2013 Esri International User Conference
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Technical Workshop

Network Analyst: Automating Workflows with Geoprocessing

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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

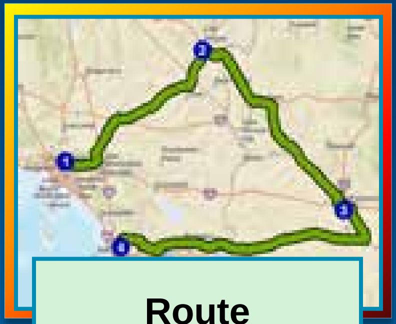
ArcGIS Network Analyst extension concepts

More Information:

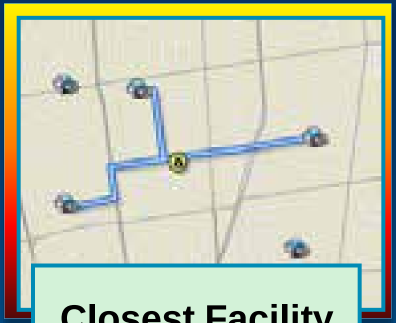
[What is the ArcGIS Network Analyst extension]() in ArcGIS help

ArcGIS
Network Analyst Extension

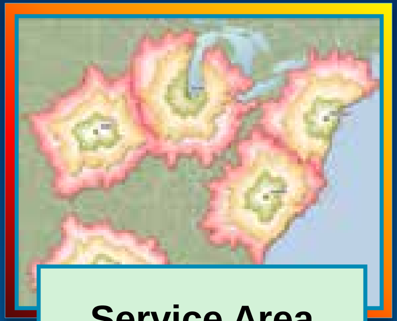
Solving transportation problems



Route

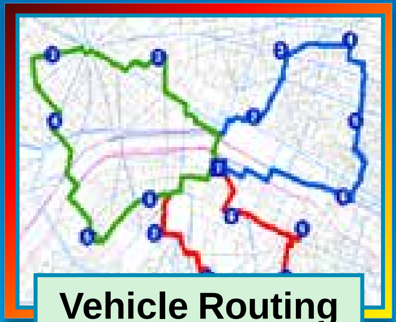


Closest Facility

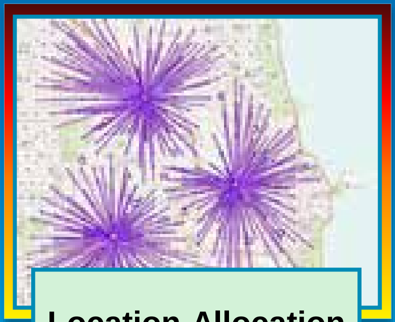


Service Area

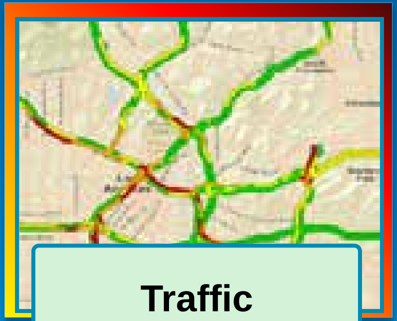
Origin-Destination Cost Matrix



Vehicle Routing Problem

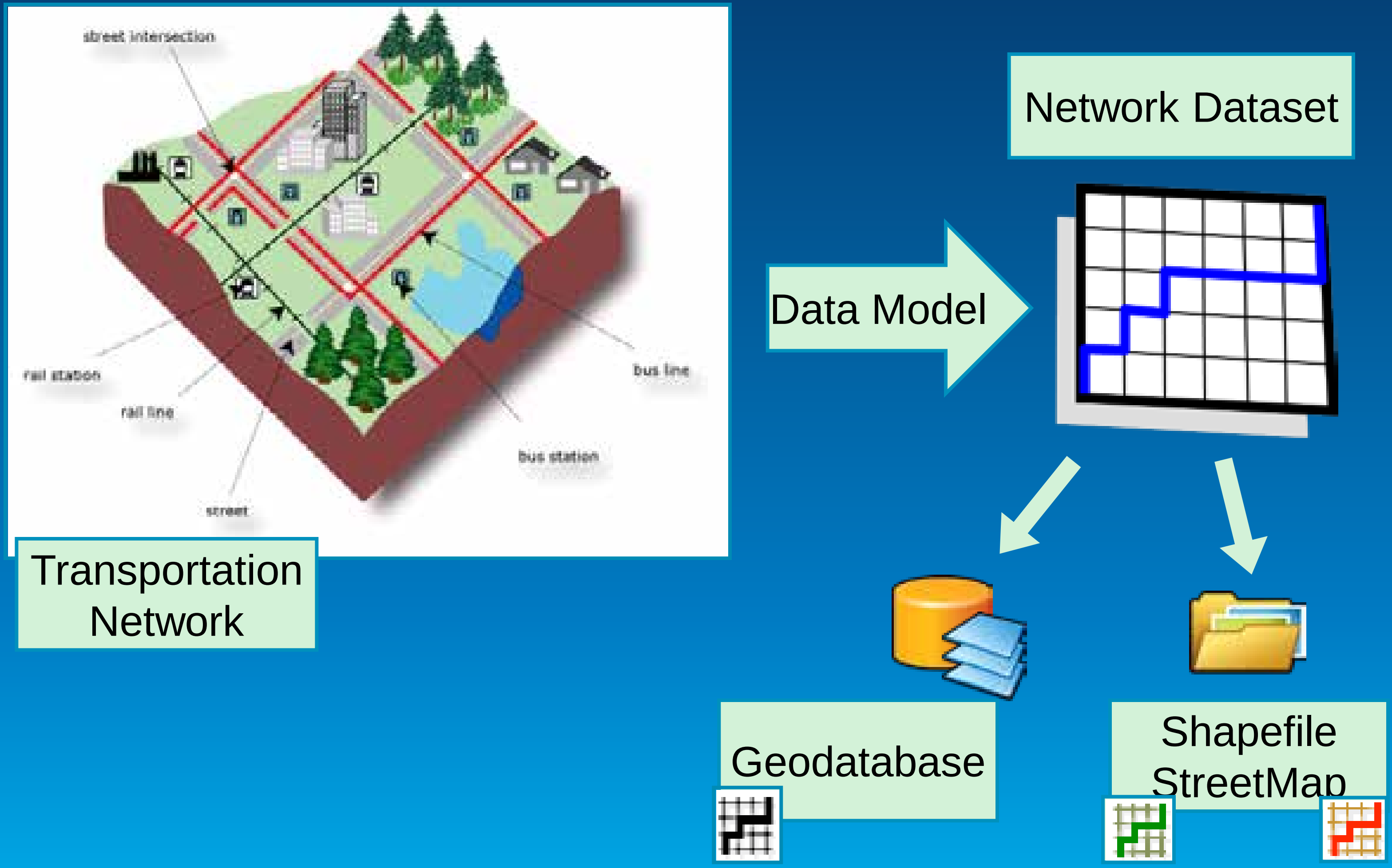


Location-Allocation



Traffic

Network Dataset



Transportation Network

Data Model

Network Dataset

Geodatabase

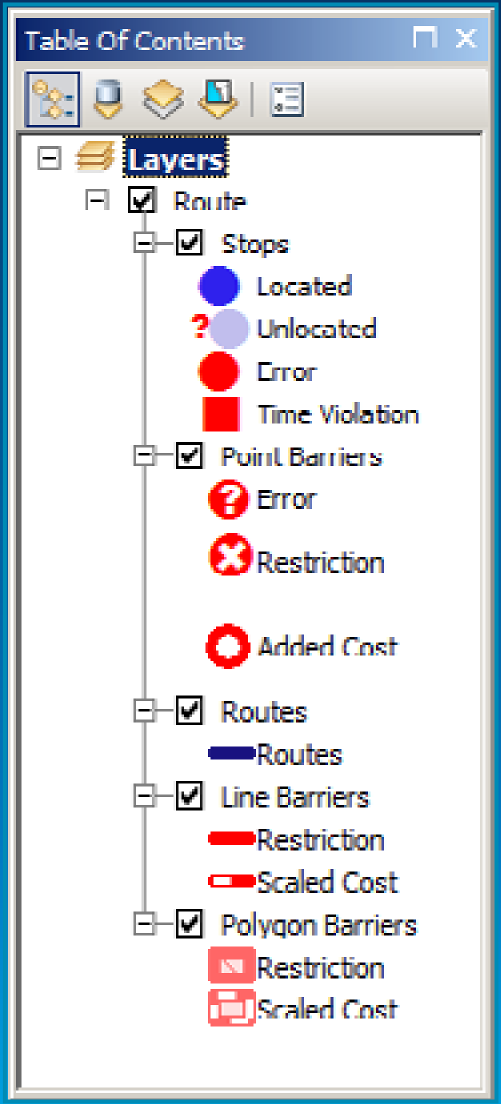
Shapefile
StreetMap

Where do you get street data?

- Data within your organization
- No street data in your organization
  - Free data
    - Data and maps media
    - TIGER (Census data)
    - OpenStreetMap
      - **OSM to NDS tools**
      - **ArcGIS Editor for OpenStreetMap**
  - Pay for data
    - NAVTEQ or TomTom
      - **Vendor street data processing tools**
    - StreetMap Premium for ArcGIS
  - Pay for analysis
    - ArcGIS.com Map Viewer
    - ArcGIS.com Network Services

Network Analysis Layer

- Composite layer configured for a specific solver
- Stores analysis properties, inputs, and outputs from the solver

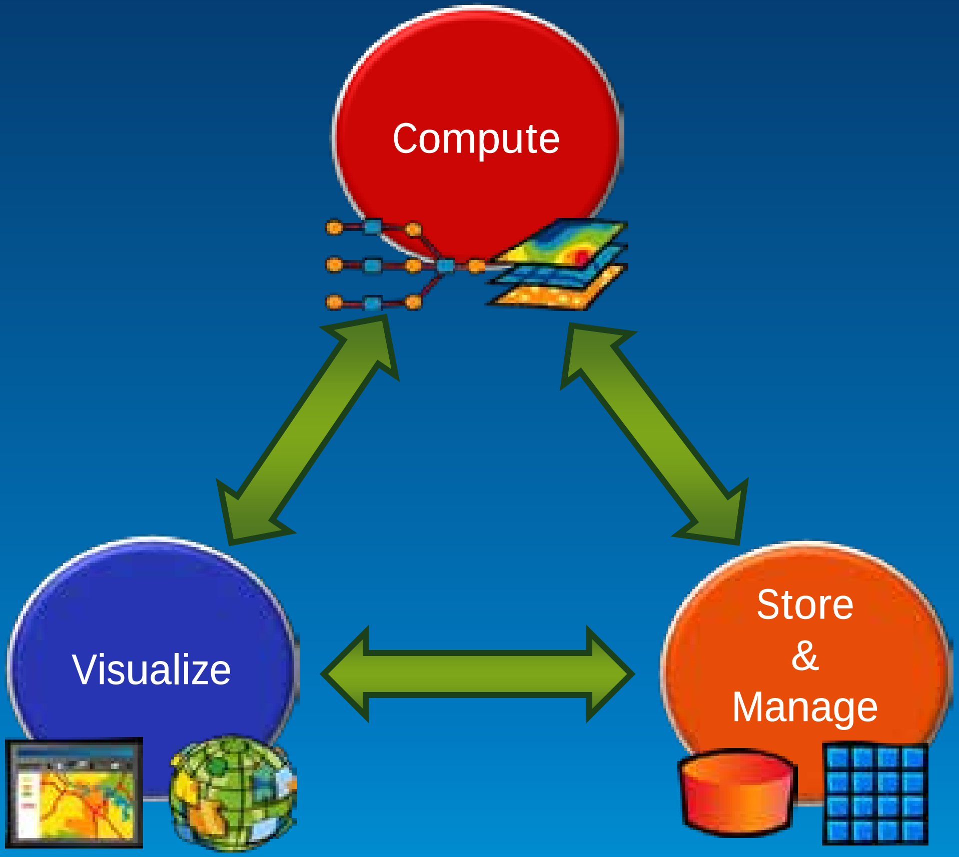


Geoprocessing Framework

More Information:

The geoprocessing framework in ArcGIS help

What is Geoprocessing?

