ArcGIS Pro SDK for .NET: An Overview of the Utility Network Management API

Rich Ruh, David Crawford

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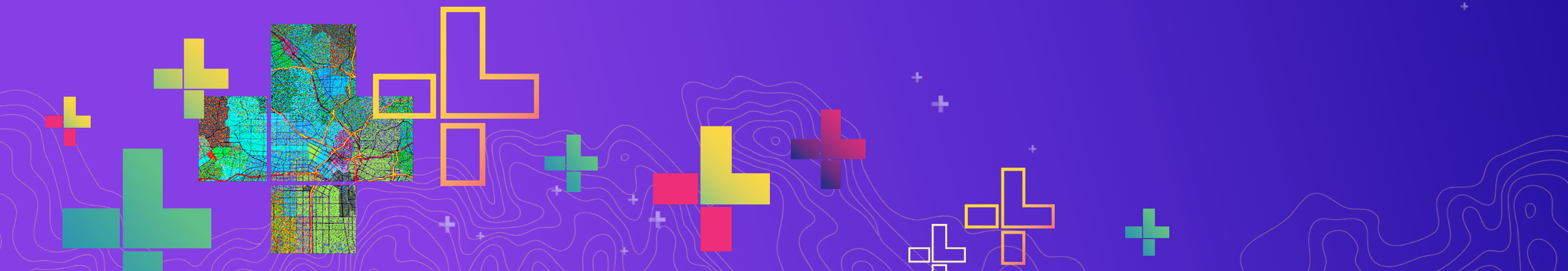


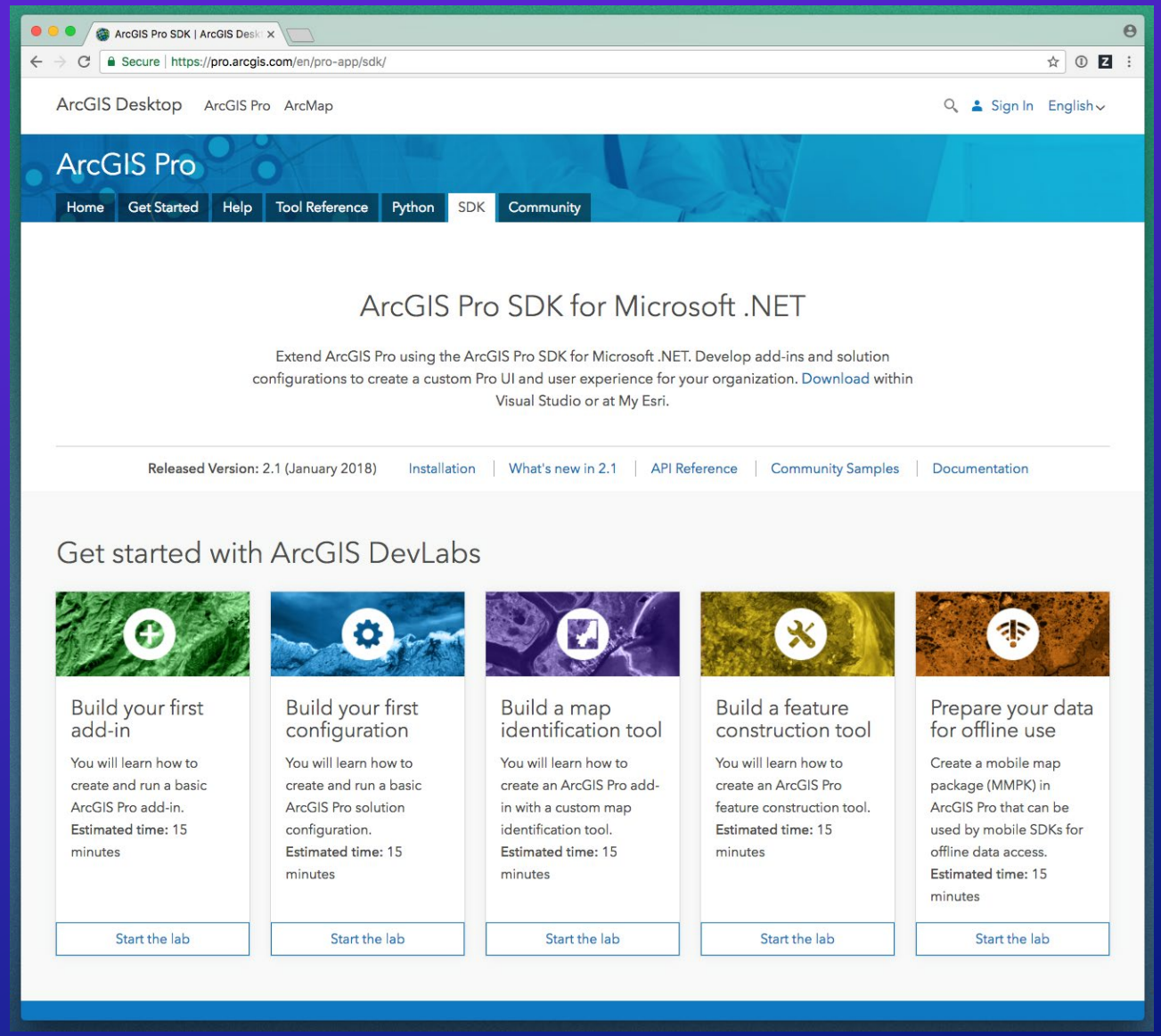
Today’s Agenda

- Getting Started
- A Survey of the Utility Network APIs
- What’s New?
- The Road Ahead
- Learning More

Getting Started

https://pro.arcgis.com/en/pro-app/sdk/

Search for: “ArcGIS Pro SDK”



Overview

- The utility network C# SDK is a managed .NET SDK that provides access to the utility network
- It is an object-oriented SDK that aligns with modern C# practices and existing frameworks
- It adheres to the principles and architecture of the general Pro SDK
- This presentation assumes a basic understanding of the utility network information model

Architectural Topics

- DML-only (Data Manipulation Language)
- Threading

Architecture: DML-only (Data Manipulation Language)

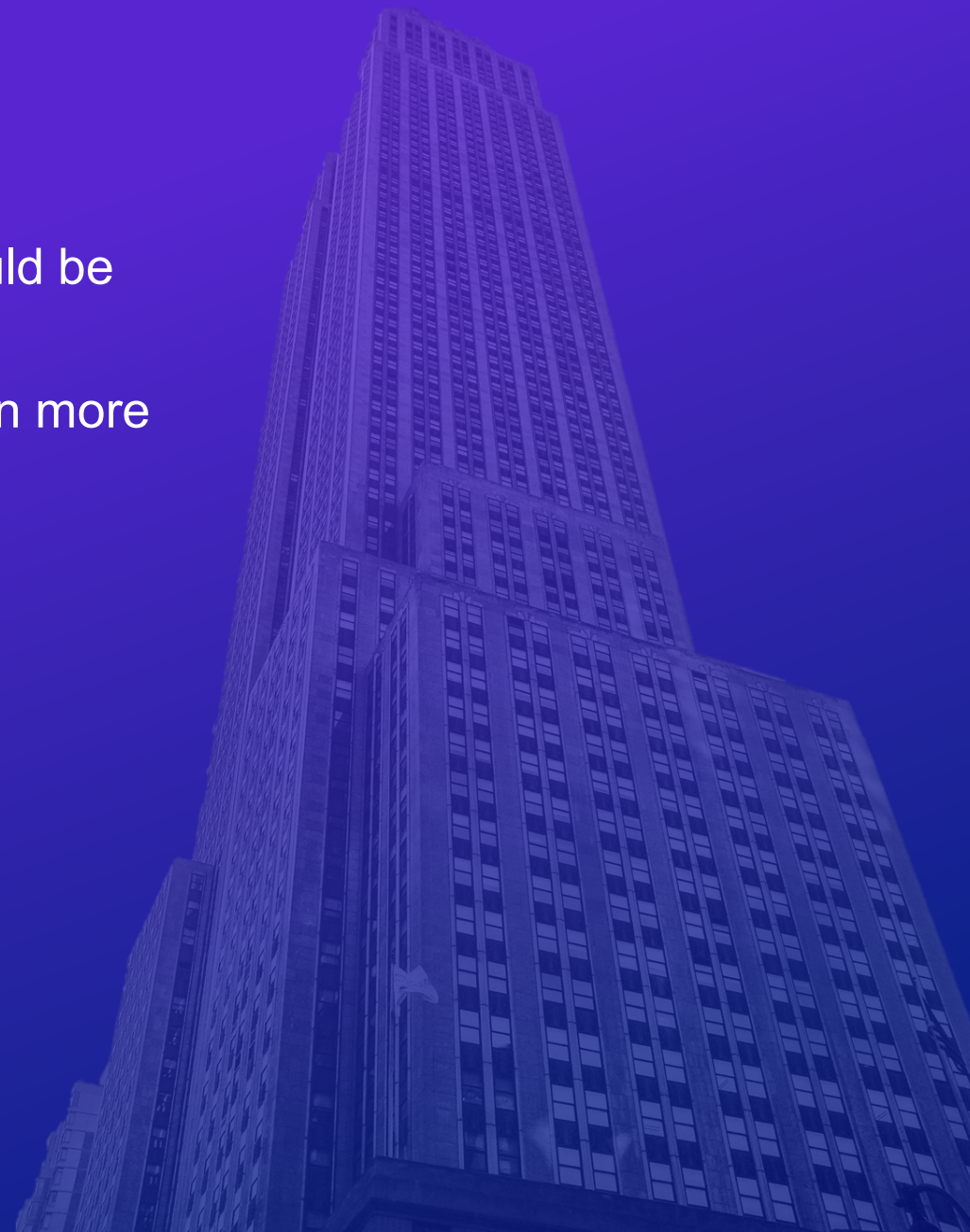
- The utility network API is a **DML-only (Data Manipulation Language)** API
  - Schema creation and modification operations such as creating domain networks, adding and deleting rules, etc., need to performed using Python
  - This is in alignment with the rest of the Geodatabase API
  - Python can be called from C# by using the Geoprocessing API

```
var args = Geoprocessing.MakeValueArray(utilityNetworkPath, @"ALL", @"rules.csv");
var result = Geoprocessing.ExecuteToolAsync("un.ImportRules", args);
```

Architecture: Threading

- Almost all of the methods in the utility network API should be called on the MCT (Main CIM Thread)
- Read Working with multithreading in ArcGIS Pro to learn more

```
Task t = QueuedTask.Run(() =>
{
  //put utility network code here
});
```



Architecture: Namespaces and Extension Methods

- The main items of the utility network are included within the `ArcGIS.Core.Data.UtilityNetwork` namespace
  - Tracing items are included within `ArcGIS.Core.Data.UtilityNetwork.Trace`
  - Network diagram items are included within `ArcGIS.Core.Data.UtilityNetwork.NetworkDiagrams`
- There are some cases where the objects in `ArcGIS.Core.Data` need to integrate with ArcGIS Pro at a higher level in the architectural stack
- In these cases, C# extensions methods are provided
  - To use these extension methods:
    - Add a reference to `ArcGIS.Desktop.Extensions` to your solution
    - Add `using ArcGIS.Core.Data.UtilityNetwork.Extensions` to the top of your source files
  - These steps allow these extension methods to appear as if they were regular methods on utility network classes
  - These extension methods are intended for use in ArcGIS Pro Add-ins, and cannot be used with CoreHost applications

Other Ways to Access the Utility Network

- In addition to the ArcGIS Pro Managed SDK, there are other ways to program against a utility network:
  - Geoprocessing models and Python scripts
  - Directly coding against the REST APIs

```
# Update subnetworks
arcpy.AddMessage("Update subnetworks")
arcpy.UpdateSubnetwork_un(utilityNetwork, domainNetworkName, "Subtransmission", "ALL_SUBNETWORKS_IN_TIER")
arcpy.UpdateSubnetwork_un(utilityNetwork, domainNetworkName, "Medium Voltage", "ALL_SUBNETWORKS_IN_TIER")
arcpy.UpdateSubnetwork_un(utilityNetwork, domainNetworkName, "Low Voltage Mesh", "ALL_SUBNETWORKS_IN_TIER")
arcpy.AddMessage("Finished updating subnetworks")
```

validateNetworkTopology

POST only

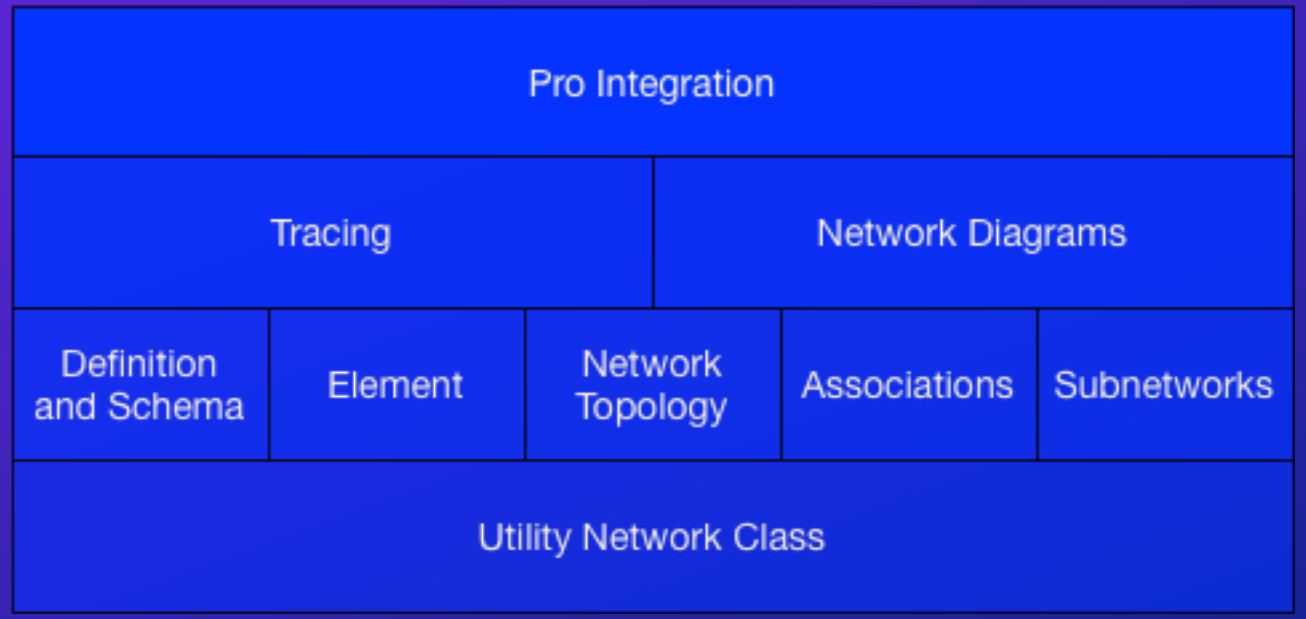
Validating the network topology for a utility network maintains consistency between feature editing space and network topology space. Validating a network topology may include all or a subset of the dirty areas present in the network.

Parameter	Details
f	Description: Optional parameter representing the output format of the response (default is JSON).
gdbVersion	Description: The name of the GDB version. Syntax: gdbVersion=<version>
sessionId	Description: The token (guid) used to lock the version. Syntax : sessionId=<guid>
validateArea	Description: The envelope of the area to validate.

