeRouteLayer_na(inNetworkDataset, outNALayer, impedanceAttribute,
                        "FIND_BEST_ORDER", "PRESENTE_FIRST", "", ["Meters"],
                        "NO_UTURNS", start_date_time="9 AM")
```

# Load the distribution center as the start location using default field
# mappings and search tolerance
```python
arcpy.AddLocations_na(outNALayer, "Store", startLocation, "", "")
```
Python Script - Basic Building Blocks

```python
# Import arcpy and other system modules
import arcpy
from arcpy import env
import traceback
import sys

try:
    # Check out the Network Analyst extension license
    arcpy.CheckOutExtension("Network")

    env.overwriteOutput = True

    # Set local variables
    inNetworkDataset = "Transportation/Streets_MD"
    outNALayer = "StoreRoute"
    impedanceAttribute = "TravelTime"
    startLocation = "Analysis/DistributionCenter"
    storeLocations = "Analysis/Stores"
    fieldMappings = "None Name $\}; Attr TravelTime ServiceTime $\"
    outLayerFile = "C:\Data\output\" + output + outNALayer + ".lyr"

    # Create a new route layer. The route starts at the distribution center and
takes the best sequence to visit the store locations.
```

Check out the Network Analyst Extension
Python Script - Basic Building Blocks

```python
# Import arcpy and other system modules
import arcpy
from arcpy import env
import traceback
import sys

try:
    # Check out the Network Analyst extension license
    arcpy.CheckOutExtension("Network")

# Set local variables
inNetworkDataset = "Transportation/Streets_ND"
outNALayer = "StoreRoute"
impedanceAttribute = "TravelTime"
startLocation = "Analysis/DistributionCenter"
storeLocations = "Analysis/Stores"
fieldMappings = "Name Name #; Attr_TravelTime ServiceTime #"
outLayerFile = "C:/data/output" + "/" + outNALayer + ".lyr"

# Set the route layer. The route starts at the distribution center and
# takes the best sequence to visit the store locations.
arcpy.MakeRouteLayer_na(inNetworkDataset, outNALayer, impedanceAttribute,
                        "FIND_BEST_ORDER","PREERVE_FIRST", ",", ["Meters"],
                        "NO UTBURNS",start date time="8 AM")
```

Set inputs and outputs
Writing Python Scripts

Python Script - Basic Building Blocks

```python
# Make network analysis layer
arcpy.CheckOutExtension("Network")
# Set environment settings
env.workspace = "C:/Data/SanFrancisco.gdb"
env.overwriteOutput = True
# Set local variables
inNetworkDataset = "Transportation/Streets_NP"
outNALayer = "StoreRoute"
impedanceAttribute = "Distance"

# Create a new route layer. The route starts at the distribution center and
# takes the best sequence to visit the store locations.
arcpy.MakeRouteLayer_na(inNetworkDataset,outNALayer,impedanceAttribute,
    "FIND_BEST_ORDER","PRESERVE_FIRST",",",["Meters"],
    "NO_UTURNS",start_date_time="8 AM")

# Load the distribution center as the start location using default field
# mappings and search tolerance
arcpy.AddLocations_na(outNALayer,"Store",startlocation,"","")
# Load the store locations as stops. Make sure the store locations are
```
# Load the distribution center as the start location using default field mappings and search tolerance
arcpy.AddLocations_na(outNALayer, "Stops", startLocation, "", "")

# Load the store locations as stops. Make sure the store locations are appended to the Stops sublayer which already contains the distribution center location. Map the Attr TravelTime property from the ServiceTime field so that the total travel time for the route will also contain the service time
arcpy.AddLocations_na(outNALayer, "Stops", storeLocations, fieldMappings, "", "", "APPEND")

# Solve the na layer
arcpy.Solve_na(outNALayer, "SKIP")

# Save the solved na layer as a layer file on disk using relative paths
arcpy.SaveToLayerFile_management(outNALayer, outLayerFile, "RELATIVE")
Writing Python Scripts

Python Script - Basic Building Blocks

```python
storelocations $\Rightarrow$ Analysis/Stores
fieldMappings $\Rightarrow$ Name, Name #, Att/TravelTime, ServiceTime #
outlayerfile $\Rightarrow$ C:\data\output + / + outNALayer + .lyr

#Create a new route layer. The route starts at the distribution center.
#Take the best sequence to visit the store locations.
arcpy.MakeRouteLayer_na(inNetworkDataset, outNALayer, impedanceAttribute,
  "FIND_BEST_ORDER", "RESERVE_FIRST", "", ["Meters"]
  "NO_UTURNS", start data_time="3 AM")

#Load the distribution center as the start
#Map the best path and search tolerance
arcpy.AddLocations_na(outNALayer, "stops")

#Load the store locations as stops. Make sure the store locations are
#Append to the Stops sublayer which already contains the distribution
#Center in the ServiceTime
#It also contains the

#Solve the na layer
arcpy.Solve_na(outNALayer, "SKIP")

#Solve the na layer.
arcpy.Solve_na(outNALayer, "SKIP")

#Save the solved na layer as a layer file on disk using relative paths.
arcpy.SaveToLayerFile_management(outNALayer, outlayerFile, "RELATIVE")
print "Script completed successfully!"