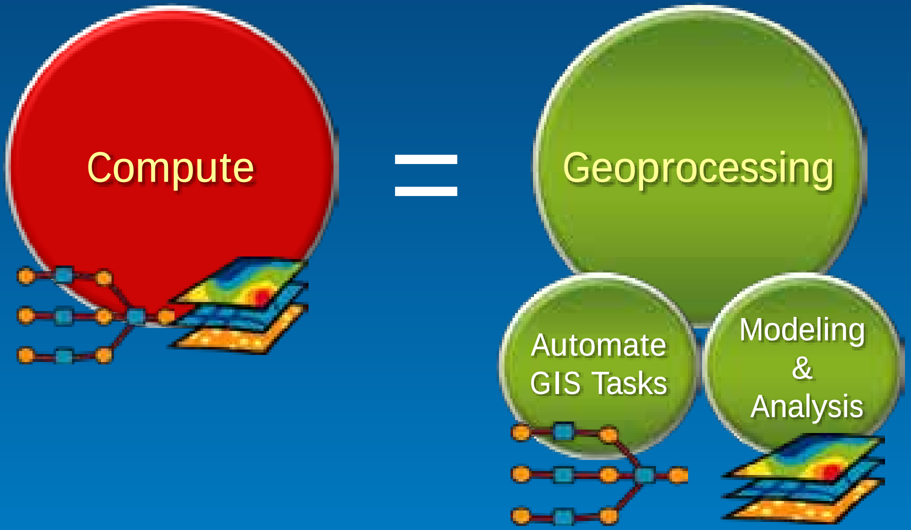


Compute

Visualize

Store
&
Manage

What is Geoprocessing?



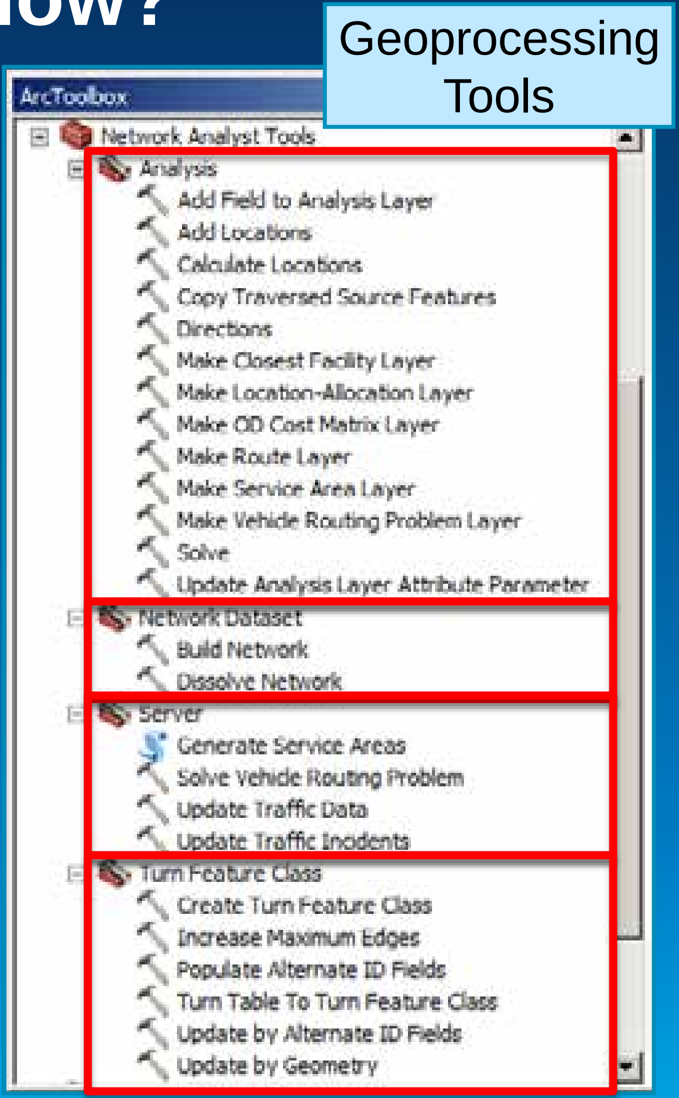
Compute = Geoprocessing

Automate GIS Tasks

Modeling & Analysis

Using Geoprocessing – How?

- Accessed through ArcToolbox
- Network Analyst Tools
  - Performing Network Analysis
  - Building networks
  - Publishing services
  - Managing turns



Geoprocessing Tools

- Network Analyst Tools
  - Analysis
    - Add Field to Analysis Layer
    - Add Locations
    - Calculate Locations
    - Copy Traversed Source Features
    - Directions
    - Make Closest Facility Layer
    - Make Location-Allocation Layer
    - Make OD Cost Matrix Layer
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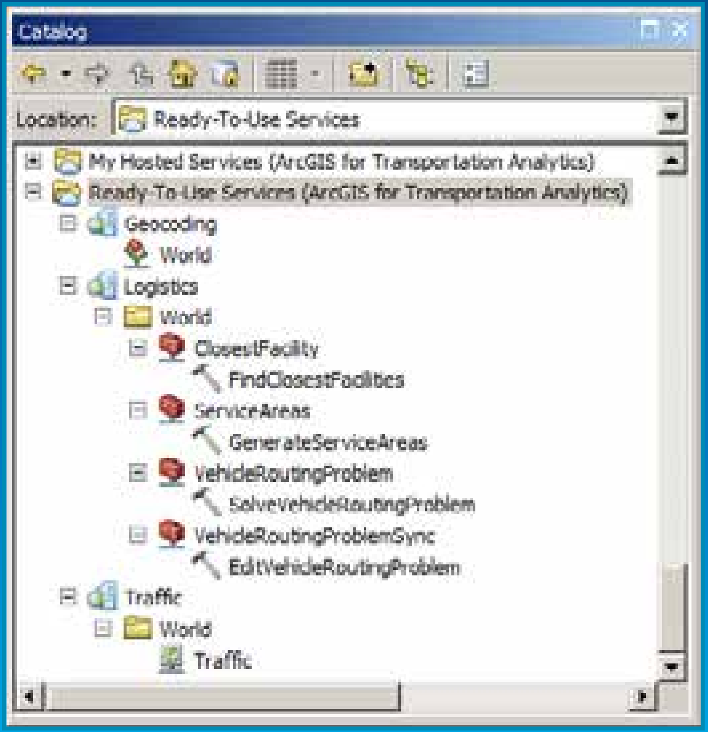
    - Solve
    - Update Analysis Layer Attribute Parameter
  - Network Dataset
    - Build Network
    - Dissolve Network
  - Server
    - Generate Service Areas
    - Solve Vehicle Routing Problem
    - Update Traffic Data
    - Update Traffic Incidents
  - Turn Feature Class
    - Create Turn Feature Class
    - Increase Maximum Edges
    - Populate Alternate ID Fields
    - Turn Table To Turn Feature Class
    - Update by Alternate ID Fields
    - Update by Geometry

Using Geoprocessing – How?

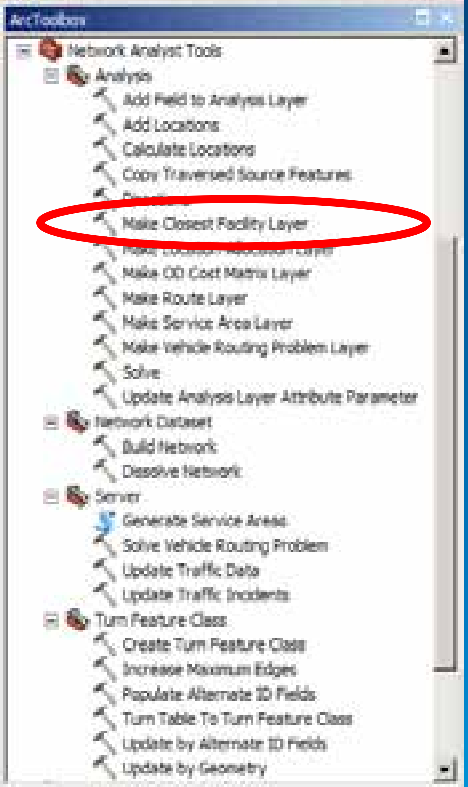
- Accessed through ArcCatalog
  - Sign in with any organization with credits
- Global, Ready-To-Use Services
  - Closest Facility
  - Service Area
  - Vehicle Routing Problem



Location: Ready-To-Use Services

Catalog
My Hosted Services (ArcGIS for Transportation Analytics)
Ready-To-Use Services (ArcGIS for Transportation Analytics)
Geocoding
World
Logistics
World
ClosestFacility
FindClosestFacilities
ServiceAreas
GenerateServiceAreas
VehicleRoutingProblem
SolveVehicleRoutingProblem
VehicleRoutingProblemSync
EditVehicleRoutingProblem
Traffic
World
Traffic

Using Geoprocessing – How?


ArcToolbox
Network Analyst Tools
Analysis
Add Field to Analysis Layer
Add Locations
Calculate Locations
Copy Traversed Source Features
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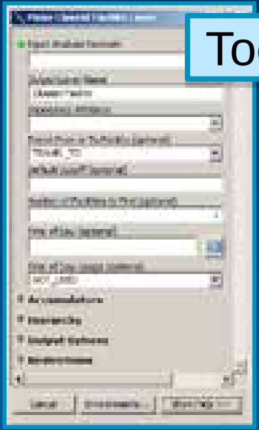
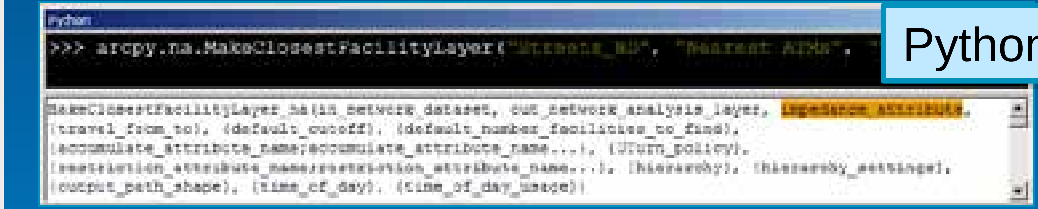
Single tool execution



Tool dialog



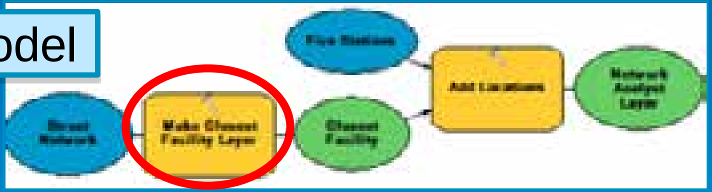
```
>>> arcpy.na.MakeClosestFacilityLayer("Streets_ND", "Nearest ATMs", "
```

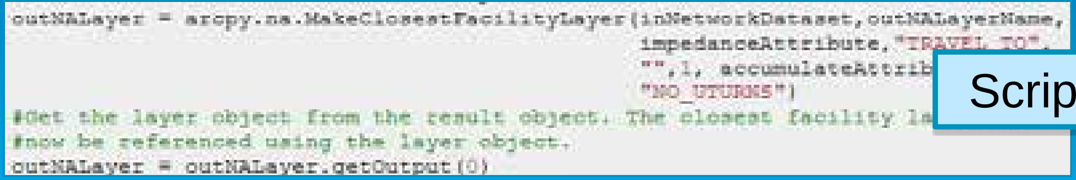
```
MakeClosestFacilityLayer_na(in_network_dataset, out_network_analysis_layer, impedance_attribute,
{travel_from_to}, {default_cutoff}, {default_number_facilities_to_find},
{accumulate_attribute_name;accumulate_attribute_name...}, {UTurn_policy},
{restriction_attribute_name;restriction_attribute_name...}, {hierarchy}, {hierarchy_settings},
{output_path_shape}, {time_of_day}, {time_of_day_usage})
```