A Survey of the Utility Network APIs

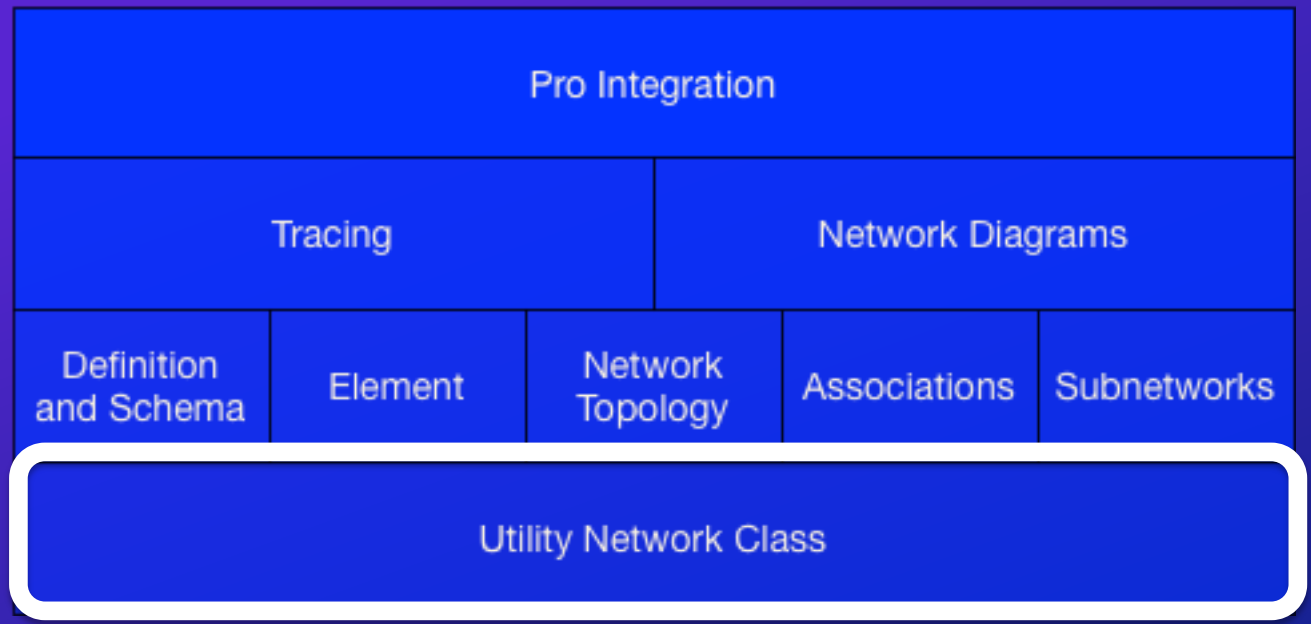
Organization of the Utility Network API

- The API can be logically divided into nine different sections
- The diagram at right provides a functional organization of the API
  - Strictly speaking, the API is a collection of classes
  - Not a layered architecture



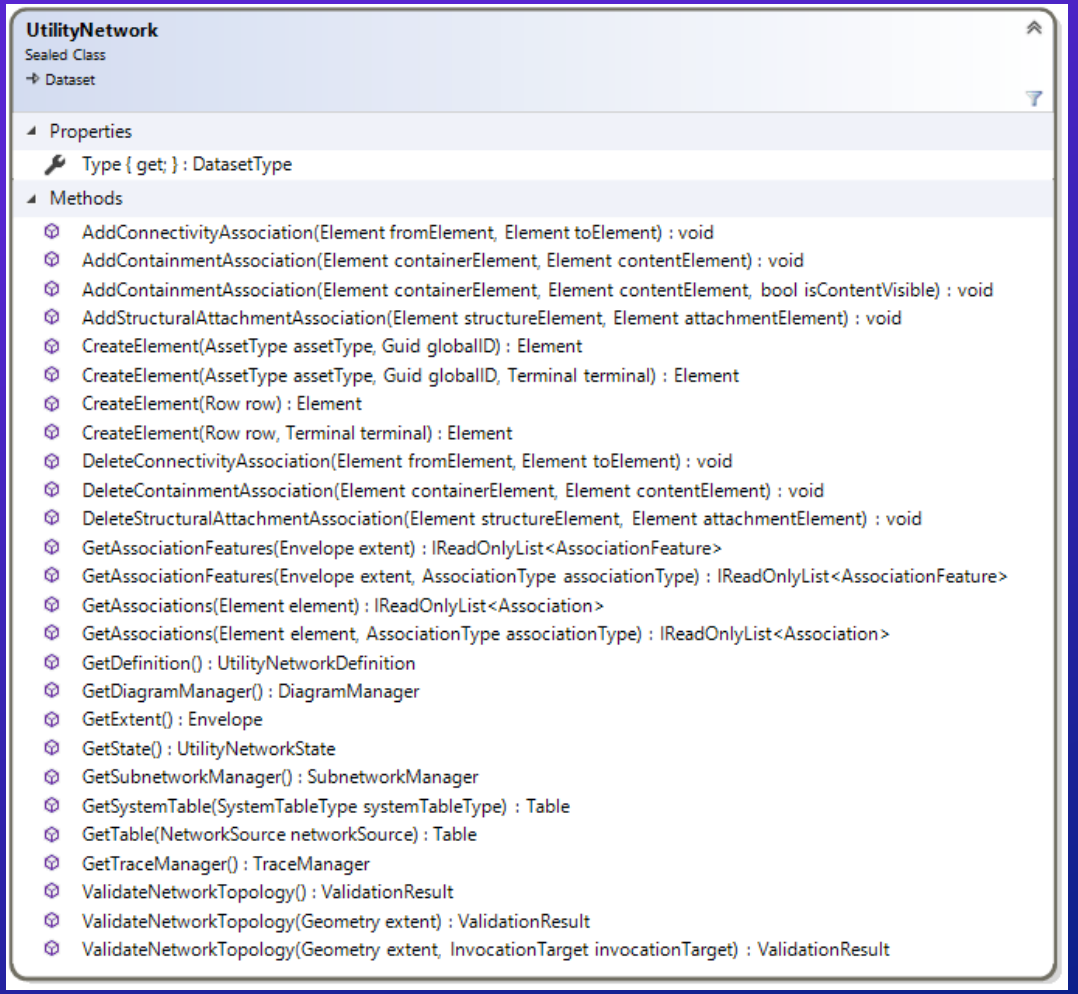
Organization of the Utility Network API

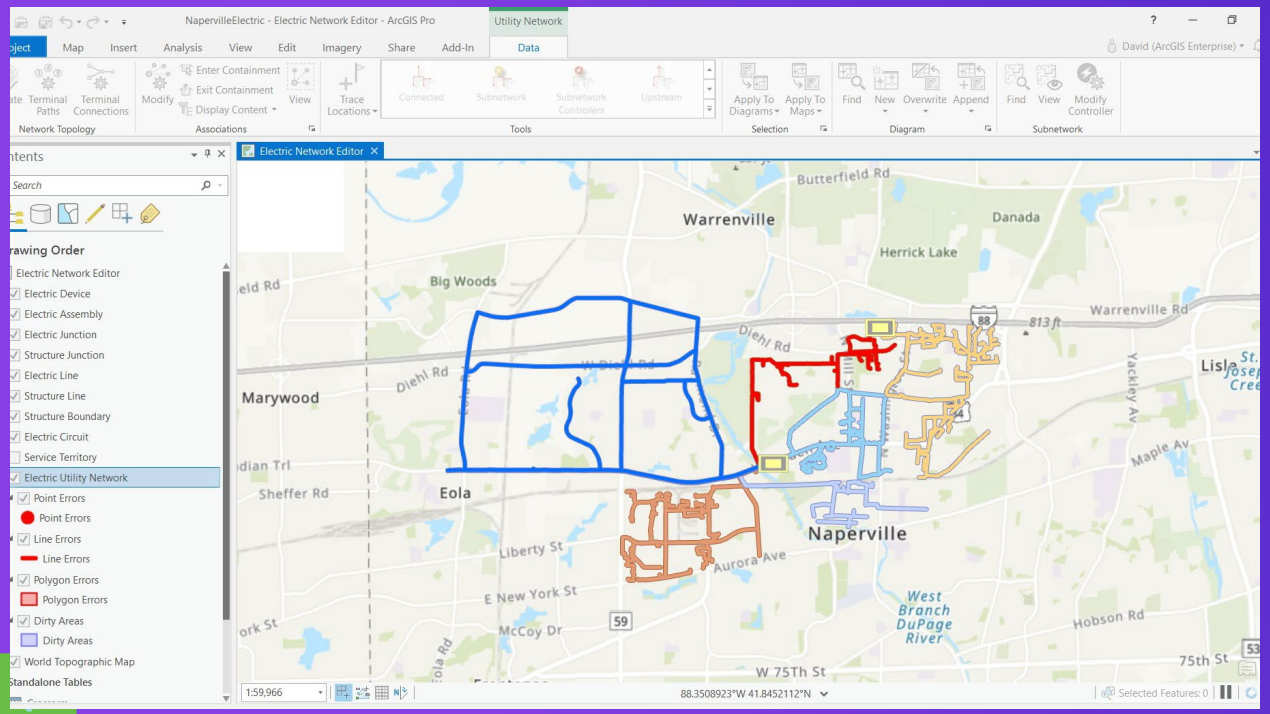
- The Utility Network Class is the root object that provides access to the utility network API



The UtilityNetwork Class

- Serves as the central hub of the utility network API
- Can be obtained from
  - A geodatabase
    - `Geodatabase.OpenDataset<UtilityNetwork>( string datasetName) : UtilityNetwork`
  - A feature class or table
    - `Table.GetControllerDataset() : IReadOnlyList<Dataset>`
  - A utility network layer
    - `GetUtilityNetwork() : UtilityNetwork`



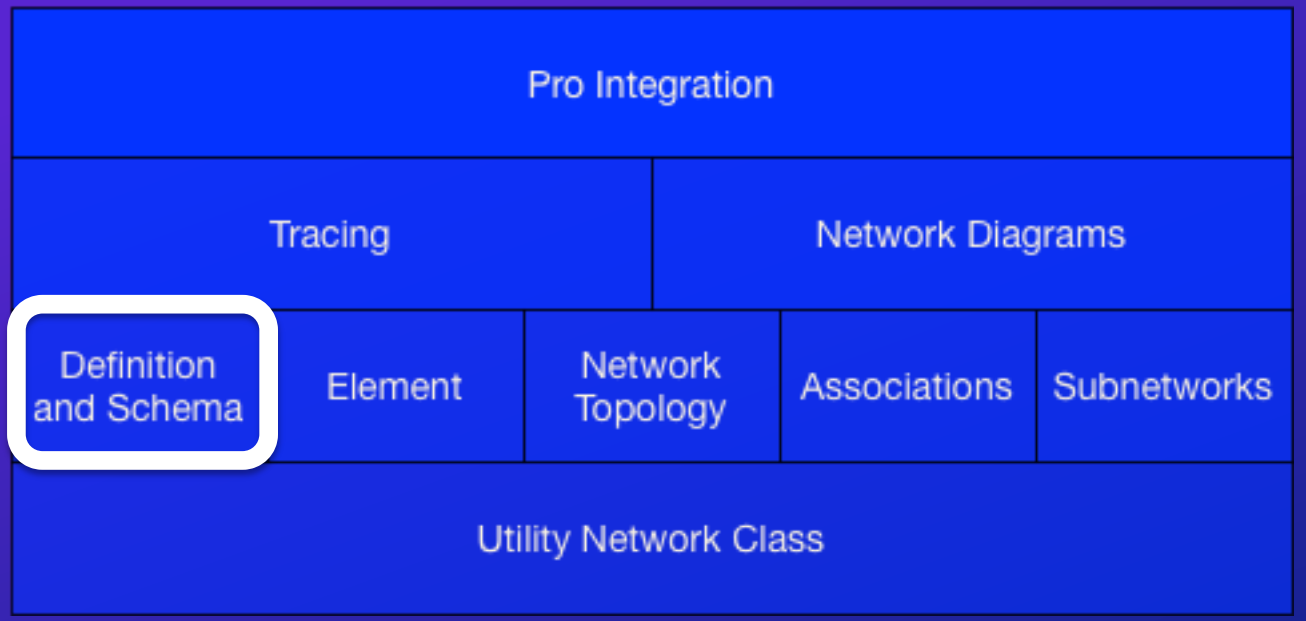


Obtaining a Utility Network Object

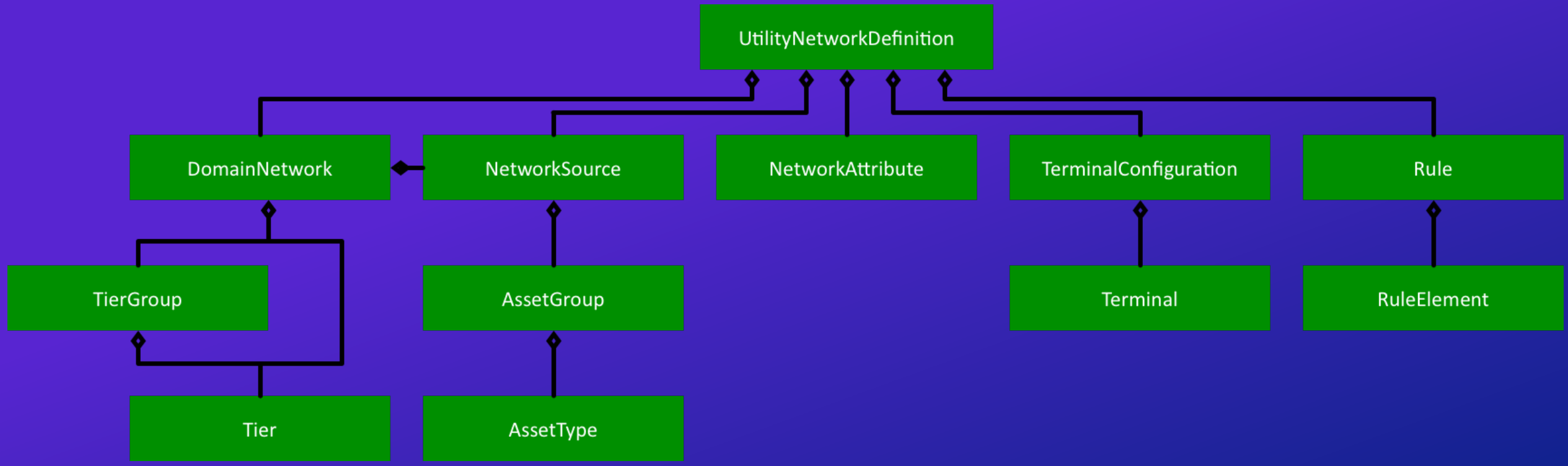
David Crawford

Organization of the Utility Network API

- Definition and Schema describes the classes and methods that provide information about the utility network schema