Solve the network analysis layer
```
Python Script - Basic Building Blocks

```python
# Sample Python script

# Import necessary libraries
import arcpy

# Define variables
startlocation = "Analysis/DistributionCenter"
storeLocations = "Analysis/Stores"
fieldMappings = "Name Name #: Attr_TravelTime ServiceTime #"
outDirectionsFile = "C:/data/output" + "/" + outNALayer + ".directions.txt"
outlayerFile = "C:/data/output" + "/" + outNALayer + ".lyr"

# Create a new route layer. The route starts at the distribution center and
# takes the best sequence to visit the store locations.
arcpy.MakeRouteLayer_na(inputNetworkDataset, outNALayer, impedenceAttribute,
"FIND_BEST_CIRC,"PRESENCE_FIRST", "", ['Meters'],
"NO_STOURS", startDataTime="8 AM")

# Load the distribution center as the start location using default field
# mappings and search tolerance
arcpy.AddLocations_na(outNALayer, "Stops", startlocation, ",", ",")

# Load the store locations as stops. Make sure the store locations are
# grouped to the stops sublayer which already contains the distribution
# center location. Map the Attr_TravelTime property from the ServiceTime
# field so that the total travel time for the route will also contain the
# service time
arcpy.AddLocations_na(outNALayer, "Stops", storelocations, fieldMappings, ",", ",", ",", "APPEND")

# Solve the na layer
arcpy.Solve_na(outNALayer, ".\"\"")

# Save the solved na layer as a layer file on disk using relative paths
arcpy.SaveToLayerFile_management(outNALayer, outlayerFile, "RELATIVE")

print "Script completed successfully"
```

Use the results
Working with analysis layers within scripts

• The network analysis layer can be referenced within the script using its name (as a string)

```python
# Create string variable to represent an analysis layer
myServiceAreaLayer = "Service Area"

# Use that variable to reference an analysis layer as a parameter
arcpy.MakeServiceAreaLayer_na(myNetworkDataset, myServiceAreaLayer, "Traffic"

arcpy.AddLocations_na(myServiceAreaLayer, "Facilities", storeLocations,
arcpy.Solve_na(myServiceAreaLayer, "SKIP")
```
Accessing sublayers in scripts

- The Select Data tool is not meant for python scripting. To access sublayers in python scripts, use the syntax:

  `<Analysis Layer Name> + os.sep + <Sublayer Name>`

```python
polygonsSubLayer = myServiceAreaLayer + os.sep + "Polygons"
arcpy.CopyFeatures_management(polygonsSubLayer, outFeatureClass)
```
Saving analysis results

• The in-memory network analysis layer can be persisted using `SaveToLayerFile` geoprocessing tool.

```python
arcpy.SaveToLayerFile_management(myServiceAreaLayer, "c:\MyPath\MyLayer.lyr", "RELAY"
```
Authoring a Python script that finds the best sequenced route for given stops
Demo: Python Script - takeaways

- The network analysis layer can be referenced within the script using its name.

- The in-memory network analysis layer can be persisted using `SaveToLayerFile` geoprocessing tool.

- The sublayers within a network analysis layer are feature layers that can be used with many other tools.

- Scripts can be created by exporting a model to a script.

- Scripts can be run at the operating system command prompt.
Building Script Tools

More Information:

Creating script tools with Python scripts in ArcGIS Desktop help
Script Tools

- Add standalone geoprocessing scripts to ArcToolbox as script tools

- Script tools behave like any other tool within ArcToolbox
  - Can use script tools in models and vice versa

- Convenient method for providing a user interface for scripts within ArcGIS desktop
Add outputs from script tool to ArcMap

- If network analysis layer is the output, make an additional derived output parameter of type Network Analyst Layer and use `arcpy.SetParameterAsText(...)`

```python
# Do your analysis workflow
myServiceAreaLayer = "Service Area"
arcpy.MakeServiceAreaLayer_na(myNetworkDataset, myServiceAreaLayer, ""