Python window

Chain tools

Model

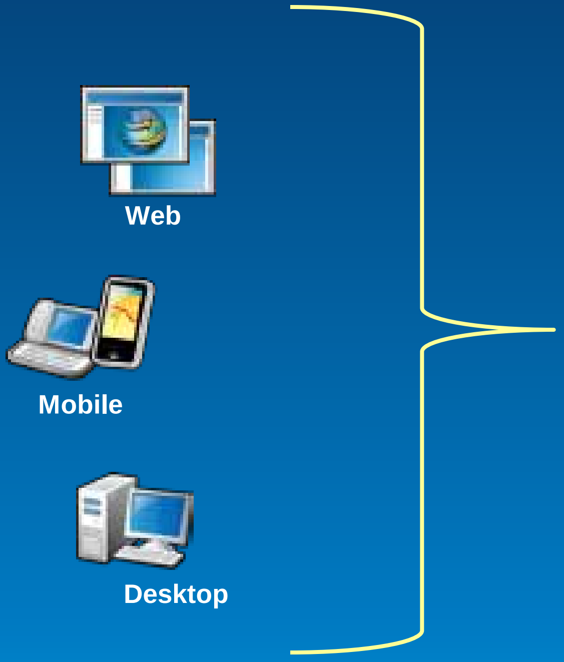


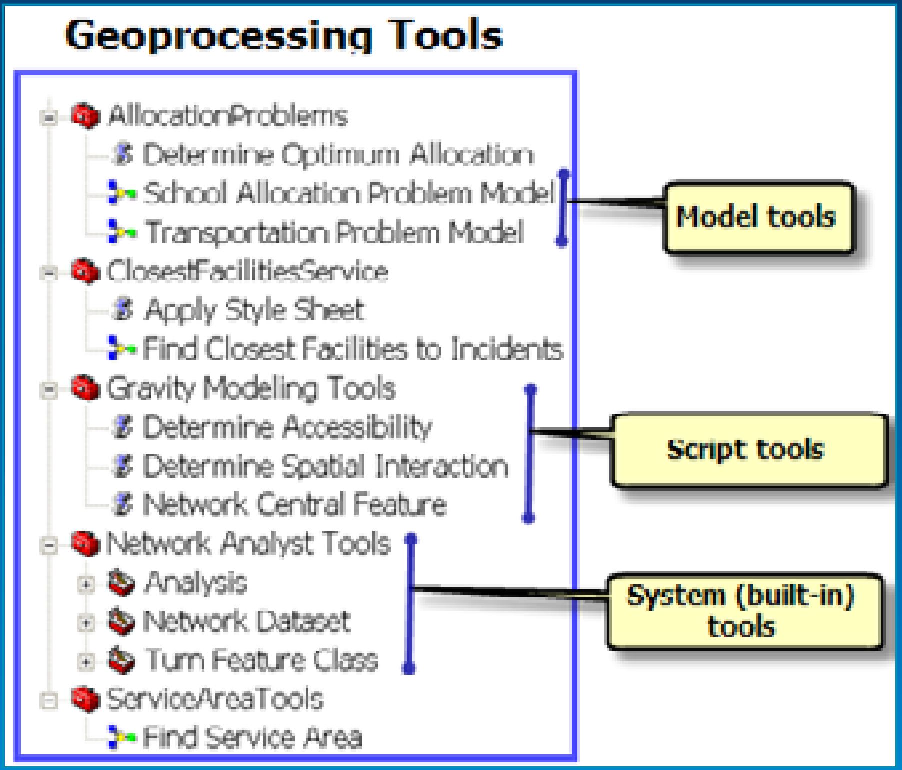


```
outNALayer = arcpy.na.MakeClosestFacilityLayer(inNetworkDataset,outNALayerName,
                                               impedanceAttribute,"TRAVEL_TO",
                                               "",1, accumulateAttrib
                                               "NO_UTURNS")
#Get the layer object from the result object. The closest facility la
#now be referenced using the layer object.
outNALayer = outNALayer.getOutput(0)
```

Script

Using Geoprocessing – Where?




Geoprocessing Tools

- AllocationProblems
  - Determine Optimum Allocation
  - School Allocation Problem Model
  - Transportation Problem Model
- ClosestFacilitiesService
  - 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
- ServiceAreaTools
  - Find Service Area

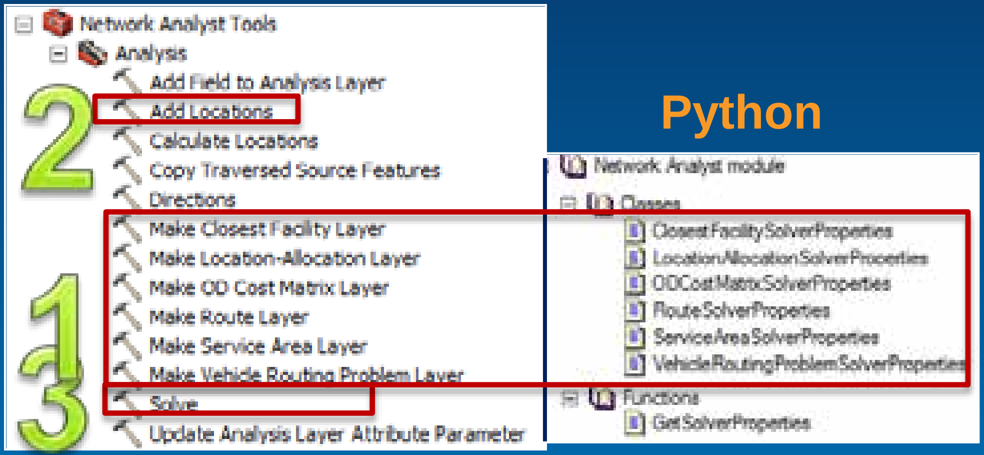
Building Geoprocessing Models

More Information:

What is ModelBuilder? in ArcGIS help

Network Analysis Workflow

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



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    - Update Analysis Layer Attribute Parameter

Python

- Network Analyst module
  - Classes
    - ClosestFacilitySolverProperties
    - LocationAllocationSolverProperties
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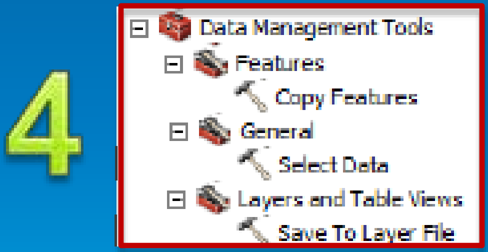
    - RouteSolverProperties
    - ServiceAreaSolverProperties
    - VehicleRoutingProblemSolverProperties
  - Functions
    - GetSolverProperties



- Data Management Tools
  - Features
    - Copy Features
  - General
    - Select Data
  - Layers and Table Views
    - Save To Layer File

Demo

Geoprocessing Models

Authoring a simple route model

Demo: Geoprocessing models - takeaways

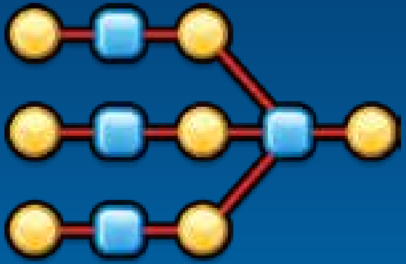
- You can easily share models

- 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

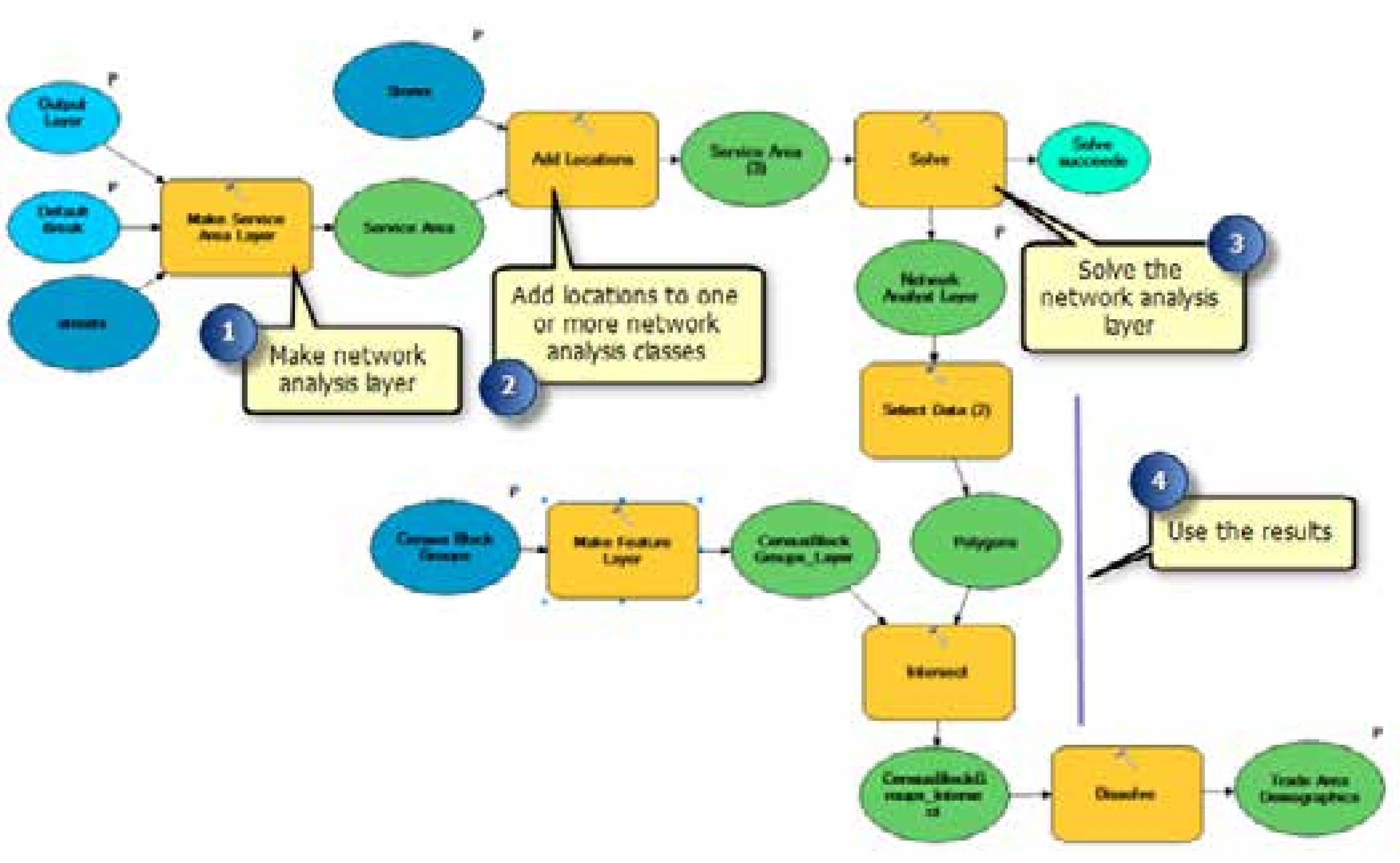
- Chain geoprocessing tools to perform a workflow



- 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



1 Make network analysis layer

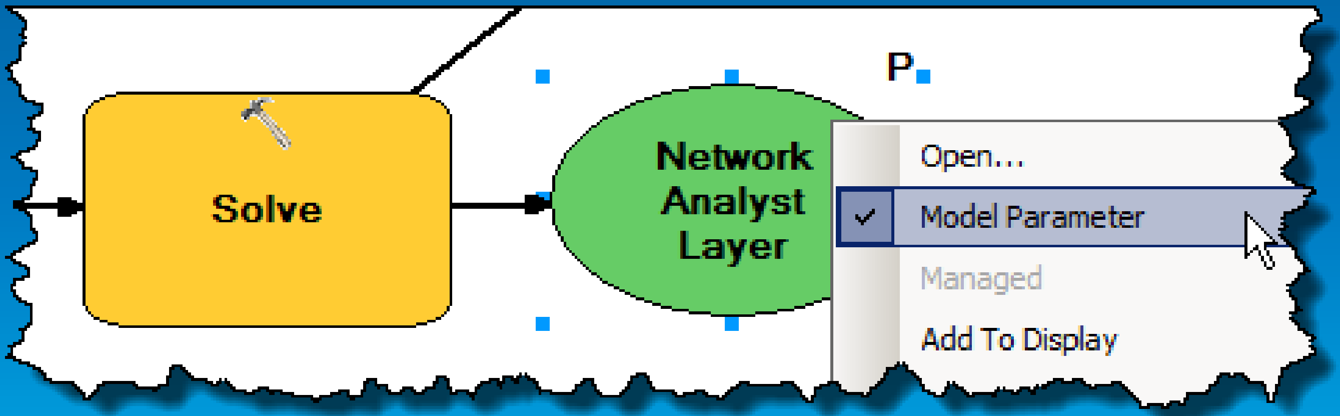
2 Add locations to one or more network analysis classes