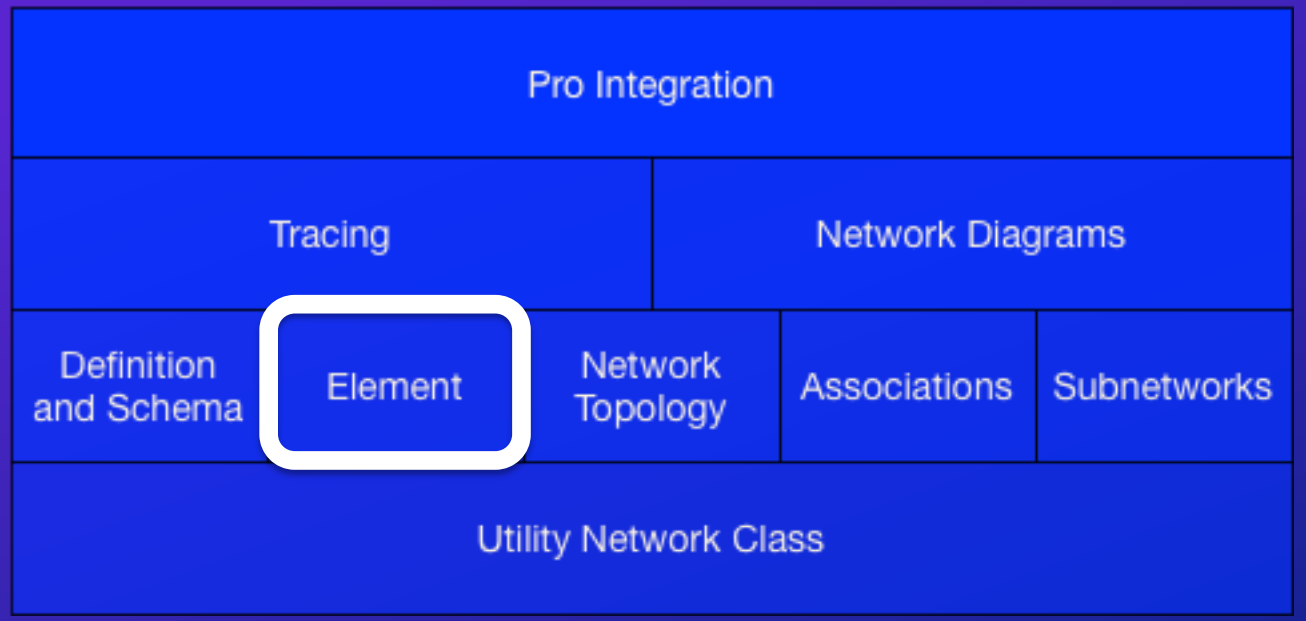
Overview of Definition and Schema Classes



- These classes provide read-only access to schema information
- These classes are value objects that are derived from information cached with the feature service

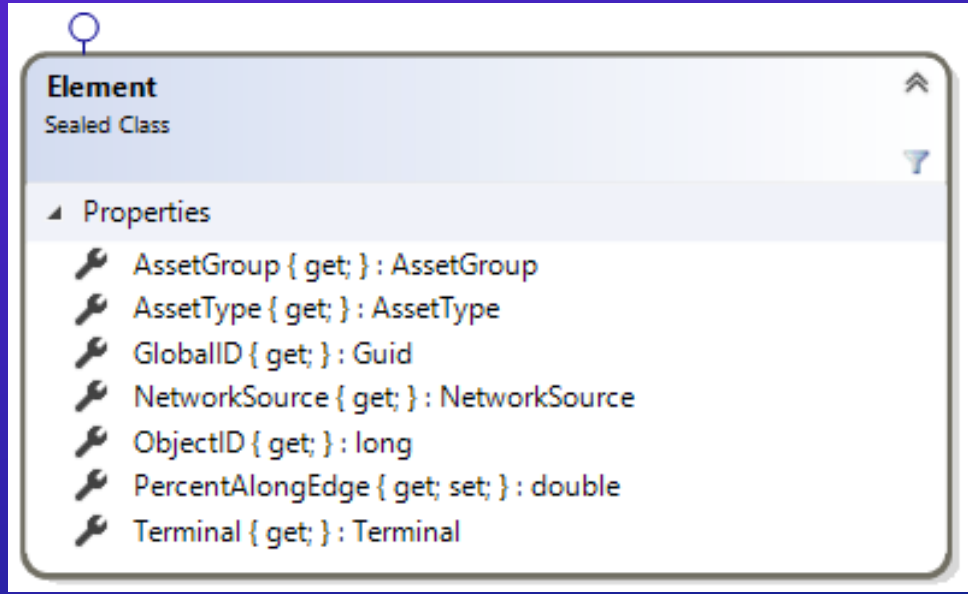
Organization of the Utility Network API

- Element covers the basic encapsulation of a row in the utility network API



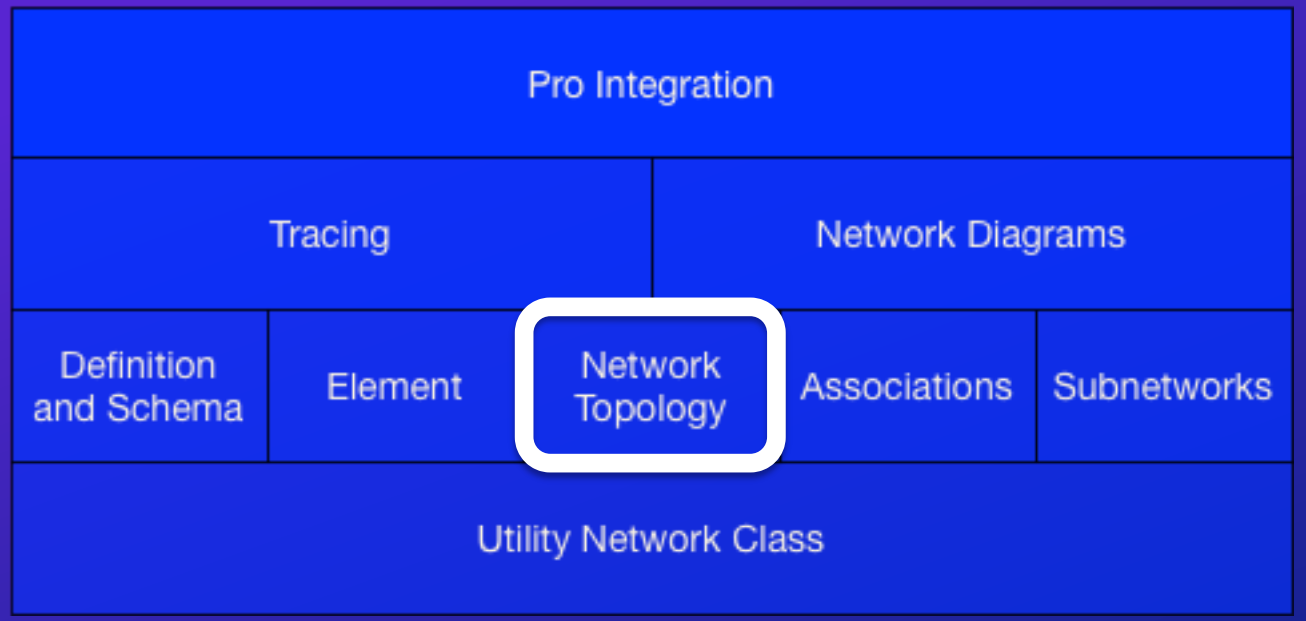
Elements

- The `Element` class represents a row inside a utility network, *plus* a terminal or percent along edge (if applicable)
- Used throughout the API:
  - Elements are used to create and delete associations
  - Elements specify starting points and barriers for use with tracing
  - Elements are returned as results from traces
  - Etc.
- Created using `CreateElement()` factory methods on the `UtilityNetwork` class



Organization of the Utility Network API

- Network Topology covers routines that query the topological index

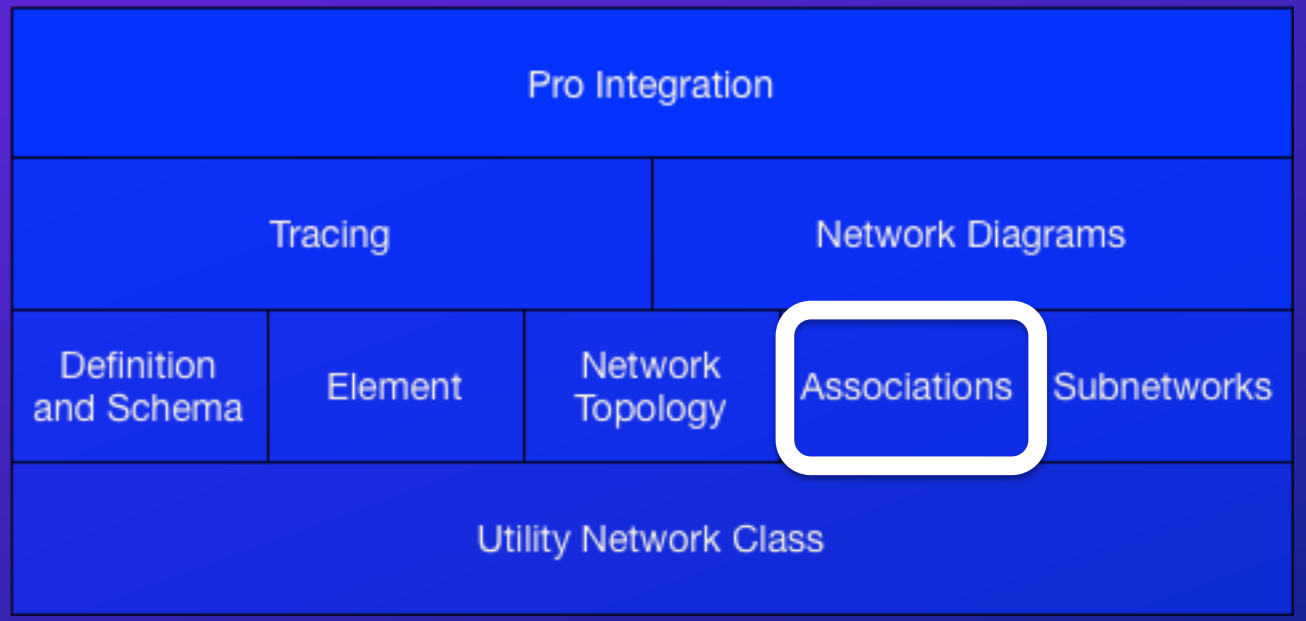


Utility Network Topology

- The network topology stores connectivity, containment, and attachment information used by the utility network to facility fast network traversal/analytical operations
- Network topology is constructed from
  - Geometric coincidence *and…*
  - Associations *in combination with…*
  - A powerful rules engine
- Topology is updated and validated with the `ValidateNetworkTopologyInEditOperation()` extension method on the `UtilityNetwork` class
- Access to fine-grained topology is not provided

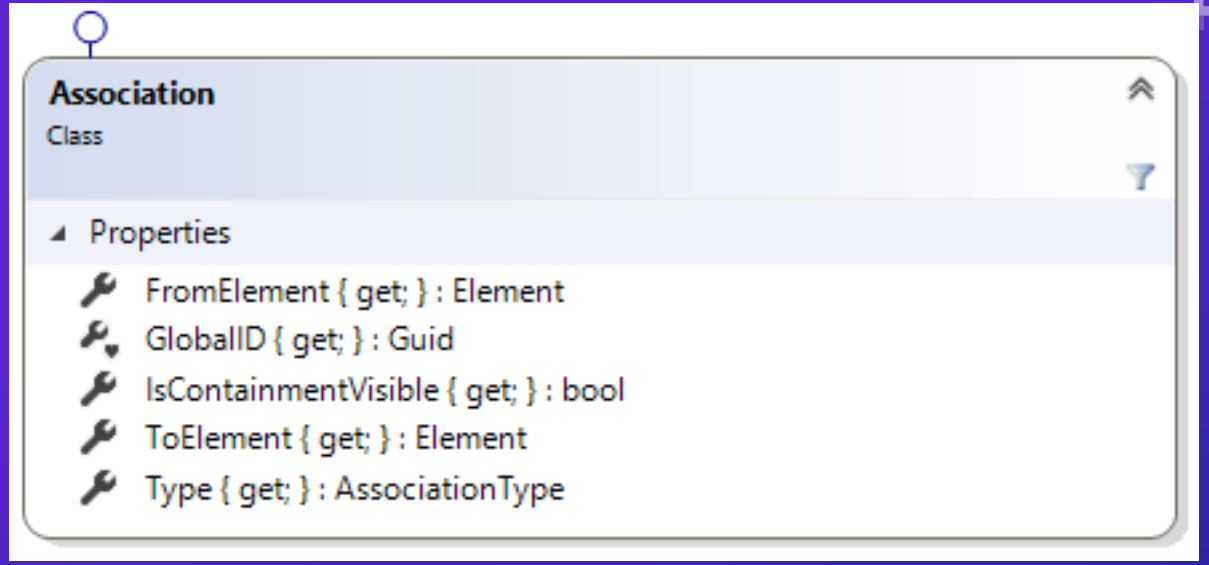
Organization of the Utility Network API

- Associations covers routines that query and edit associations between utility network rows



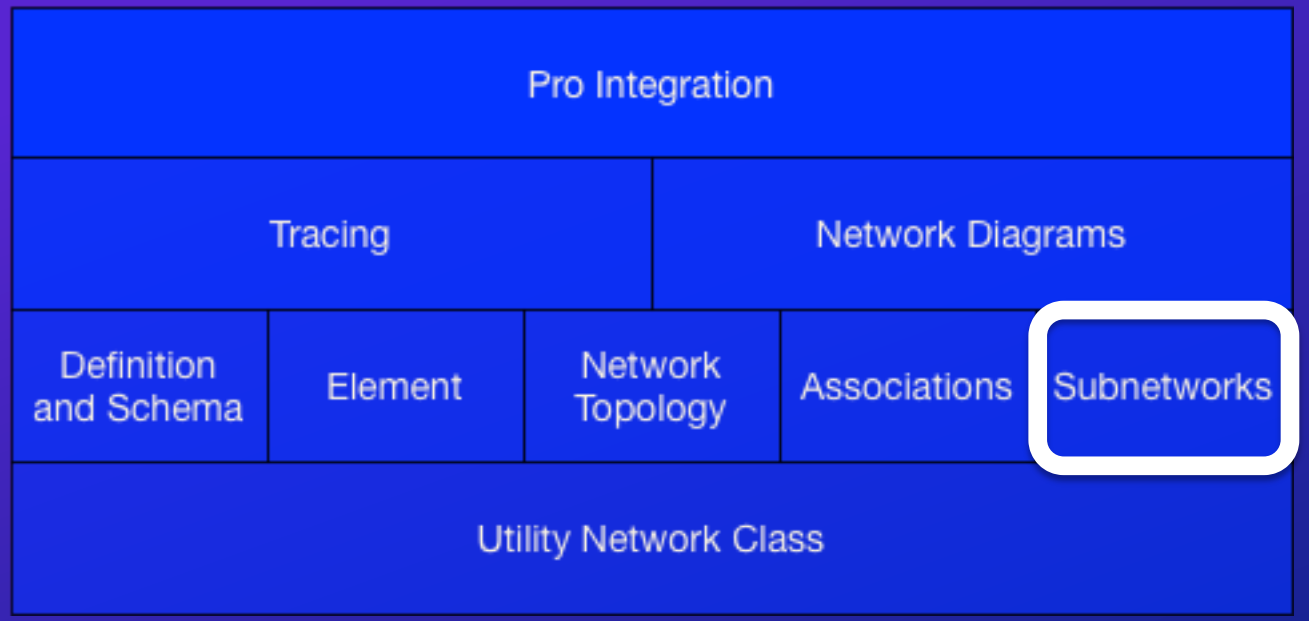
Associations

- Association Types
  - Connectivity
  - Containment
  - Structural Attachment
- Query
  - Get associations for a given Element
- Edit
  - Create or delete associations



Organization of the Utility Network API

- Subnetworks provides classes and routines to query and edit utility network subnetworks