# Set your analysis layer as an output parameter for the script tool
arcpy.SetParameterAsText(1, myServiceAreaLayer)
```
1. Creating a script tool to provide a UI for a Python script
2. Solve an allocation problem assigning students to schools with capacity constraints
Determine Optimum Allocation Script Tool

• Scripts can take advantage of all the capabilities provided by the python language

• Call third party applications that support python interface to have a “tightly coupled” approach

• For example, calling linear programming (LP) solvers using PuLP
  - PuLP is a public domain Python module for modeling LP problems
  - PuLP can work with a variety of LP solvers such as COIN-OR, GLPK, XPRESS, CPLEX.
Demo: Script Tool - takeaways

• If network analysis layer is the output, make an additional derived output parameter of type Network Analyst Layer and use `arcpy.SetParameterAsText()`

• Custom validation logic can be programmed for the script tool user interface by programming the Tool Validator class

• Use `Describe()` to determine the properties of the network dataset and the network analysis layer

  Network Analyst Layer Describe Properties
  Network Dataset Describe Properties

• The output network analysis layer supports pre-defined symbology using layer files
The road ahead (10.1)

• Network Analyst Python module (arcpy.na)
  - Easy access to Network Analyst functionality from Python, along with helper functions and classes
  - Ability to edit a Network Analysis layer without having to create a new one

• New tools
  - Working with traversal results

  - Easy publishing of GP Services
Summary
Summary

• Geoprocessing framework for network analyses
  - Network Analyst Tools (system tools)
  - Models and Model tools (no programming)
  - Script and Script tools (python code)

• Automate repetitive tasks

• Easier than writing ArcObjects code

• Incorporate network analysis in larger process
Resources
Support and Resources

- **ArcGIS Desktop Help on Geoprocessing**
- **Network Analyst Help**
- **Geoprocessing Resource Center**
- **ArcGIS Network Analyst Extension Discussion Forum**
Network Analyst at UC2011
Tech Workshops

• ArcGIS Network Analyst – An Introduction

• ArcGIS Network Analyst – Performing Network Analysis

• Performing Network Analysis with ArcGIS Server

• ArcGIS Network Analyst – Creating Network Datasets

• ArcGIS Network Analyst – Automating Workflows with Geoprocessing
Demo Theaters

- Patterns for Measuring and Mapping Access Using Network Analysis

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

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

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

- ArcGIS Network Analyst – Location-Allocation and Accounting for Competition in Site Selection
<table>
<thead>
<tr>
<th>Time</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 am</td>
<td>ArcGIS Network Analyst - An Introduction</td>
<td>ArcGIS Network Analyst - Automating workflows with Geoprocessing</td>
<td>ArcGIS Network Analyst - Performing Network Analysis</td>
</tr>
<tr>
<td>9 am</td>
<td>ArcGIS Network Analyst - Performing Network Analysis</td>
<td>ArcGIS Network Analyst - Creating Network Datasets</td>
<td></td>
</tr>
<tr>
<td>10 am</td>
<td>ArcGIS Network Analyst - Performing Network Analysis</td>
<td>ArcGIS Network Analyst - Creating Network Datasets</td>
<td></td>
</tr>
<tr>
<td>11 am</td>
<td>Patterns for Mapping Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 pm</td>
<td>Modeling Real-World Problems with the VRP Solver</td>
<td>ArcGIS Network Analyst - An Introduction</td>
<td>ArcGIS Network Analyst - Creating Network Datasets</td>
</tr>
<tr>
<td>1 pm</td>
<td></td>
<td>ArcGIS Network Analyst - An Introduction</td>
<td></td>
</tr>
<tr>
<td>2 pm</td>
<td></td>
<td>ArcGIS Network Analyst - Creating Network Datasets</td>
<td></td>
</tr>
<tr>
<td>3 pm</td>
<td>Performing Network Analysis with ArcGIS Server</td>
<td>ArcGIS Network Analyst – Routing Inside Buildings With 3D Networks</td>
<td></td>
</tr>
<tr>
<td>4 pm</td>
<td>What is Network Analyst?</td>
<td>ArcGIS Network Analyst – Location-Allocation in site selection</td>
<td></td>
</tr>
</tbody>
</table>
Related Tech Workshops - Geoprocessing

- **Geoprocessing Models**
  - Building Tools with ModelBuilder
    - Wednesday 10:15 - Room 14B
    - Thursday 3:15 – Room 4
  - Getting Started with ModelBuilder
    - Wednesday 1:30 - Room 5A/B

- **Python Scripts and Script Tools**
  - Python – Getting Started
    - Thursday 8:30 – Room 2
  - Building Tools with Python
    - Thursday 10:15 – Room 9
In Conclusion…

• Please fill out session surveys!
• Questions
• Still have questions?
  - Spatial Analysis Island (Exhibit Hall C)