3 Solve the network analysis layer

4 Use the results

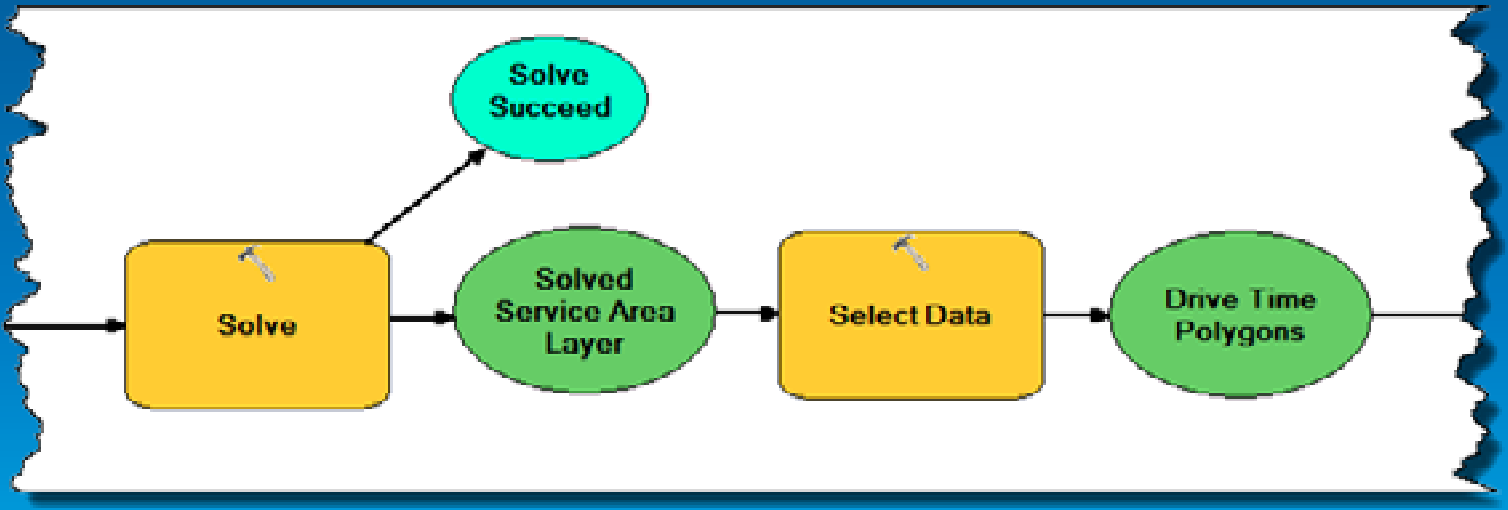
Adding analysis results to ArcMap

- If you want to visualize the results in ArcMap, when 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

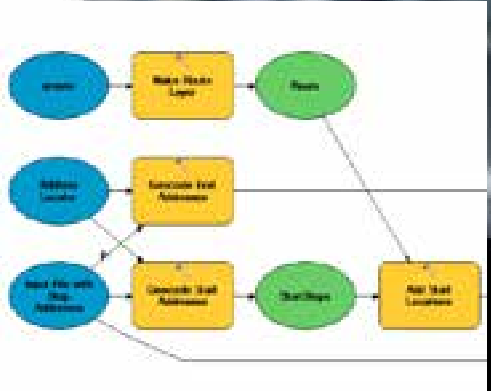
- If you want to use your analysis results as an input to another geoprocessing tool, use the Select Data tool to access individual sublayers

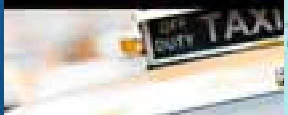


Demo

Geoprocessing Models

Authoring a model to determine multiple routes from a text file containing start and end addresses





Demo: Geoprocessing models - takeaways

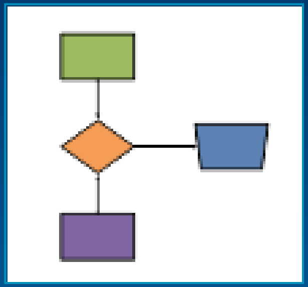
- Use the Select Data tool to access sublayers of a network analysis layer
- Incorporate external data (csv in this example) into your analysis
- Automate your workflows without code
- Model tools can be added as buttons on any toolbar
- If network analysis layer is intermediate data, explicitly delete it as a last step

Writing Python Scripts

More Information:

- What is Python? in ArcGIS help

Python Scripts

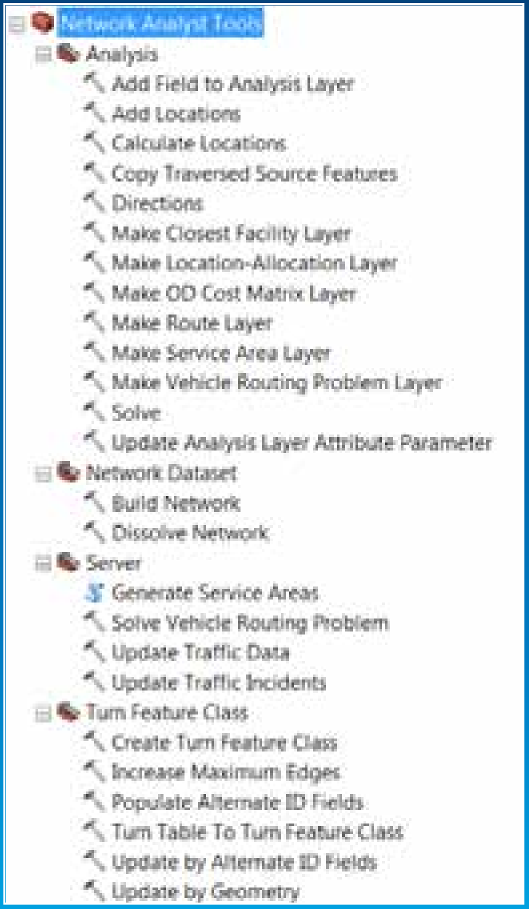


- Used for
  - Conditional logic
  - Looping
  - Cursors, creating geometry
  - Accessing built-in and third party python modules
- ArcPy site package
  - Network Analyst module
  - Access other geoprocessing tools
  - Other useful functions and classes such as Describe

What is the Network Analyst Module?

Simplify access to Network Analyst functionality from Python

arcpy.na



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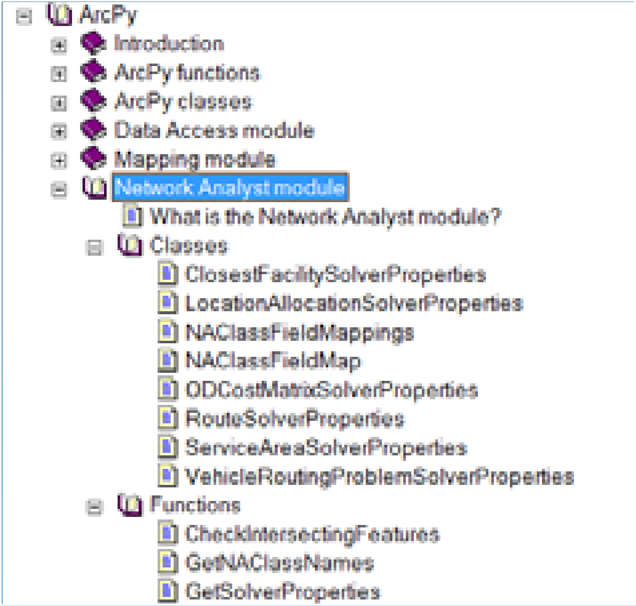
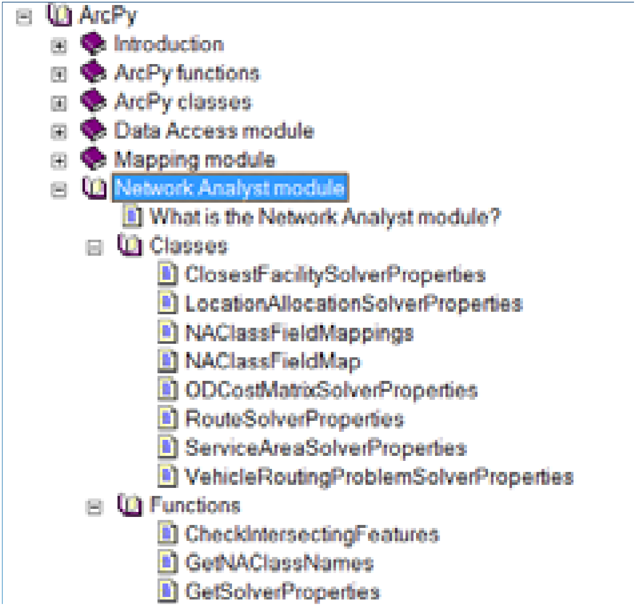


- ArcPy
  - Introduction
  - ArcPy functions
  - ArcPy classes
  - Data Access module
  - Mapping module
  - Network Analyst module
    - What is the Network Analyst module?
    - Classes
      - ClosestFacilitySolverProperties
      - LocationAllocationSolverProperties
      - NAClassFieldMappings
      - NAClassFieldMap
      - ODCostMatrixSolverProperties
      - RouteSolverProperties
      - ServiceAreaSolverProperties
      - VehicleRoutingProblemSolverProperties
    - Functions
      - CheckIntersectingFeatures
      - GetNAClassNames
      - GetSolverProperties

Network Analyst Module

- Support editing analysis properties of network analysis layers
  - No need to re-create layers
  - Speeds up execution
  - Simplifies script logic
  - Automate workflows from Python window