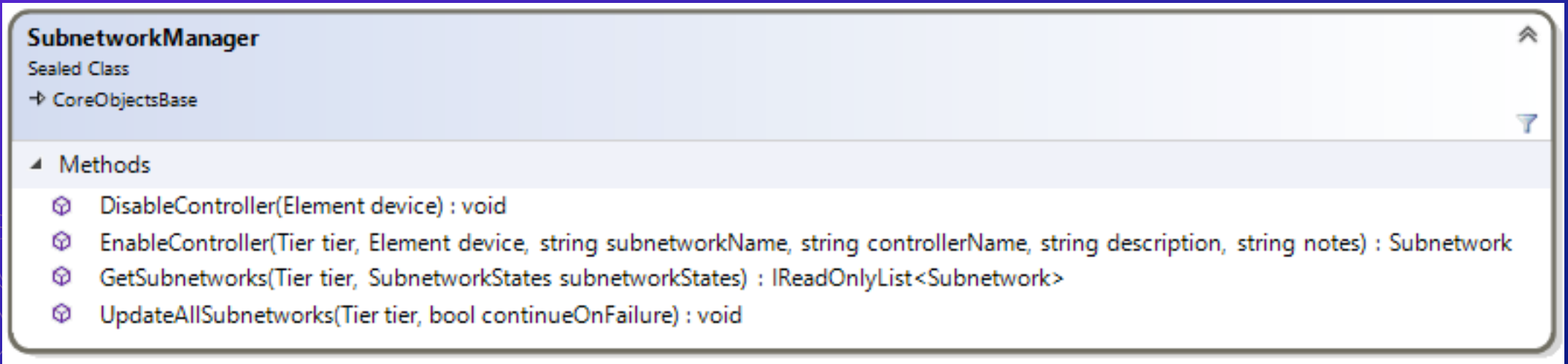


Subnetworks

- The management of subnetworks allows organizations to optimize the delivery of resources and track the status of a network
- A single subnetwork can be used to model such things as a circuit in electric networks, and a zone in gas and water networks
- The `SubnetworkManager` is a class that contains a collection of subnetwork management routines

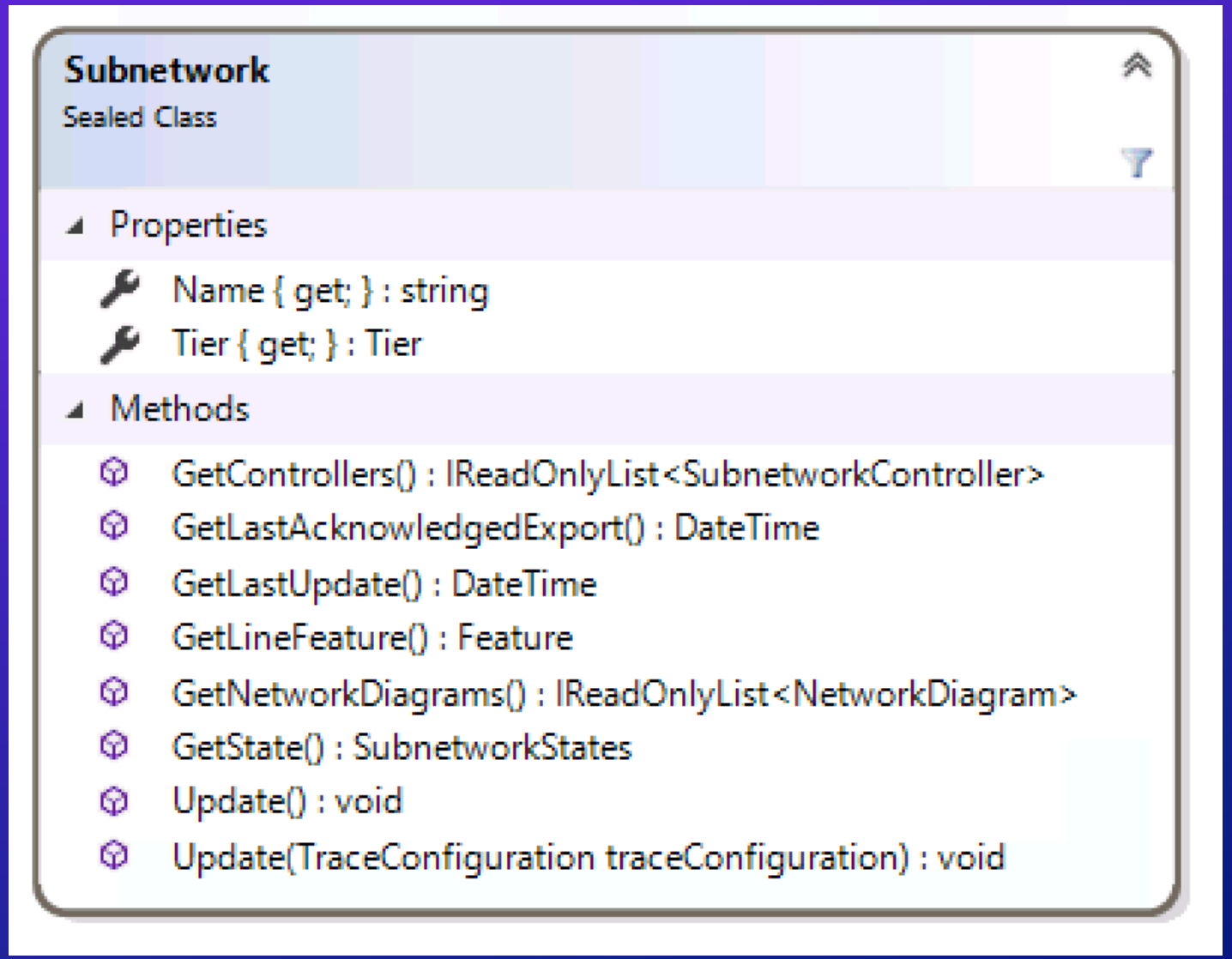
Subnetwork Manager

- Query
  - `GetSubnetworks()` allows retrieval of Subnetworks based on their state
- Edit
  - Add and remove controllers with `EnableControllerInEditOperation()` and `DisableControllerInEditOperation()`
    - Extension methods
  - Update all subnetworks with `UpdateAllSubnetworks()`



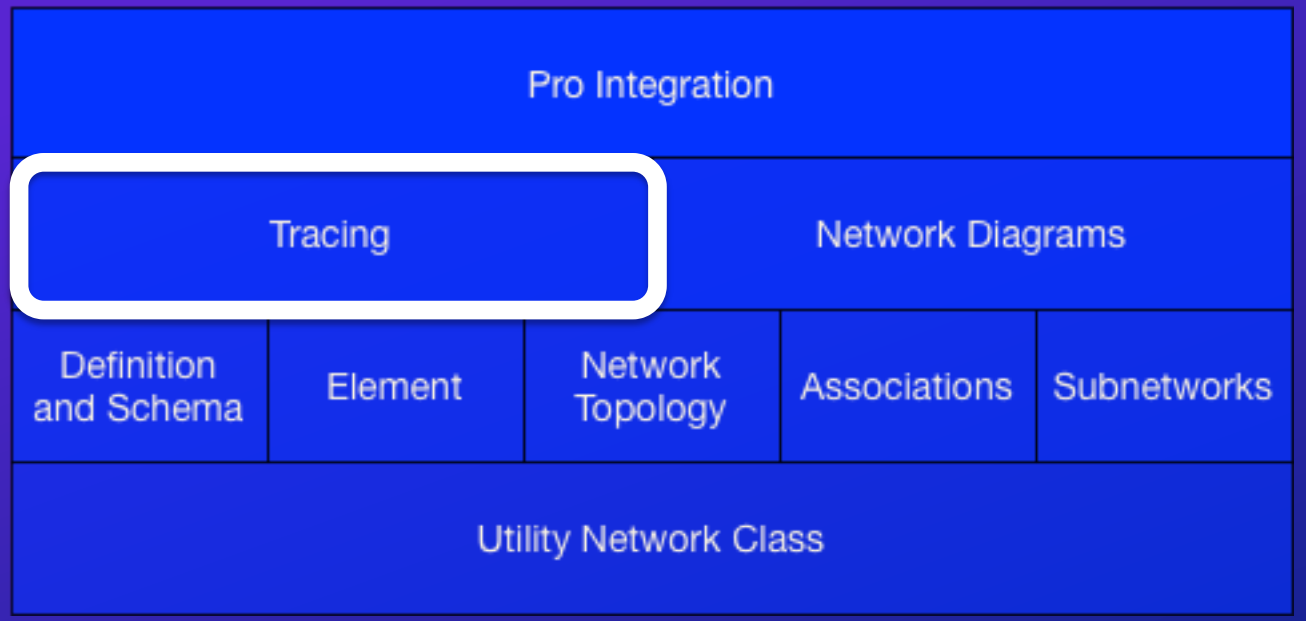
The Subnetwork Class

- Represents a subnetwork
- Update a subnetwork
  - Redraw the map after!
  - `MapView.Redraw(true)`
- Fetch the SubnetLine feature
- Return set of system network diagrams associated with this subnetwork



Organization of the Utility Network API

- Tracing provides tracing functionality
- Tracing entails assembling a subset of utility network elements that meet a specified criteria
- Tracing uses network data to provide business value to utilities
  - Answers questions and solves problems about the current state of the network
  - Helps design future facilities
  - Helps organize business practices