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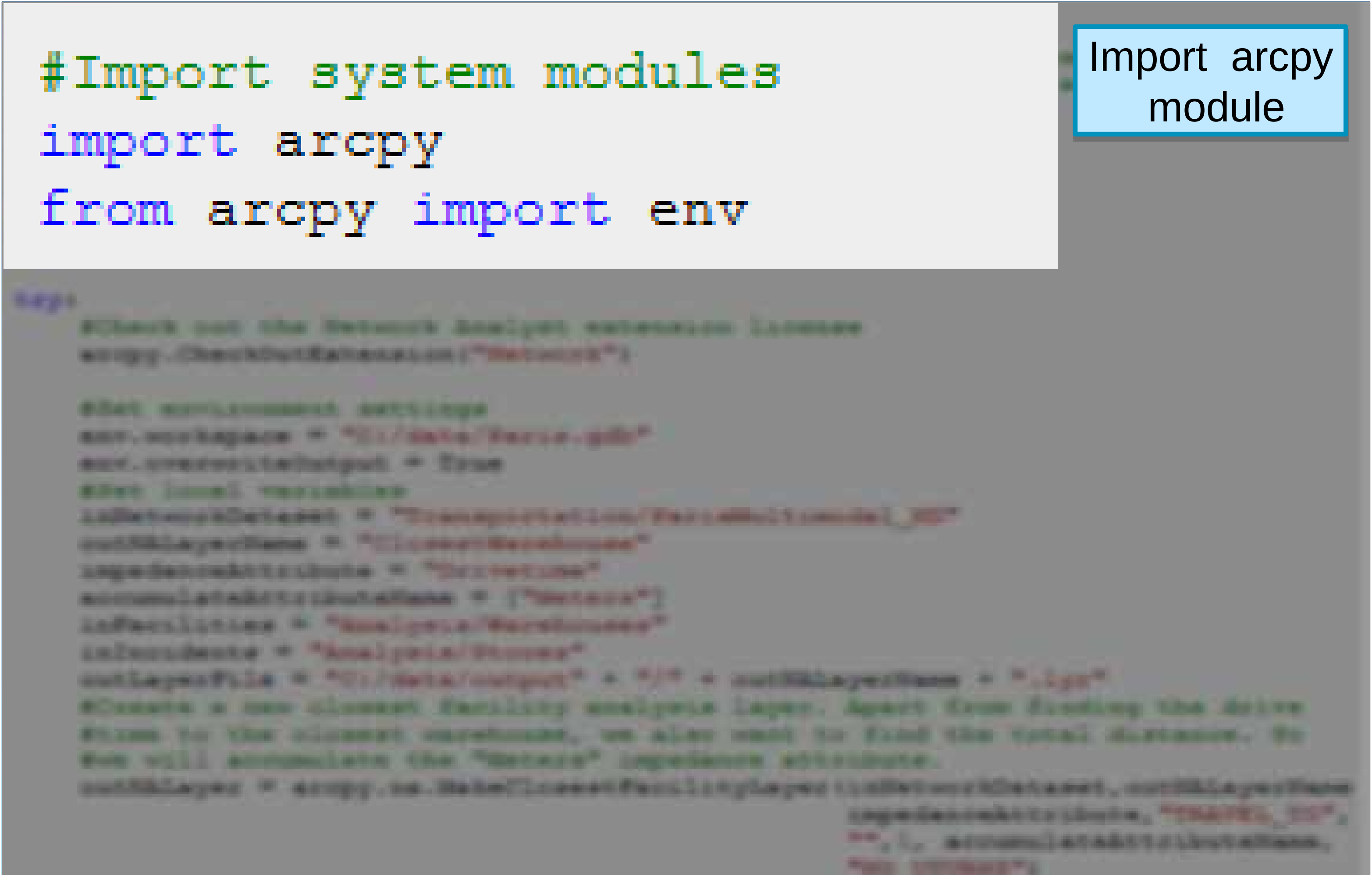
- Provide helper functions and classes to easily use Network Analyst GP tools from Python

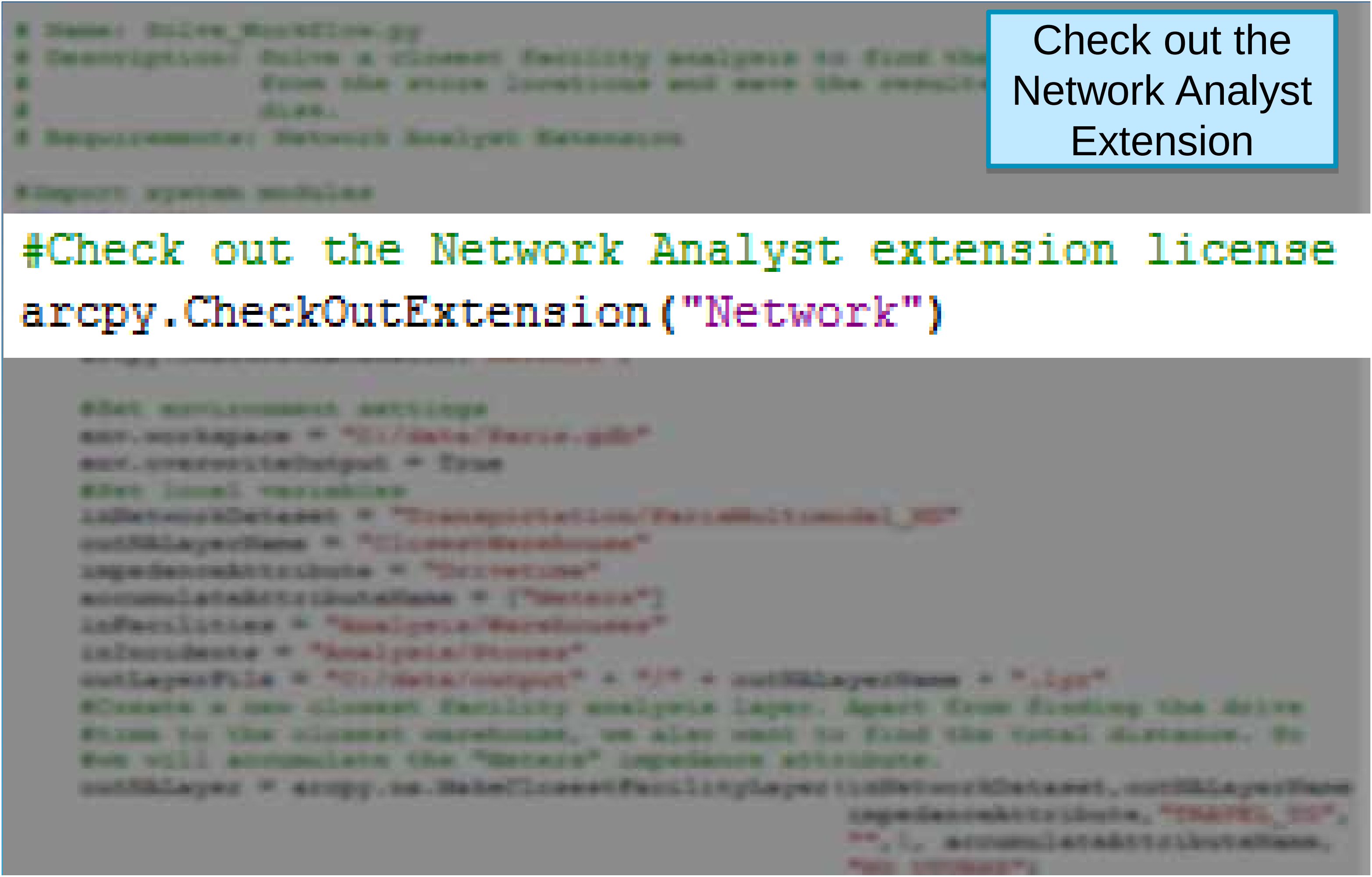
Python Script - Basic Building Blocks



```
#Import system modules
import arcpy
from arcpy import env
```

Import arcpy module

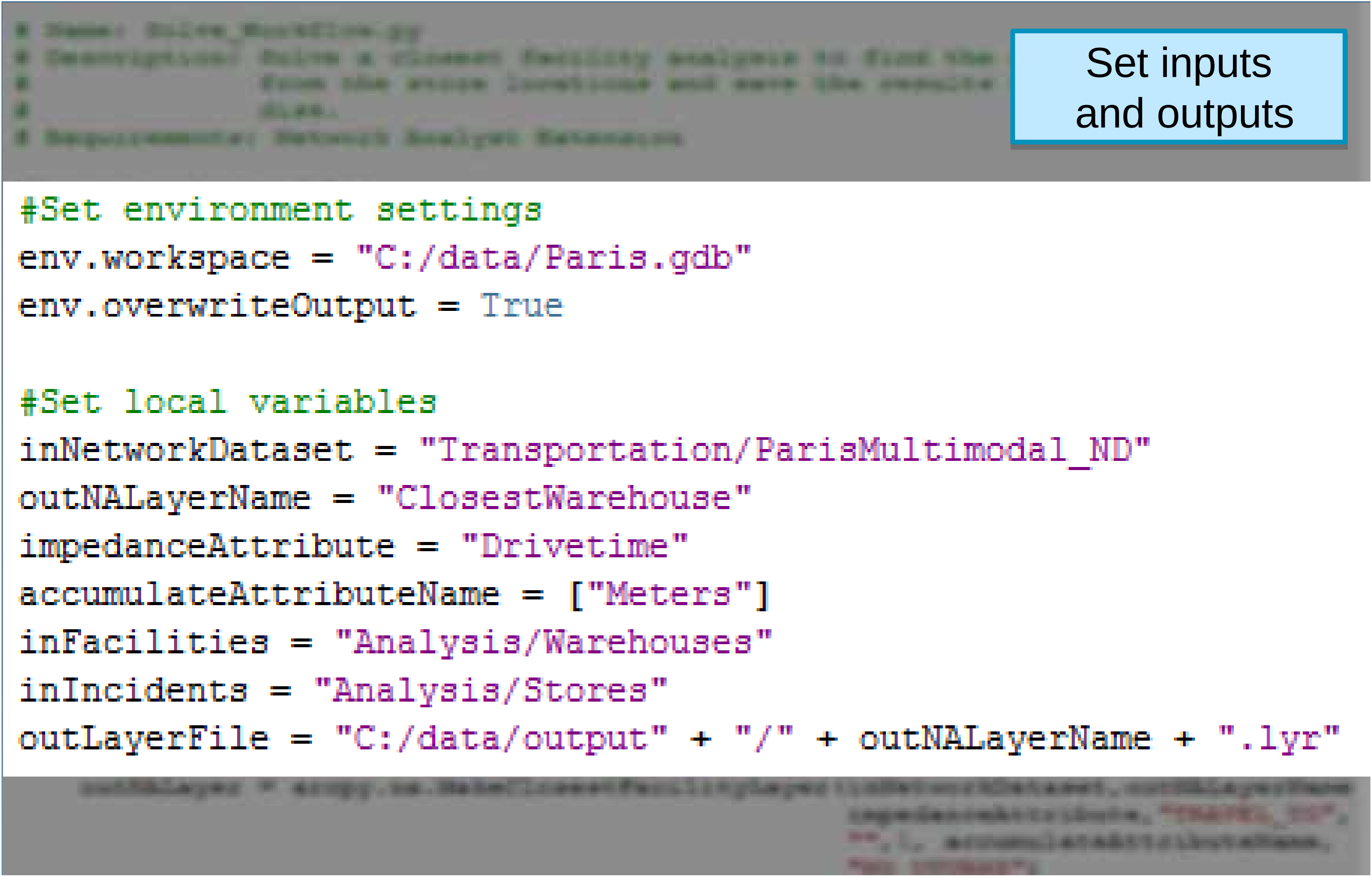
Python Script - Basic Building Blocks



Check out the Network Analyst Extension

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

Python Script - Basic Building Blocks

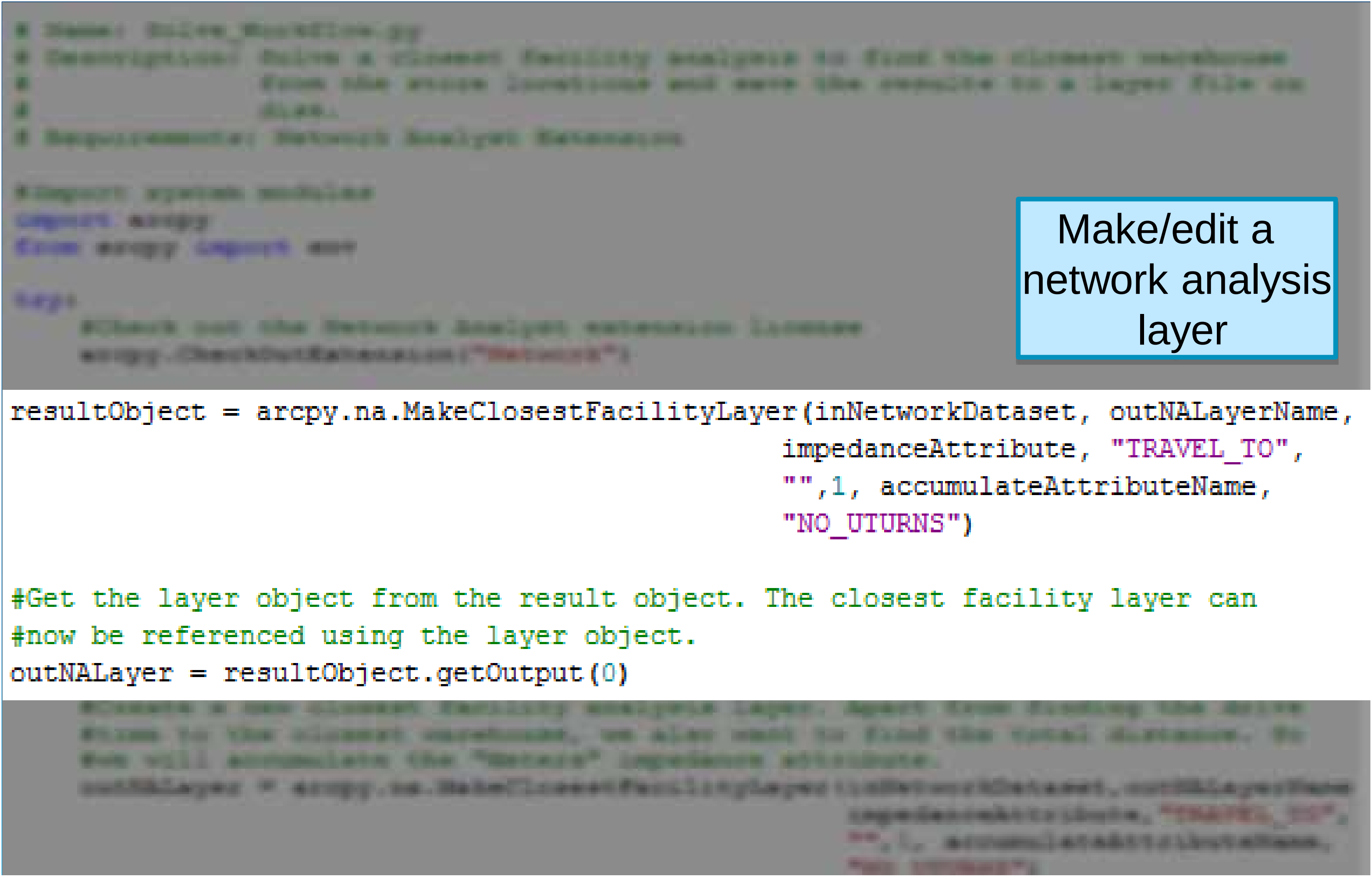


Set inputs and outputs

```
#Set environment settings
env.workspace = "C:/data/Paris.gdb"
env.overwriteOutput = True

#Set local variables
inNetworkDataset = "Transportation/ParisMultimodal_ND"
outNALayerName = "ClosestWarehouse"
impedanceAttribute = "Drivetime"
accumulateAttributeName = ["Meters"]
inFacilities = "Analysis/Warehouses"
inIncidents = "Analysis/Stores"
outLayerFile = "C:/data/output" + "/" + outNALayerName + ".lyr"
```

Python Script - Basic Building Blocks

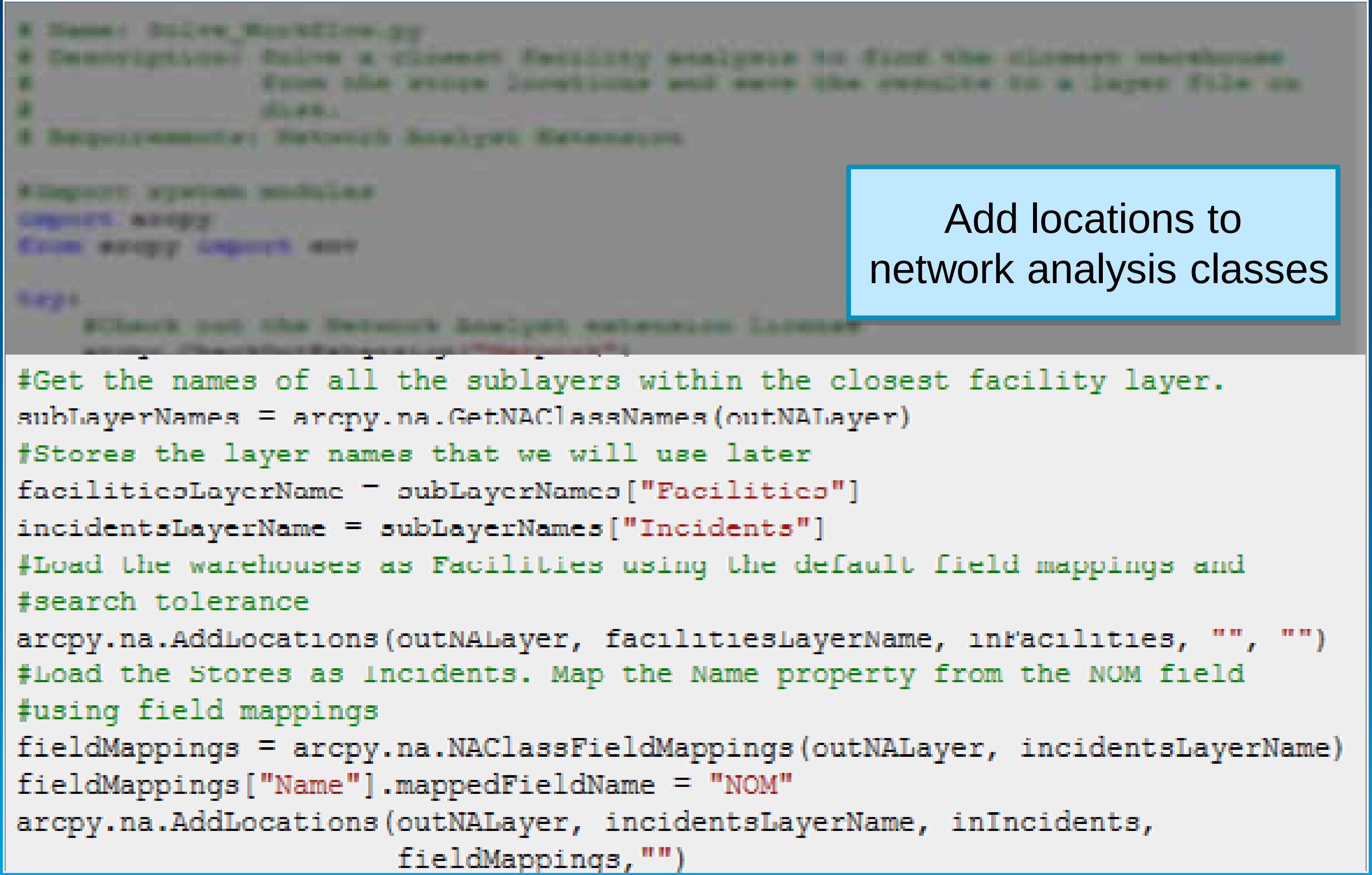


Make/edit a network analysis layer

```
resultObject = arcpy.na.MakeClosestFacilityLayer(inNetworkDataset, outNALayerName,
                                                  impedanceAttribute, "TRAVEL_TO",
                                                  "",1, accumulateAttributeName,
                                                  "NO_UTURNS")

#Get the layer object from the result object. The closest facility layer can
#now be referenced using the layer object.
outNALayer = resultObject.getOutput(0)
```

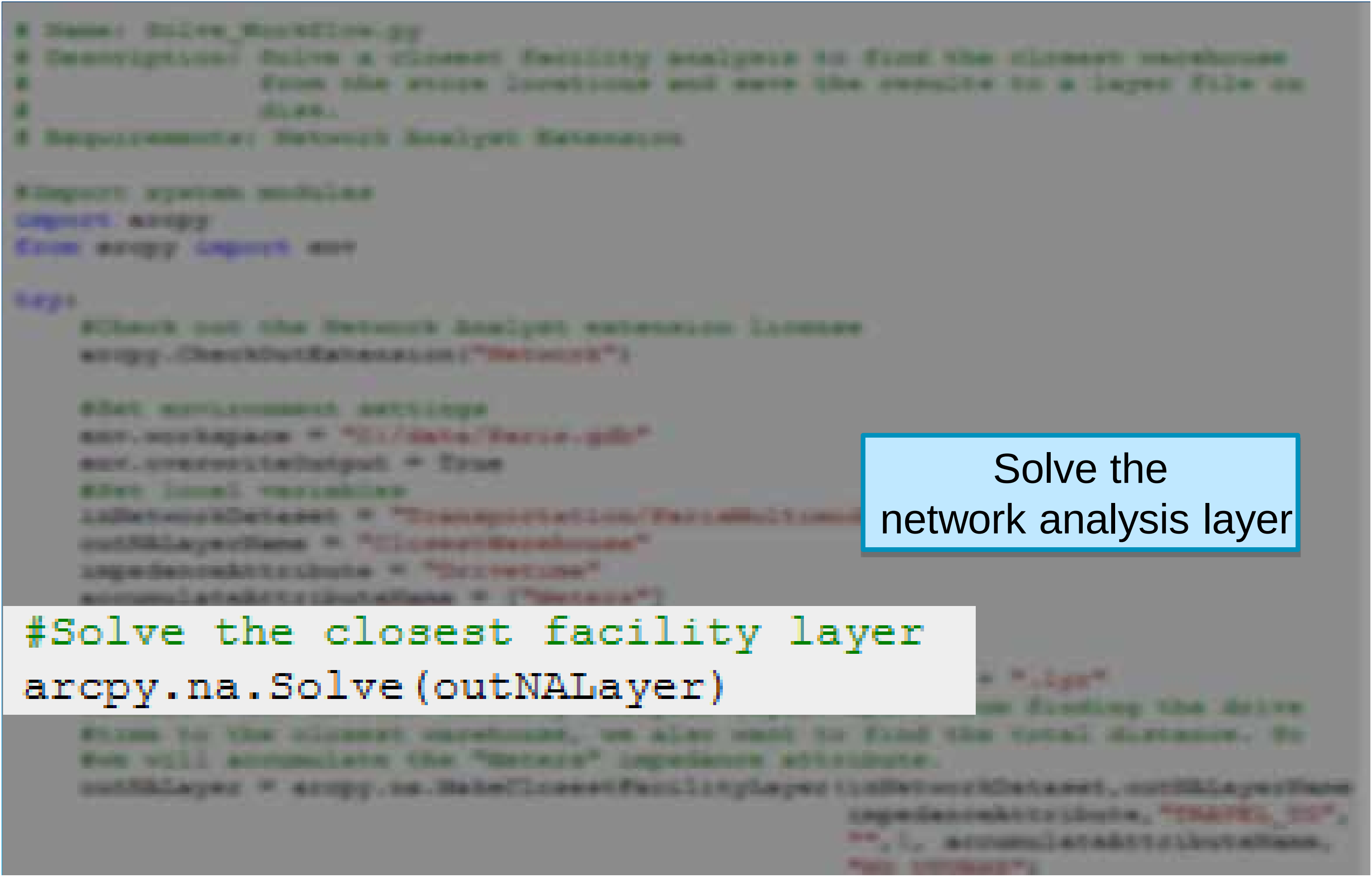
Python Script - Basic Building Blocks



Add locations to network analysis classes

```
#Get the names of all the sublayers within the closest facility layer.
subLayerNames = arcpy.na.GetNAClassNames(outNALayer)
#Stores the layer names that we will use later
facilitiesLayerName = subLayerNames["Facilities"]
incidentsLayerName = subLayerNames["Incidents"]
#Load the warehouses as Facilities using the default field mappings and
#search tolerance
arcpy.na.AddLocations(outNALayer, facilitiesLayerName, inFacilities, "", "")
#Load the Stores as Incidents. Map the Name property from the NOM field
#using field mappings
fieldMappings = arcpy.na.NAClassFieldMappings(outNALayer, incidentsLayerName)
fieldMappings["Name"].mappedFieldName = "NOM"
arcpy.na.AddLocations(outNALayer, incidentsLayerName, inIncidents,
                      fieldMappings,"")
```