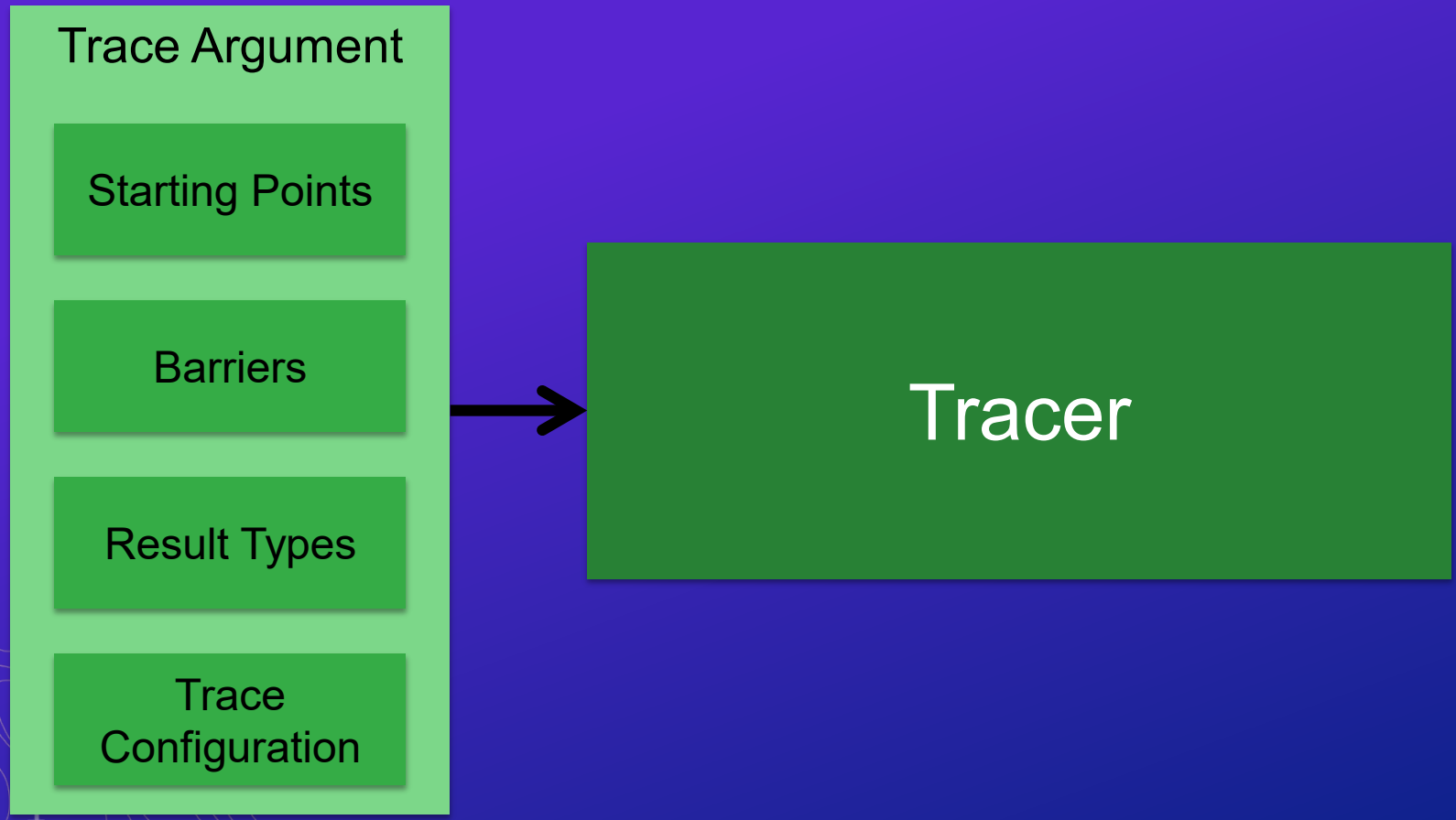


Components of a Trace

- Different kinds of traces are implemented with Tracer objects

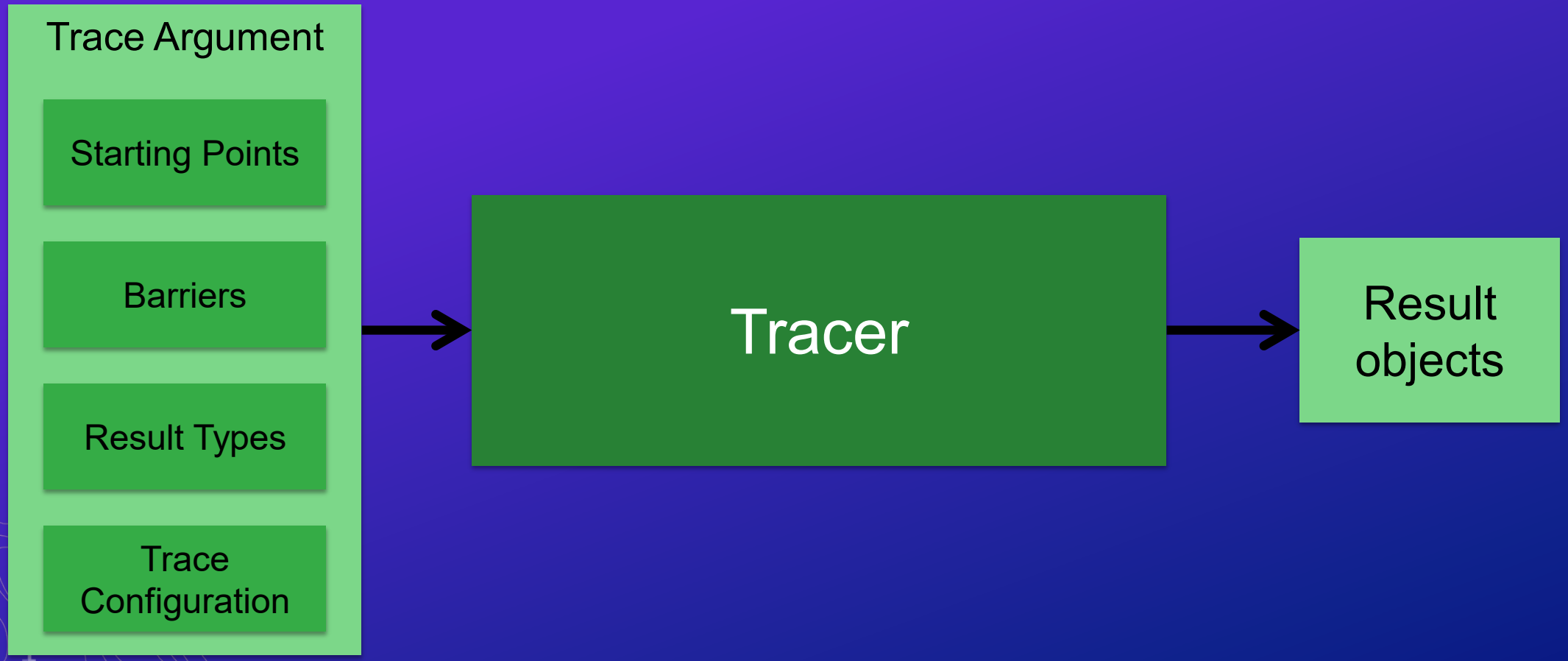
Components of a Trace

- A Trace Argument encapsulates the input parameters for a trace



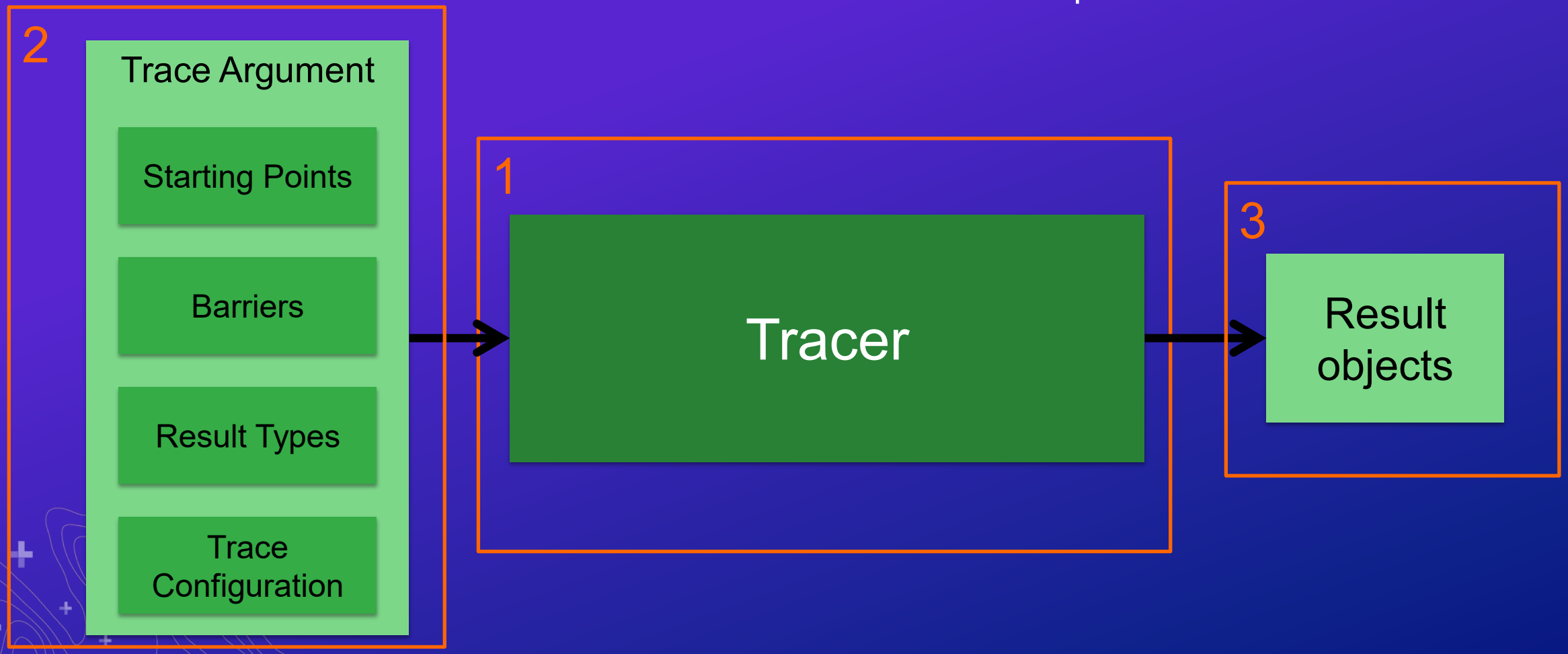
Components of a Trace

- The Tracer generates a set of Result objects as output



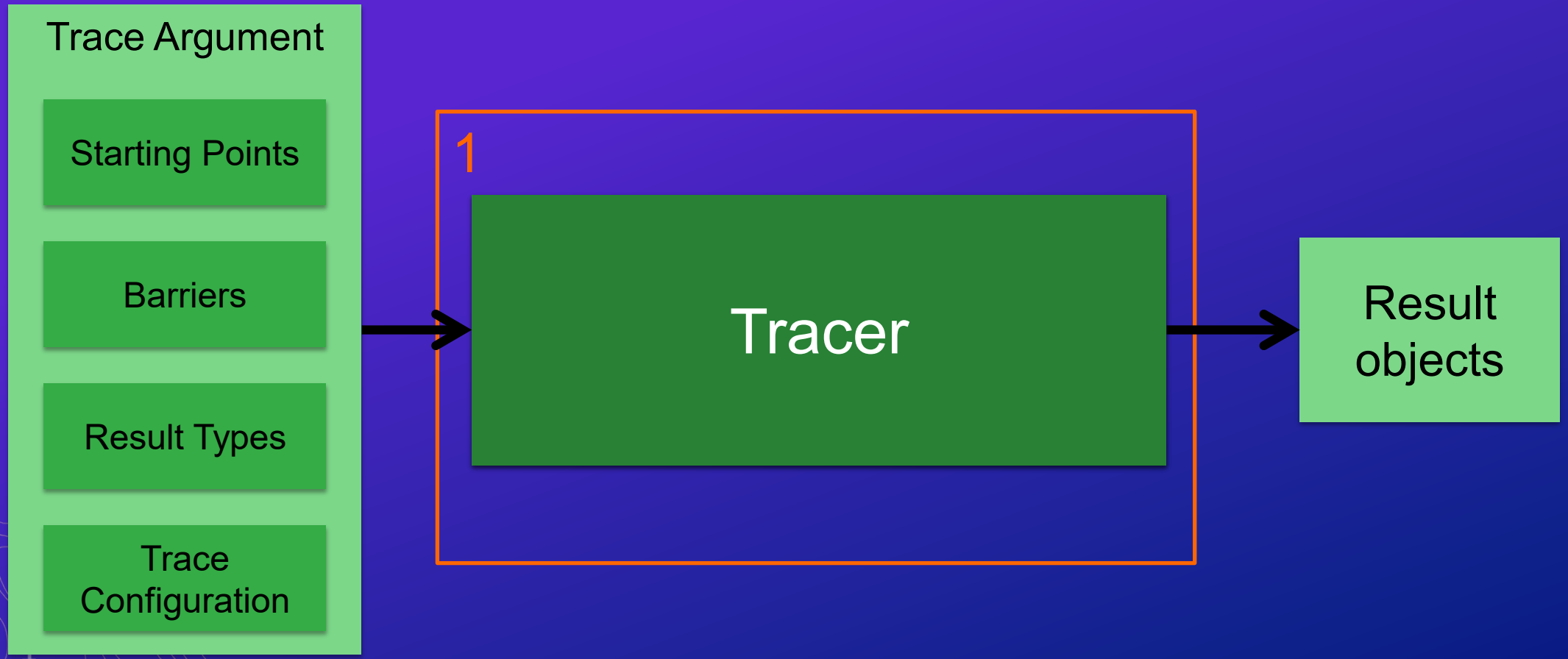
Components of a Trace

We'll cover each of these parts in more detail

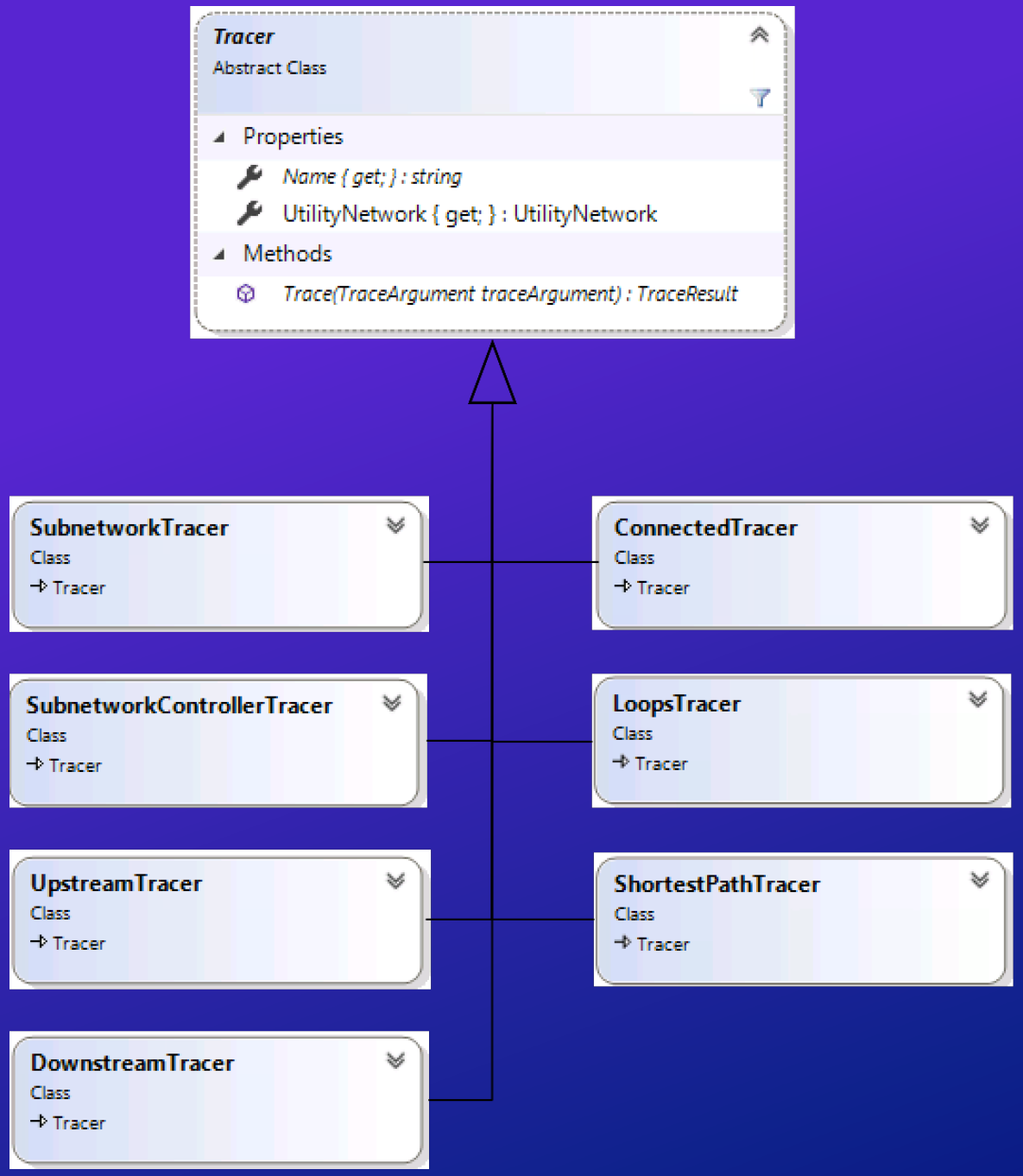


1 Tracer

- Tracers define the tracing algorithm to be used
- Tracer objects are created using `TraceManager`