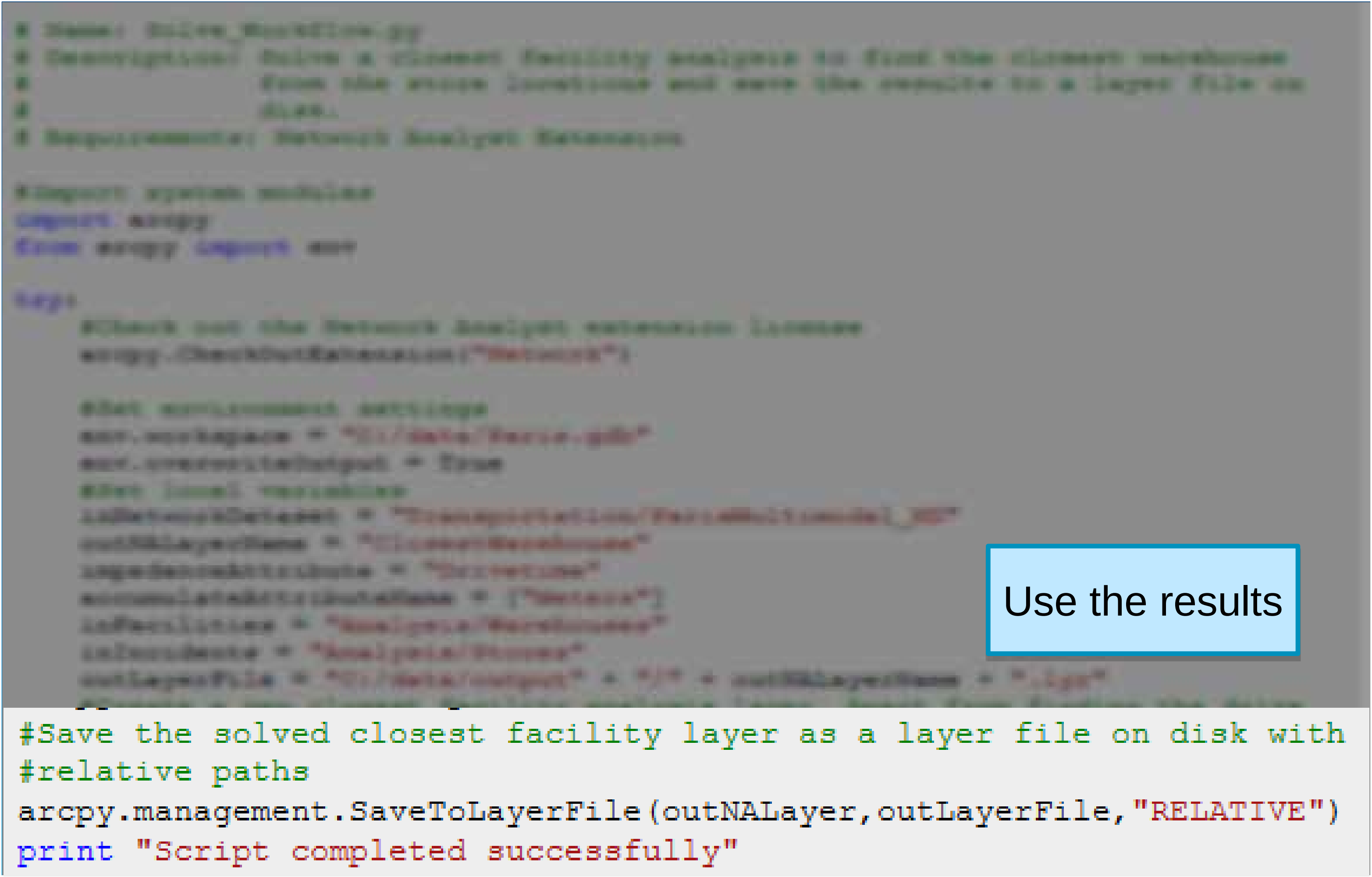
Python Script - Basic Building Blocks



```
#Solve the closest facility layer
arcpy.na.Solve(outNALayer)
```

Solve the network analysis layer

Python Script - Basic Building Blocks

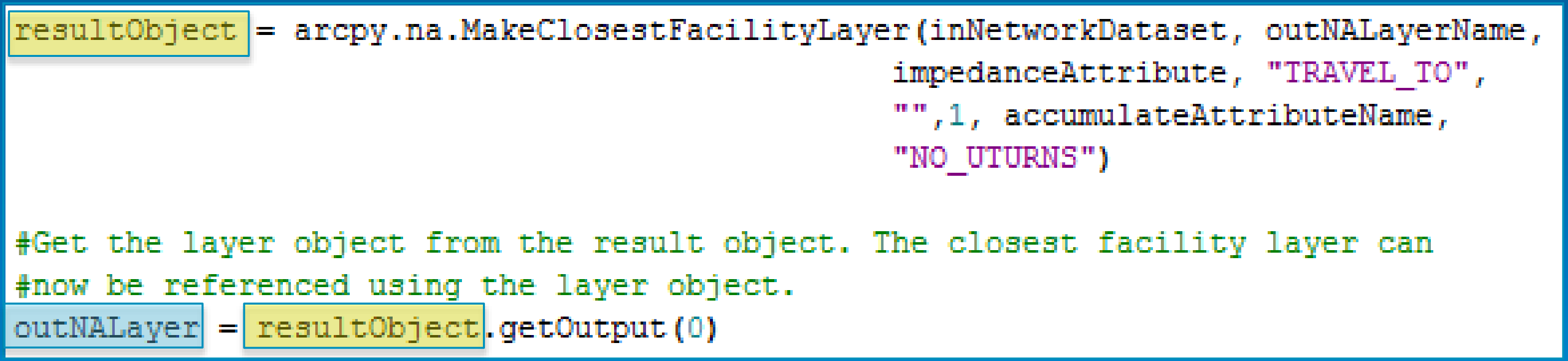


```
#Save the solved closest facility layer as a layer file on disk with
#relative paths
arcpy.management.SaveToLayerFile(outNALayer,outLayerFile,"RELATIVE")
print "Script completed successfully"
```

Use the results

Working with analysis layers within scripts

- The network layer can be accessed as a layer object via the result object of a Make<solver>Layer function



```
resultObject = arcpy.na.MakeClosestFacilityLayer(inNetworkDataset, outNALayerName,
                                               impedanceAttribute, "TRAVEL_TO",
                                               "",1, accumulateAttributeName,
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#Get the layer object from the result object. The closest facility layer can
#now be referenced using the layer object.
outNALayer = resultObject.getOutput(0)
```
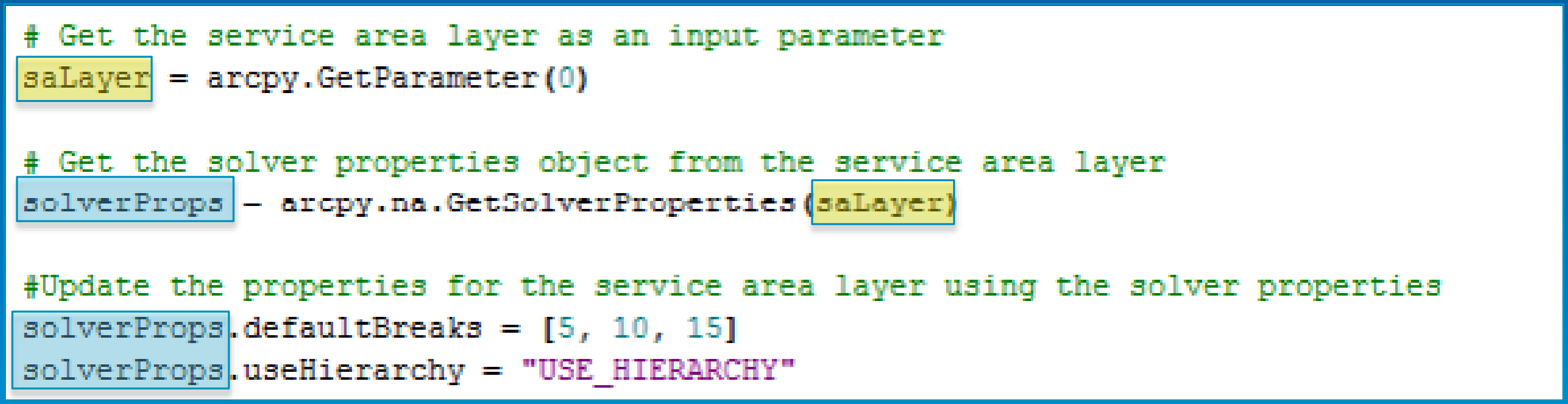

Working with analysis layers within scripts

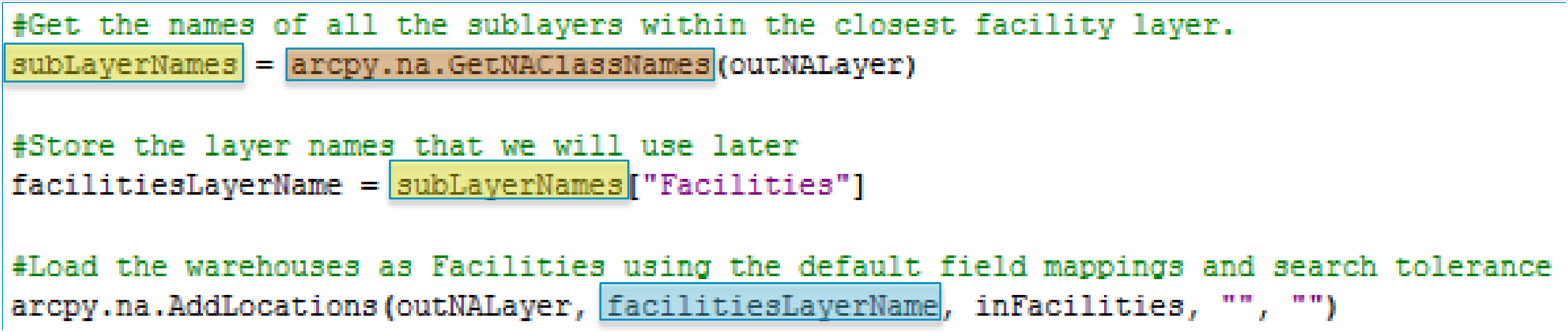
- The network analysis layer can be edited via the solver properties of an existing layer object



```
# Get the service area layer as an input parameter
saLayer = arcpy.GetParameter(0)

# Get the solver properties object from the service area layer
solverProps = arcpy.na.GetSolverProperties(saLayer)

#Update the properties for the service area layer using the solver properties
solverProps.defaultBreaks = [5, 10, 15]
solverProps.useHierarchy = "USE_HIERARCHY"
```

Accessing sublayers in scripts

- To access sublayers in python scripts, use the arcpy.na.GetNAClassNames function
  - The Select Data tool is not meant for python scripting
  - Write scripts that work across ArcGIS language versions
    - Avoid using localized strings in scripts such as sublayer names

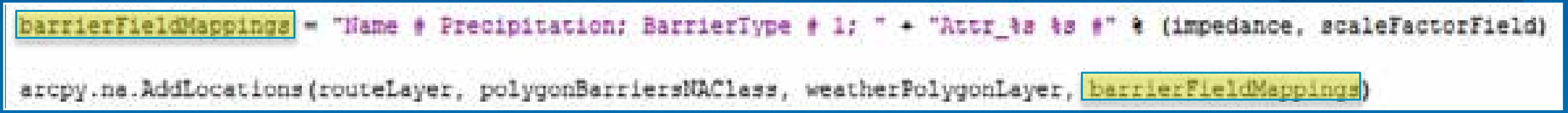


```
#Get the names of all the sublayers within the closest facility layer.
subLayerNames = arcpy.na.GetNAClassNames(outNALayer)

#Store the layer names that we will use later
facilitiesLayerName = subLayerNames["Facilities"]

#Load the warehouses as Facilities using the default field mappings and search tolerance
arcpy.na.AddLocations(outNALayer, facilitiesLayerName, inFacilities, "", "")
```

Working with analysis layers within scripts

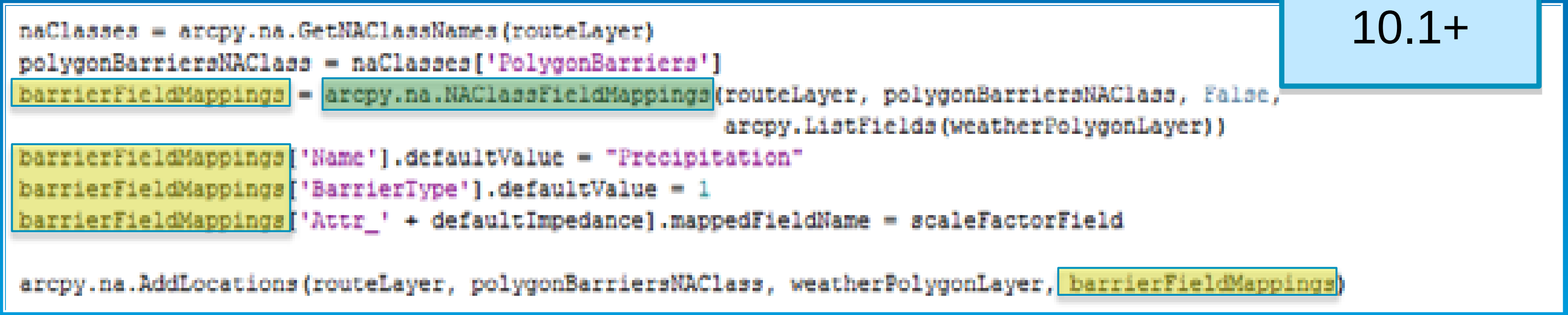
- Helper classes for complex parameter types
  - Easily specify field mappings in Add Locations tool by using `arcpy.na.NAClassFieldMappings`

10.0



```
barrierFieldMappings = "Name # Precipitation; BarrierType # 1; " + "Attr_%s %s #" % (impedance, scaleFactorField)

arcpy.na.AddLocations(routeLayer, polygonBarriersNAClass, weatherPolygonLayer, barrierFieldMappings)
```

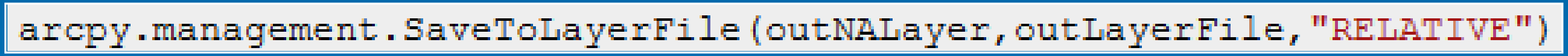
10.1+



```
naClasses = arcpy.na.GetNAClassNames(routeLayer)
polygonBarriersNAClass = naClasses['PolygonBarriers']
barrierFieldMappings = arcpy.na.NAClassFieldMappings(routeLayer, polygonBarriersNAClass, False,
                                                      arcpy.ListFields(weatherPolygonLayer))
barrierFieldMappings['Name'].defaultValue = "Precipitation"
barrierFieldMappings['BarrierType'].defaultValue = 1
barrierFieldMappings['Attr_' + defaultImpedance].mappedFieldName = scaleFactorField

arcpy.na.AddLocations(routeLayer, polygonBarriersNAClass, weatherPolygonLayer, barrierFieldMappings)
```

Saving analysis results

- The in-memory network analysis layer can be persisted using SaveToLayerFile geoprocessing tool in the management module



```
arcpy.management.SaveToLayerFile(outNALayer,outLayerFile,"RELATIVE")
```

- Layer files can then be dragged from disk into ArcMap manually

Demo

Demo: Python Script

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 run at the operating system command prompt

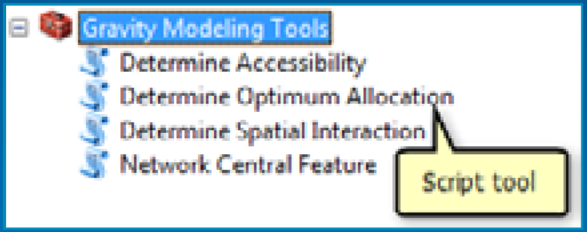
Building Script Tools

More Information:

What is a script tool? in ArcGIS help

Script Tools

- Script tools allow you to work with your scripts through a user interface, instead of a command line

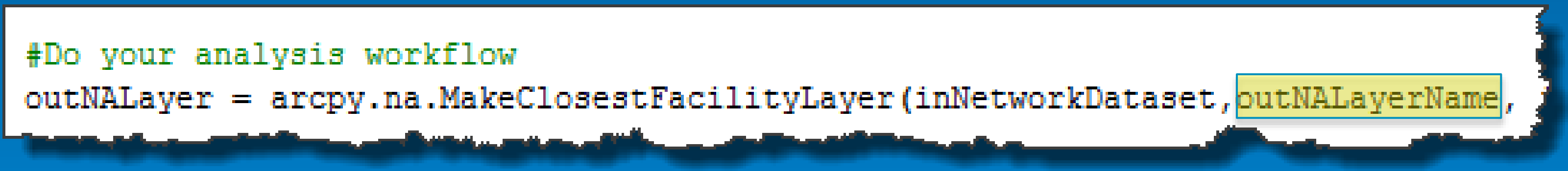


Gravity Modeling Tools
Determine Accessibility
Determine Optimum Allocation
Determine Spatial Interaction
Network Central Feature

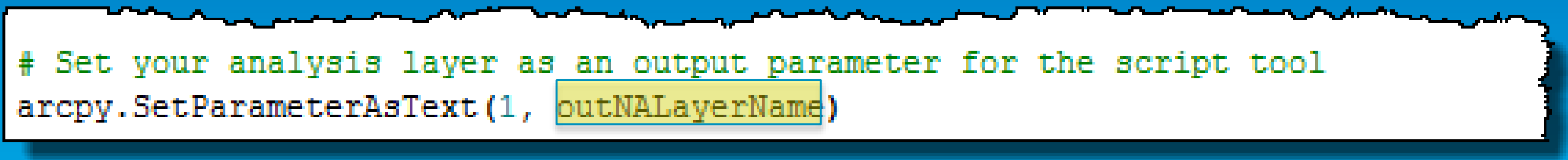
- Script tools behave like any other tool within ArcToolbox
  - Can use script tools in models and vice versa

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(…)



```
#Do your analysis workflow
outNALayer = arcpy.na.MakeClosestFacilityLayer(inNetworkDataset,outNALayerName,
```



```
# Set your analysis layer as an output parameter for the script tool
arcpy.SetParameterAsText(1, outNALayerName)
```

Demo

Script Tool

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

Home
Home

Claim Locations
ClaimLocations

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

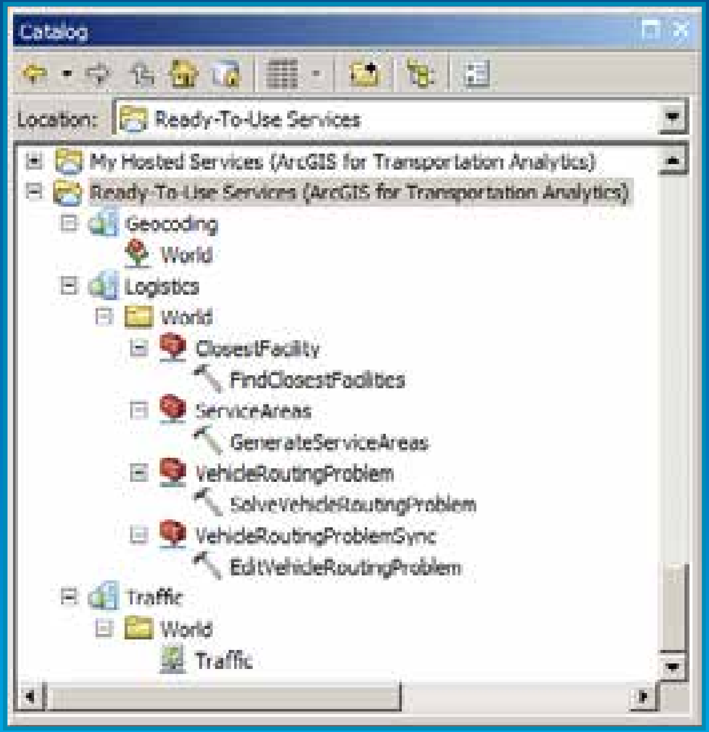
- For example, calling linear programming (LP) solvers using PuLP
  - PuLP is a public domain Python module for modeling LP problems
  - PuLP can work with a variety of LP solvers such as COIN-OR, GLPK, XPRESS, CPLEX.

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
- The output network analysis layer supports pre-defined symbology using layer files

What’s new in 10.2

- Global, Ready-To-Use services



Location: Ready-To-Use Services

Catalog
My Hosted Services (ArcGIS for Transportation Analytics)
Ready-To-Use Services (ArcGIS for Transportation Analytics)
Geocoding
World
Logistics
World
ClosestFacility
FindClosestFacilities
ServiceAreas
GenerateServiceAreas
VehicleRoutingProblem
SolveVehicleRoutingProblem
VehicleRoutingProblemSync
EditVehicleRoutingProblem
Traffic
World
Traffic

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

- Tutorials
  - Network Analyst tutorial
  - Network Analyst geoprocessing service examples
- Code samples in Network Analyst tools toolbox
- ArcGIS Network Analyst Extension Discussion Forum
- ArcGIS for Transportation Analytics Group on arcgis.com
- Python for ArcGIS resource center

Network Analyst at the User’s Conference

Network Analyst team presentations

	Tuesday	Wednesday	Thursday
8:30 am	Network Analyst: An Introduction Room 32 B	Network Analyst: Network Analysis with ArcGIS Online and On-premise Services Room 32 A Network Analyst: Creating Network Datasets Room 32 B	Designing your Network Analyst Workflow Hall F: Room 1
9 am			
10 am	Network Analyst: Performing Network Analysis Room 32 B	Network Analyst: Automating Workflows with Geoprocessing Room 32 A	Network Analyst: Locating Facilities with Resource Constraints Using the Capacitated Location-Allocation Solver Analysis and Geoprocessing Exhibit Hall B
11 am			
12 pm		Network Analyst: Routing and Directions using Data and Services on ArcGIS Online Analysis and Geoprocessing Exhibit Hall B	Network Analyst: How to Build Efficient Vehicle Routes that Improve Cost and Customer Satisfaction Using Network Analyst Analysis and Geoprocessing Exhibit Hall B
1 pm	Network Analyst: How to Route Inside and Between Buildings Using 3D Network Capabilities Analysis and Geoprocessing Exhibit Hall B Network Analyst: Network Analysis with ArcGIS Online and On-premise Services Room 32 B	Network Analyst: An Introduction Room 32 B	Network Analyst: Automating Workflows with Geoprocessing Room 32 A Network Analyst: Performing Network Analysis Room 32 B
2 pm			
3 pm	Network Analyst: Creating Network Datasets Room 32 B	Yay, Transit! Using GTFS Public Transit Data for Pedestrian Analysis and Transit Accessibility Analysis and Geoprocessing Exhibit Hall B Real-time Traffic and Other New Capabilities of Network Analysis Analysis and Geoprocessing Exhibit Hall B	
4 pm		Designing your Network Analyst Workflow Hall G: Room 2	
5 pm			

Other Network Analyst presentations

	Tuesday	Wednesday	Thursday
8:30 am	**Transportation Network Analysis and Planning** Room 26 B **Multi-Modal Transportation and Logistics: Leading Examples** Room 28 E		**Esri & OpenStreetMap: Tools, Apps, Maps!** Hall G: Room 2
9 am			
10 am	**Electric Vehicles: GIS for EV Infrastructure** Room 29 A/B **Transportation Planning for Rural Areas** Room 26 B		
11 am		**ArcGIS GeoEvent processor for Server - Monitoring Routes** Hall G: Room 2	**Using Streetmap Premium** Online GIS Exhibit Hall C
12 pm			
1 pm	**Customer and Route Optimization in Public Works** Room 30 B **Indoor Location, Tracking, and Routing** Room 31 B	**Public Transit: Accessibility and Land Use** Room 28 A **Facilities and Real Property Management** Room 31 B	**Pedestrian Routing, Transit, and Tolls** Room 26 B
2 pm			
3 pm	**GIS for Non-Motorized Transport** Room 26 B		
4 pm			
5 pm	**Using Streetmap Premium** Online GIS Exhibit Hall C		

Thank you…

Please fill out the session evaluation

First Offering ID: 1364

Second Offering ID: 1449

Online – www.esri.com/ucsessionsurveys

Paper – pick up and put in drop box