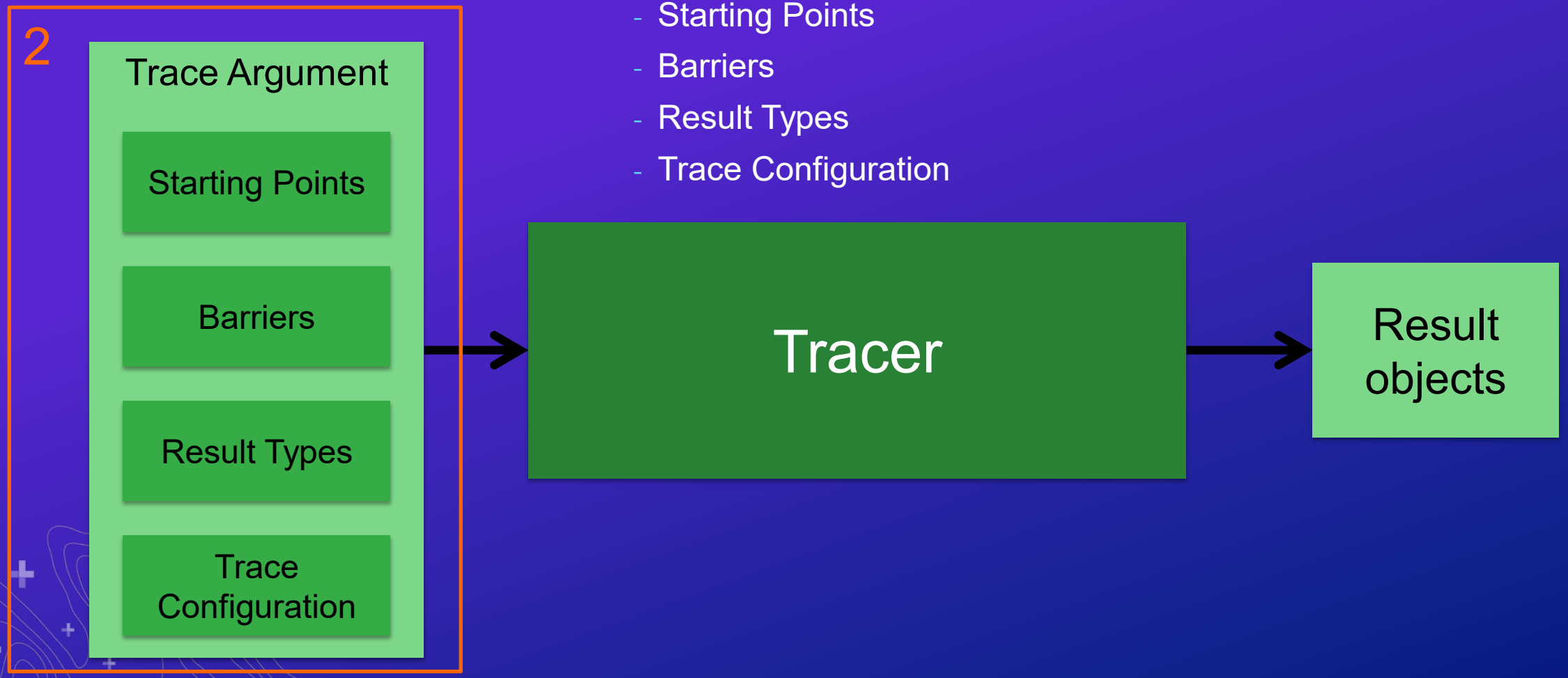


Tracer Objects



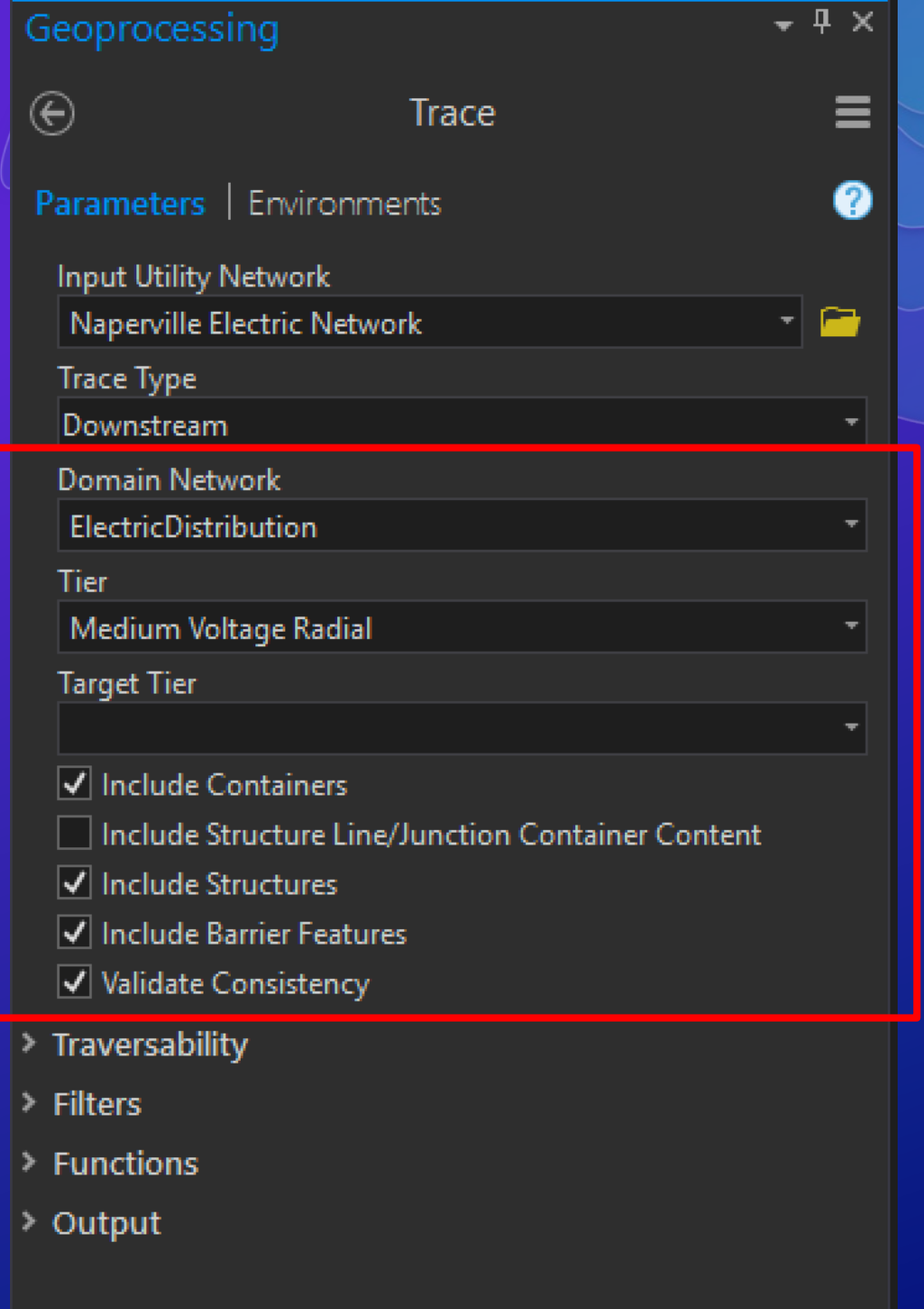
2 Trace Argument

- The `TraceArgument` class consolidates trace parameters
  - Starting Points
  - Barriers
  - Result Types
  - Trace Configuration



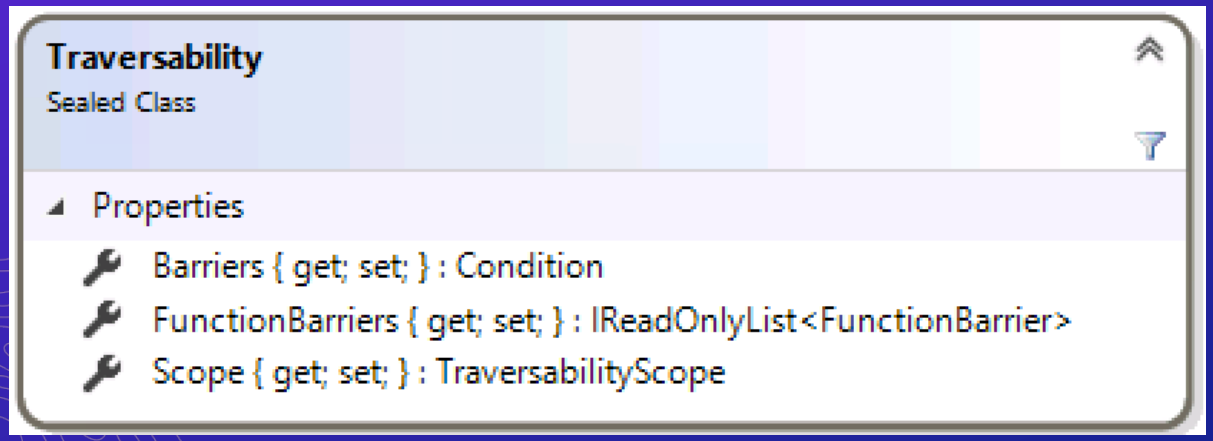
Trace Configuration — Basic Properties

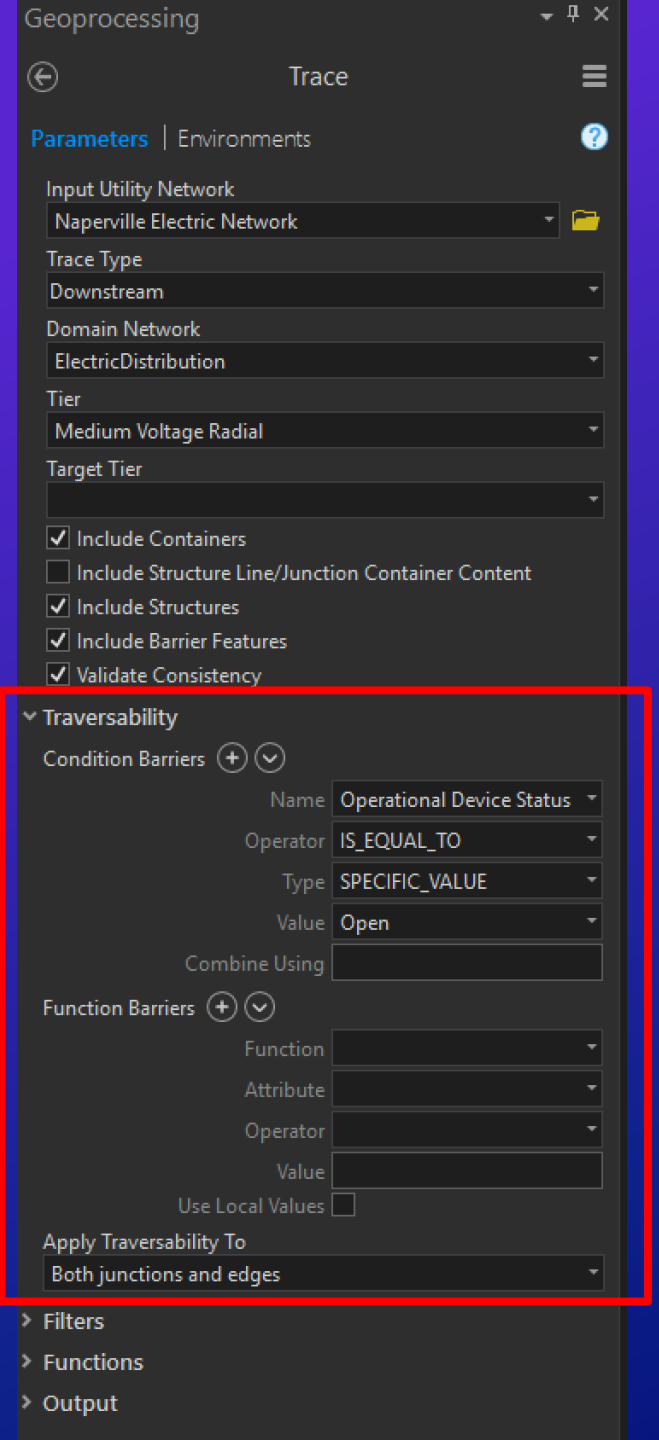
```
IncludeContainers: bool
IncludeContent: bool
IncludeStructures: bool
IncludeBarriersWithResults : bool
DomainNetwork : DomainNetwork
SourceTier : Tier
TargetTier : Tier
ValidateConsistency : bool
```



Trace Configuration — Traversability

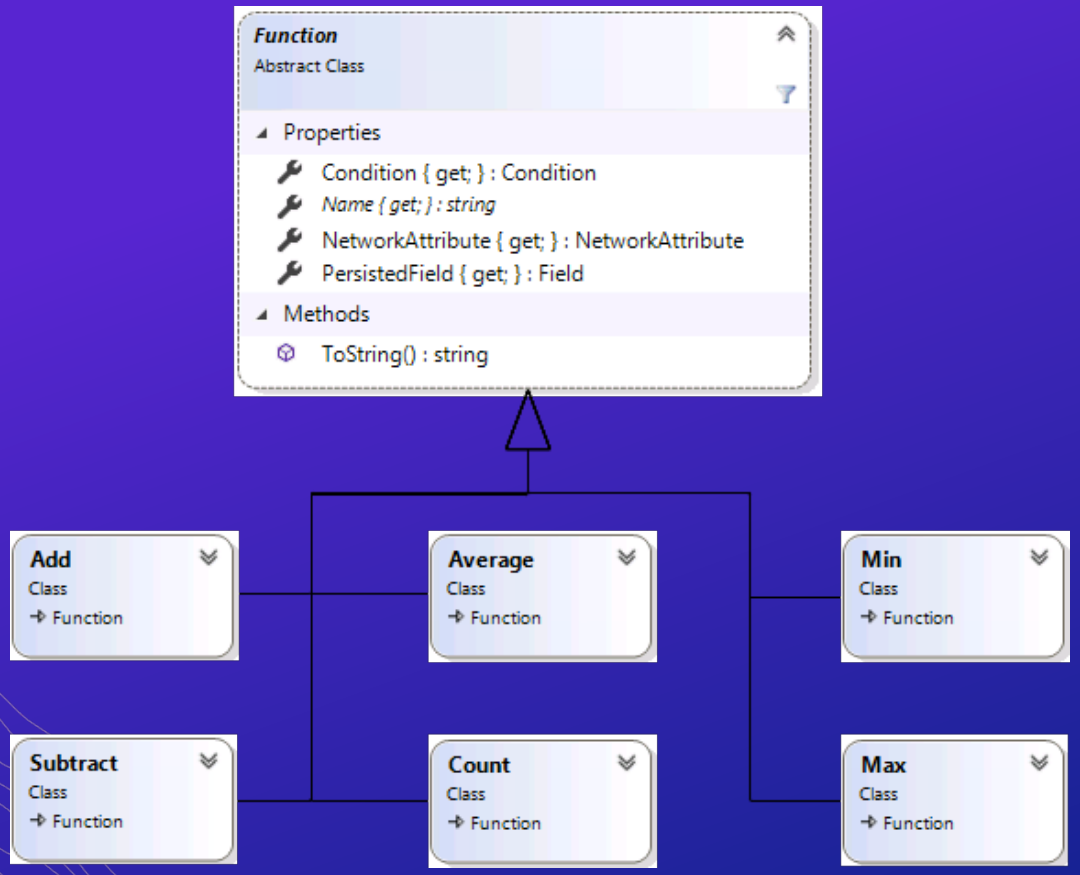
- Traversability is based on
  - Barriers
    - Comparisons of network attributes (`NetworkAttributeComparison`), *or*
    - Checking for the existence of a Category (`CategoryComparison`)
    - These can be combined with boolean And and Or operations to form more complex filters
  - Function Barriers
    - Evaluation of a functional expression

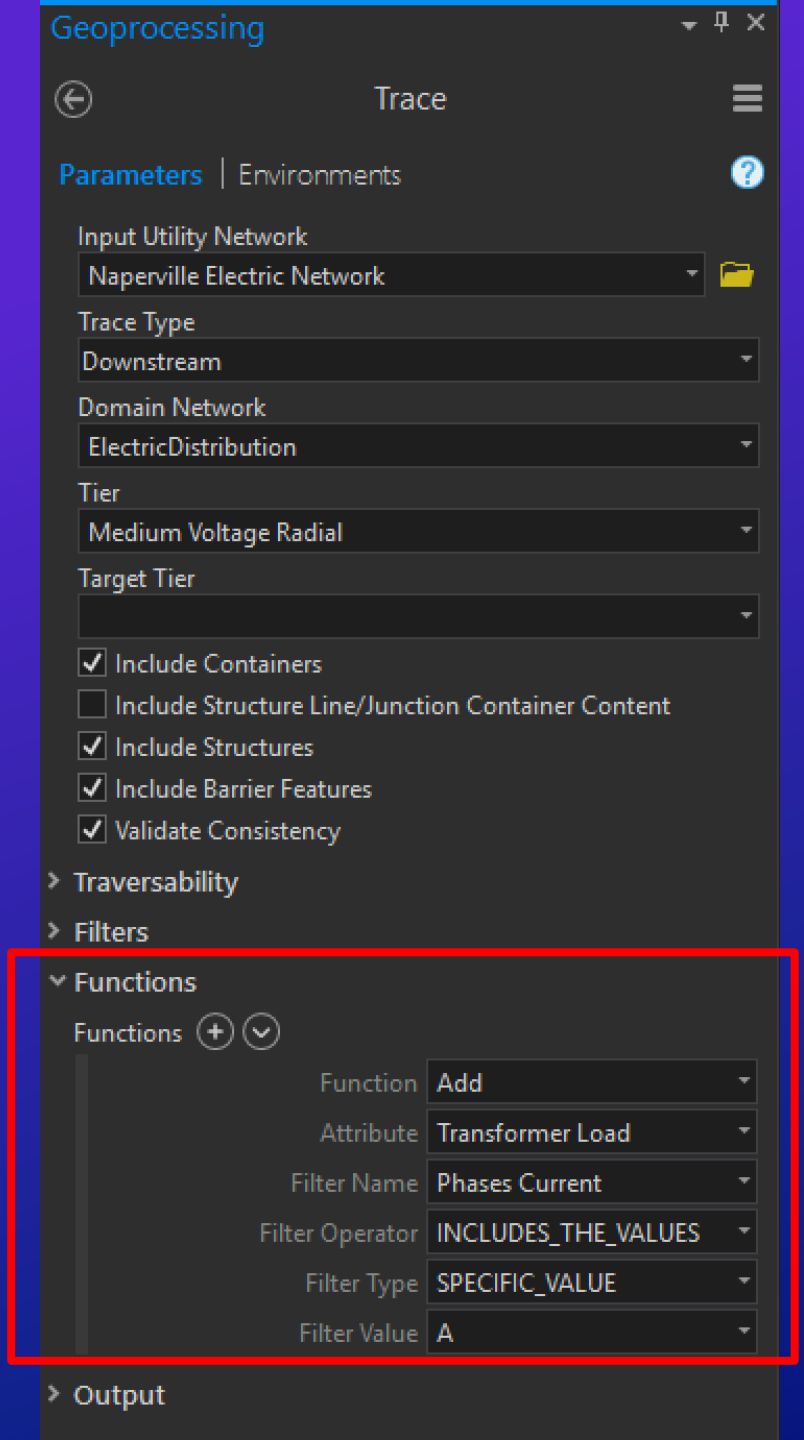




Trace Configuration — Functions

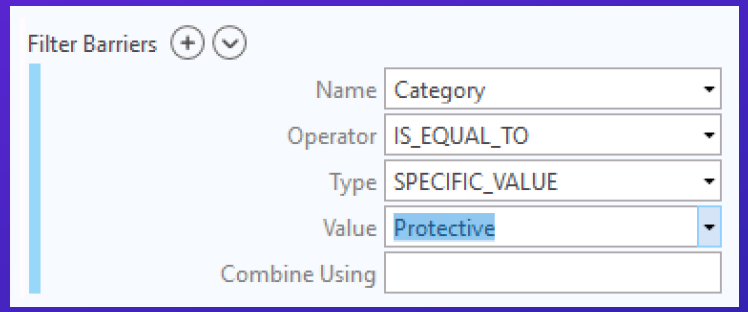
- The caller can specify a collection of functions for a trace
  - These functions calculate values based on a network attribute
- At the conclusion of the trace, function results can be obtained



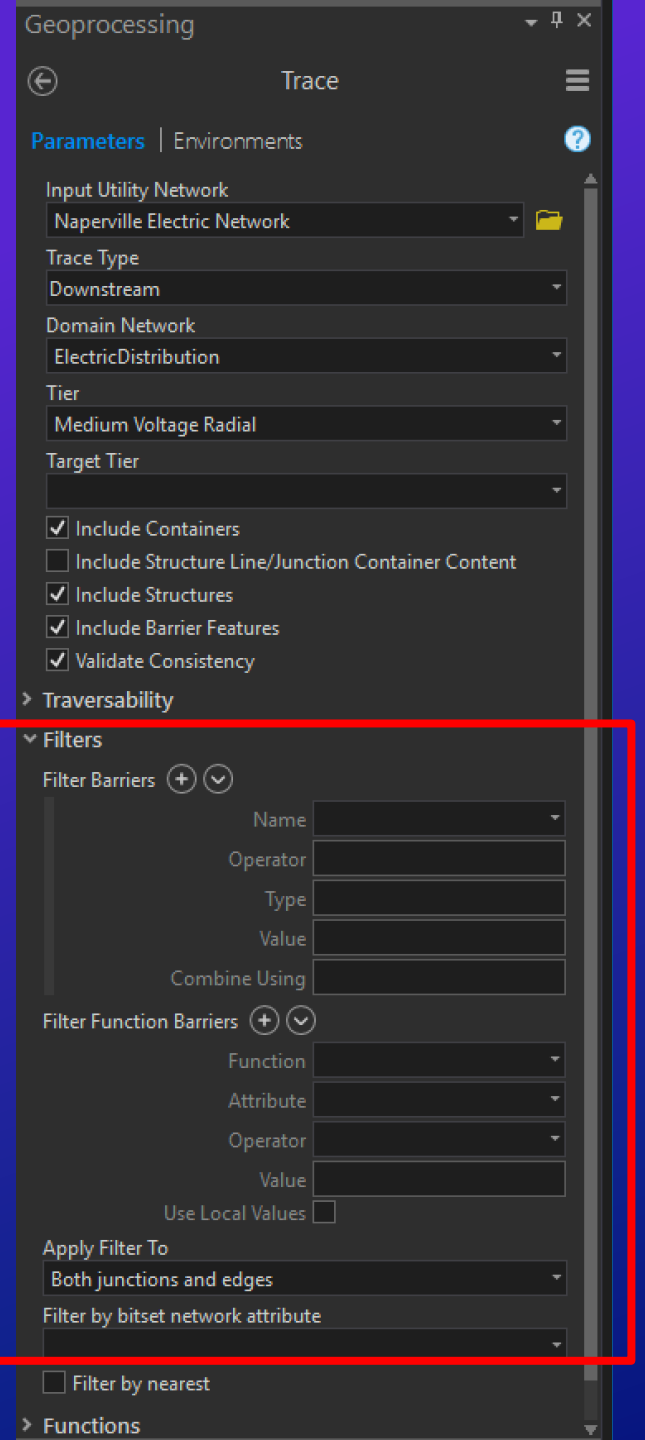


Trace Configuration — Filters

- Filters are a mechanism to stop tracing when returning results
- They do not stop traversability to the controller
- For example, returning the next upstream protective device
  - Create a filter as follows:



  - If you tried to do this with traversability, the trace would fail because this condition would prevent finding the subnetwork source



Filters

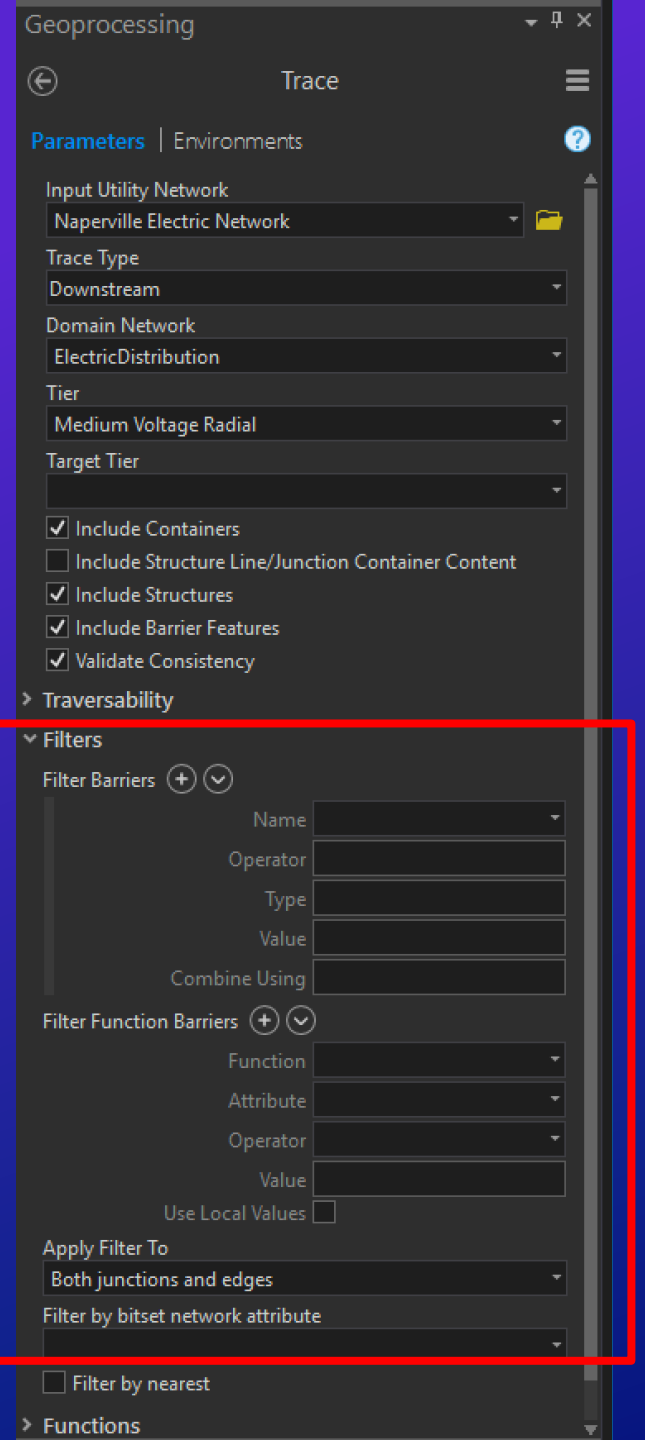
- There are a number of different ways to define filters
  - Use a Condition based on network attributes or categories
  - Use a functional expression
  - Use a bitset filter
  - Use a nearest neighbor filter

Filter

Sealed Class

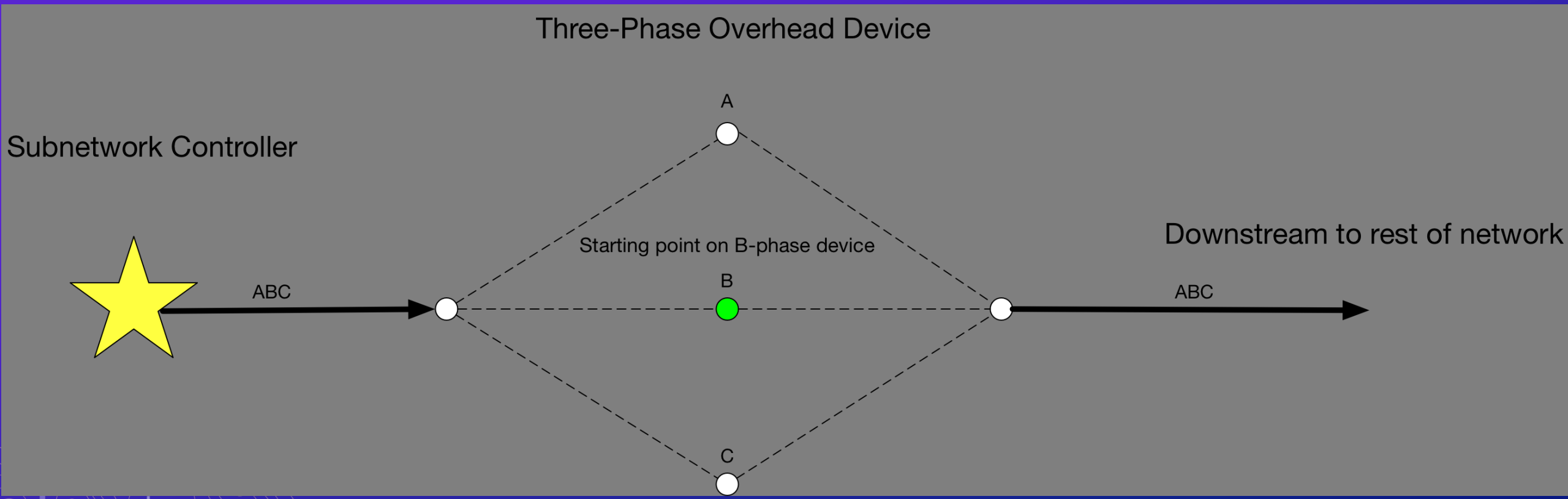
Properties

- Barriers { get; set; } : Condition
- BitsetNetworkAttribute { get; set; } : NetworkAttribute
- FunctionBarriers { get; set; } : IReadOnlyList<FunctionBarrier>
- NearestNeighbor { get; set; } : NearestNeighbor
- Scope { get; set; } : TraversabilityScope



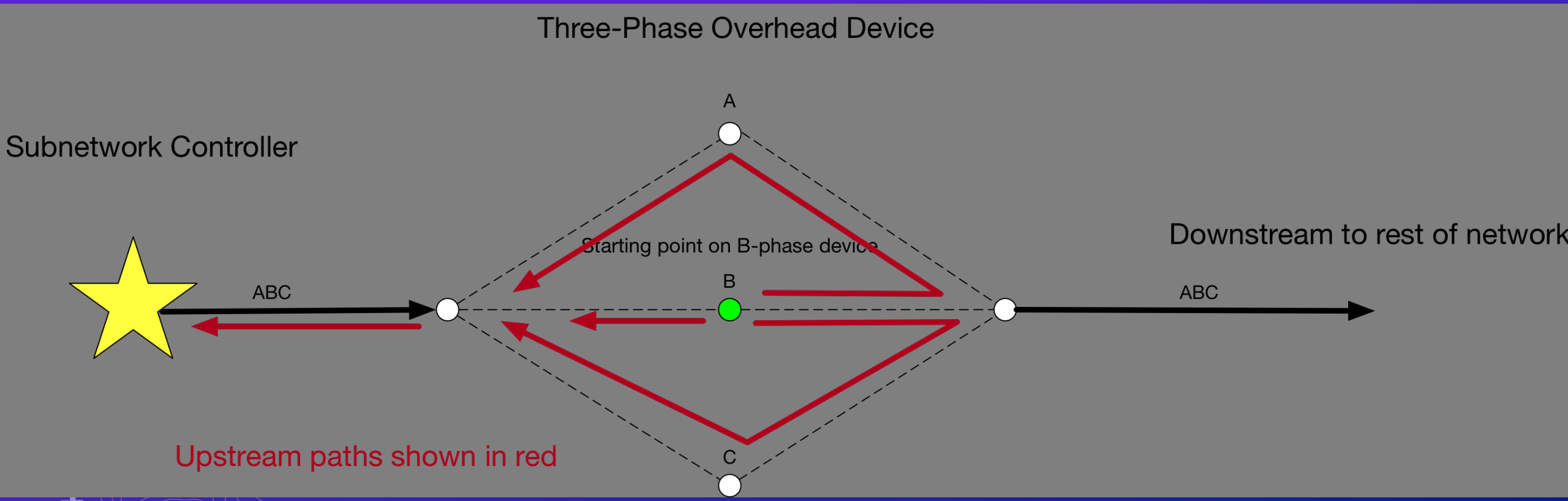
Filter by Bitset Network Attribute - 1

- There are cases where traces need to be aware that a network attribute is a bitset that controls traversability
- Consider the following network, where phase is represented as a bitset network attribute



Filter by Bitset Network Attribute - 2

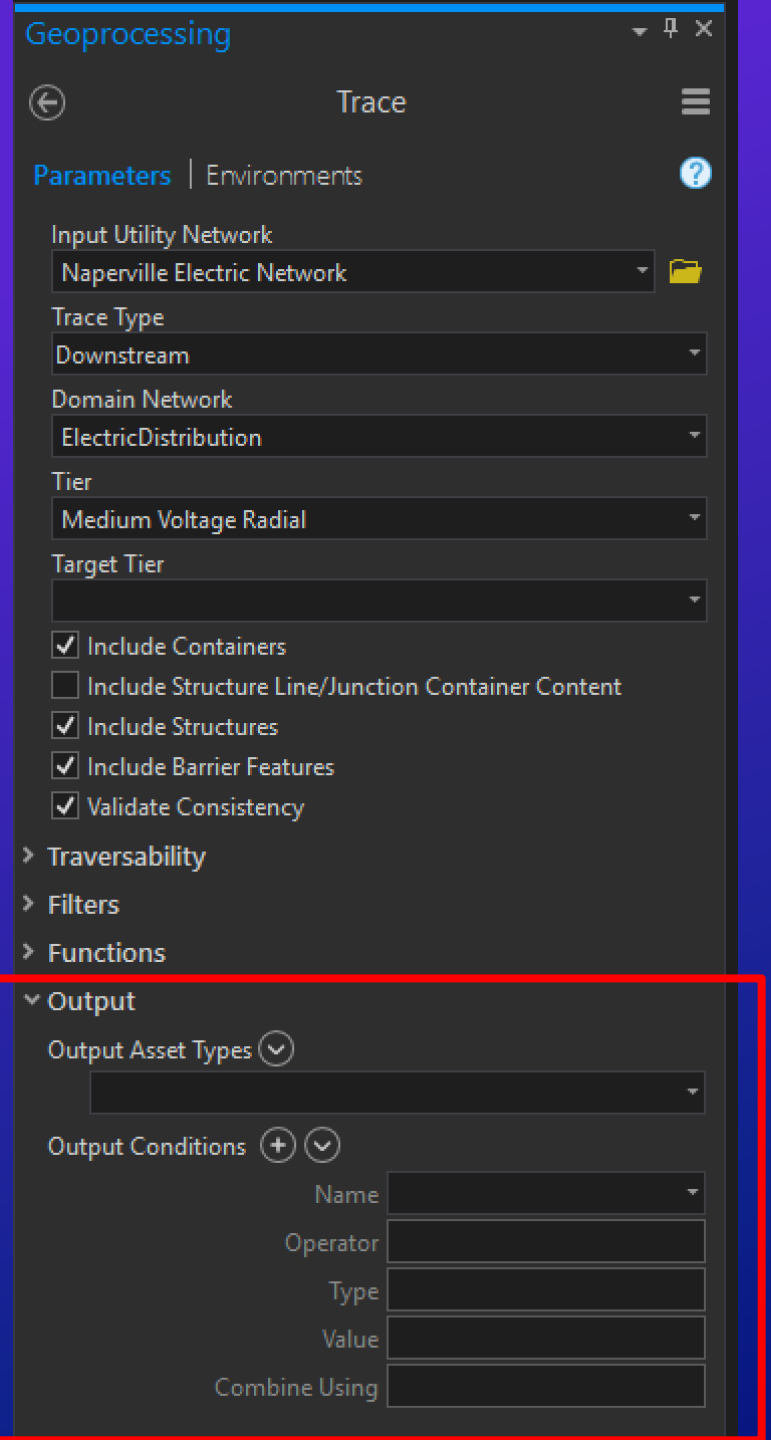
- If you do an upstream trace the results are not what you expect (electrically)



- It is applicable to downstream, upstream, and loop traces

Trace Configuration — Output

- Output filtering is applied as the final step of the tracing process
  - It takes place *after* traversability, filtering, and function calculation
- Two kinds of output filtering are provided
  - Output Condition
  - Output Asset Types

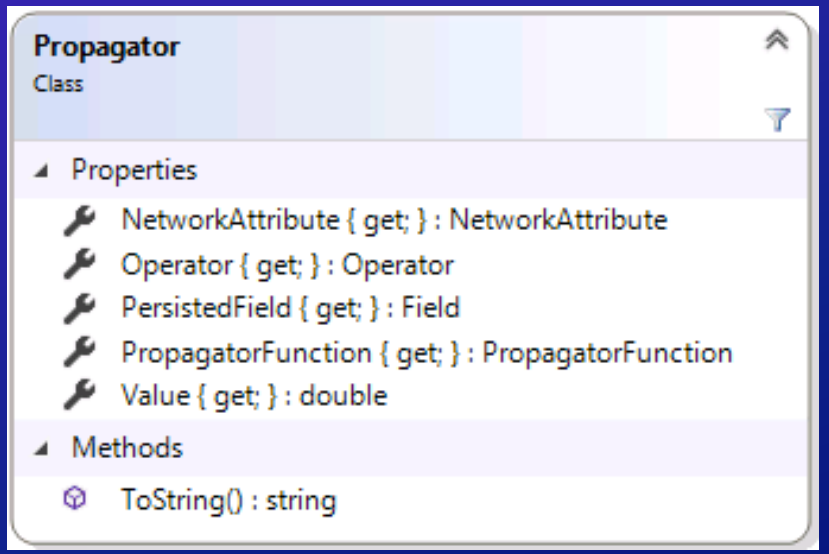


Trace Configuration — Propagators

- A propagator defines the propagation of a network attribute along a traversal, as well as provide a filter to stop traversal
- Propagators are only applicable to subnetwork-based traces (subnetwork, subnetworksource, upstream, downstream)
- The canonical example is phase propagation- open devices along the network will restrict some phases from continuing along the trace

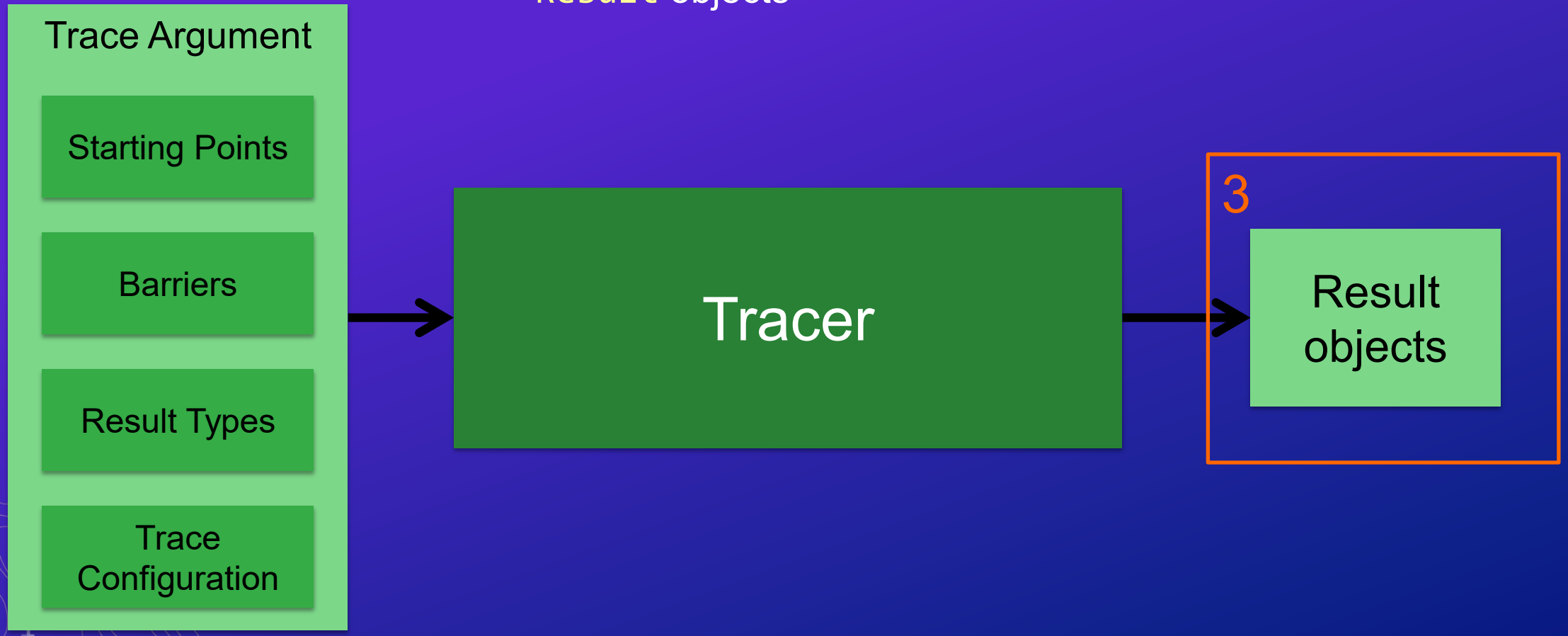
How Propagators Work

- Propagator values are computed as a pre-process step before the main trace takes place
  - Starting at each controller, the propagator uses its `PropagatorFunction` and `NetworkAttribute` to calculate a value at each element
  - This pre-process traversal covers the extent of a subnetwork
- During the trace itself, propagator filters are tested at the same time as traversal filters



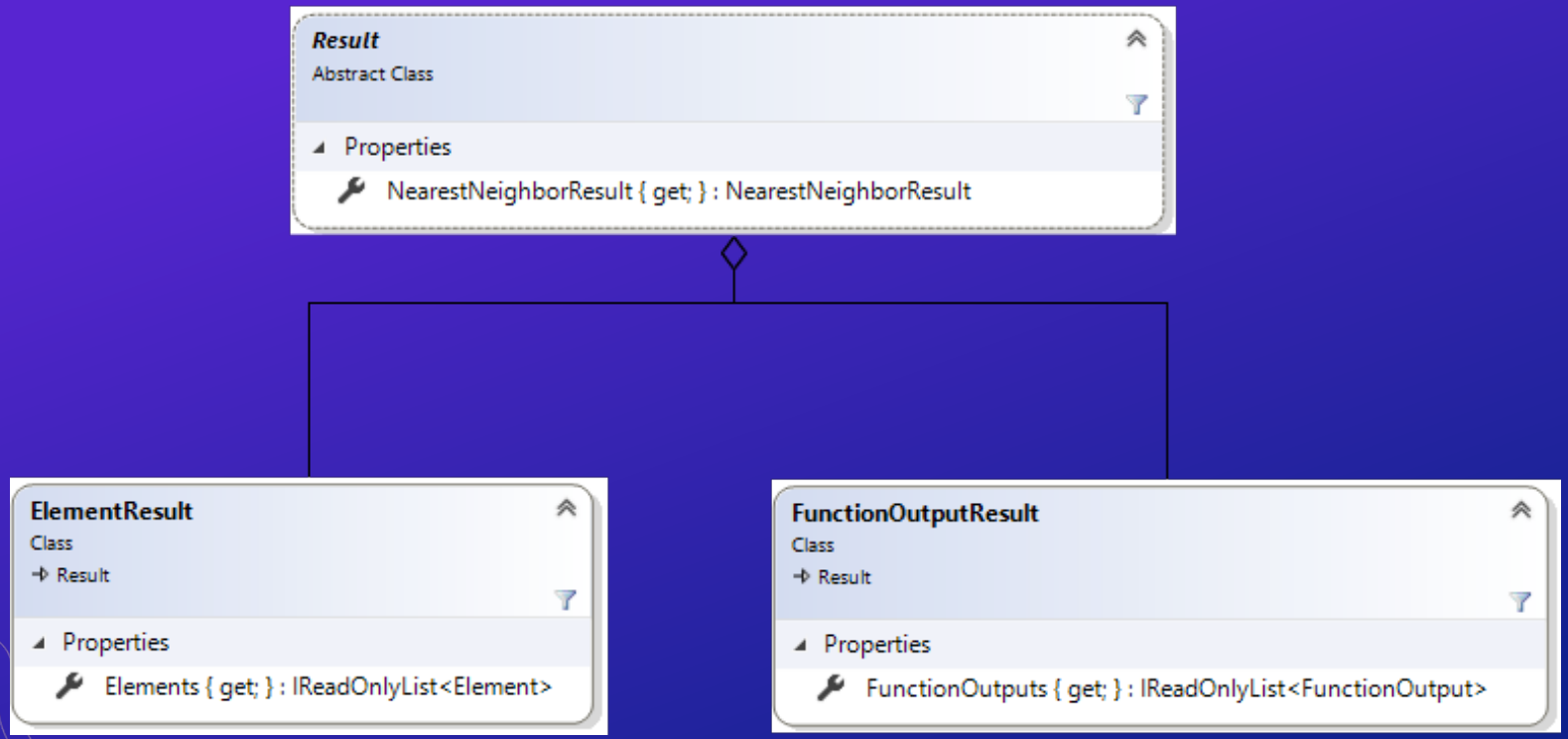
3 Trace Result

- Information is returned from a trace operation with a set of `Result` objects



Trace Results

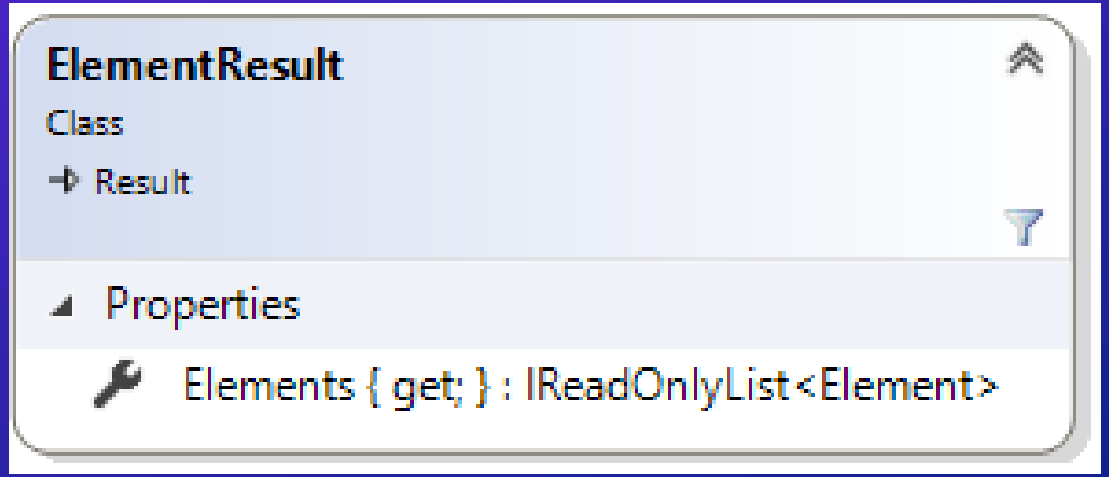
- The `Trace()` method on the `Tracer` class returns a set of `Result` objects
- One `Result` object is returned for each `ResultType` specified in `TraceArgument.ResultTypes`



Returning a List of Element Objects

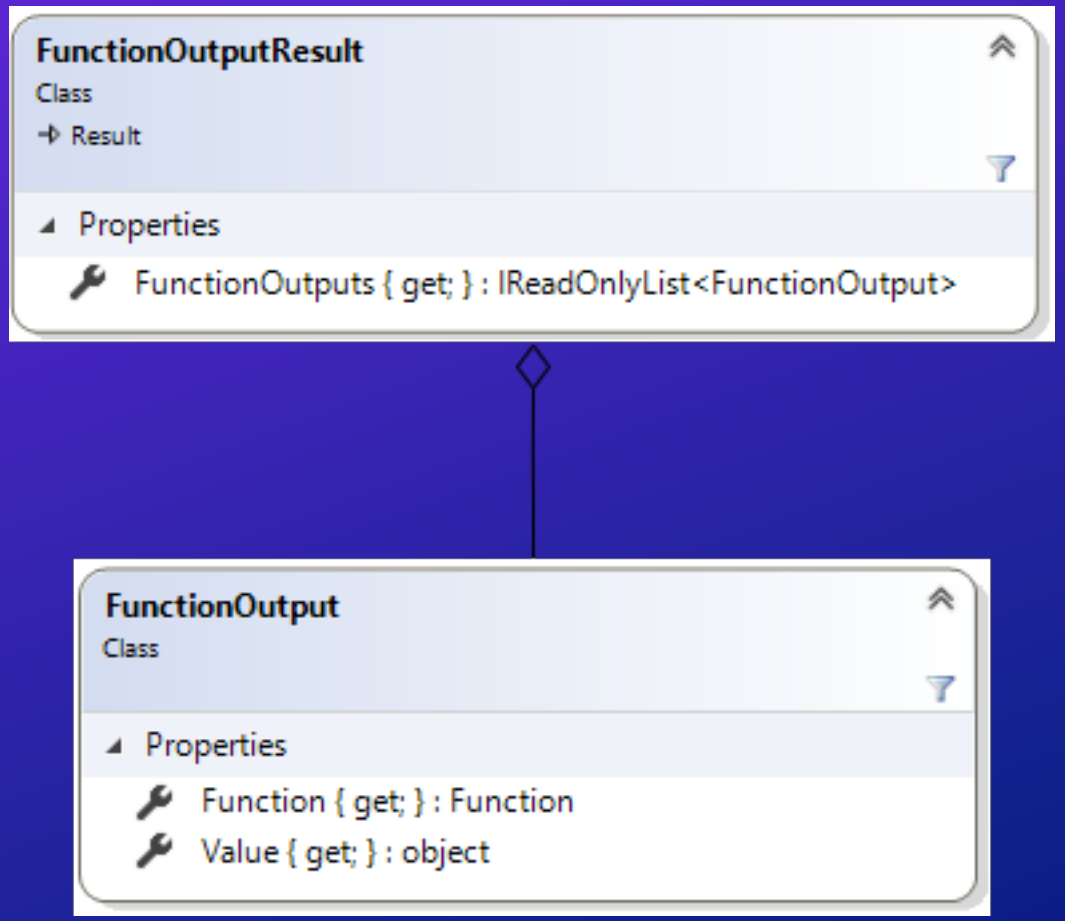
- The `ElementResult` class contains a list of `Element` objects

```
Elements : IReadOnlyList<Element>
```



Returning Function Results

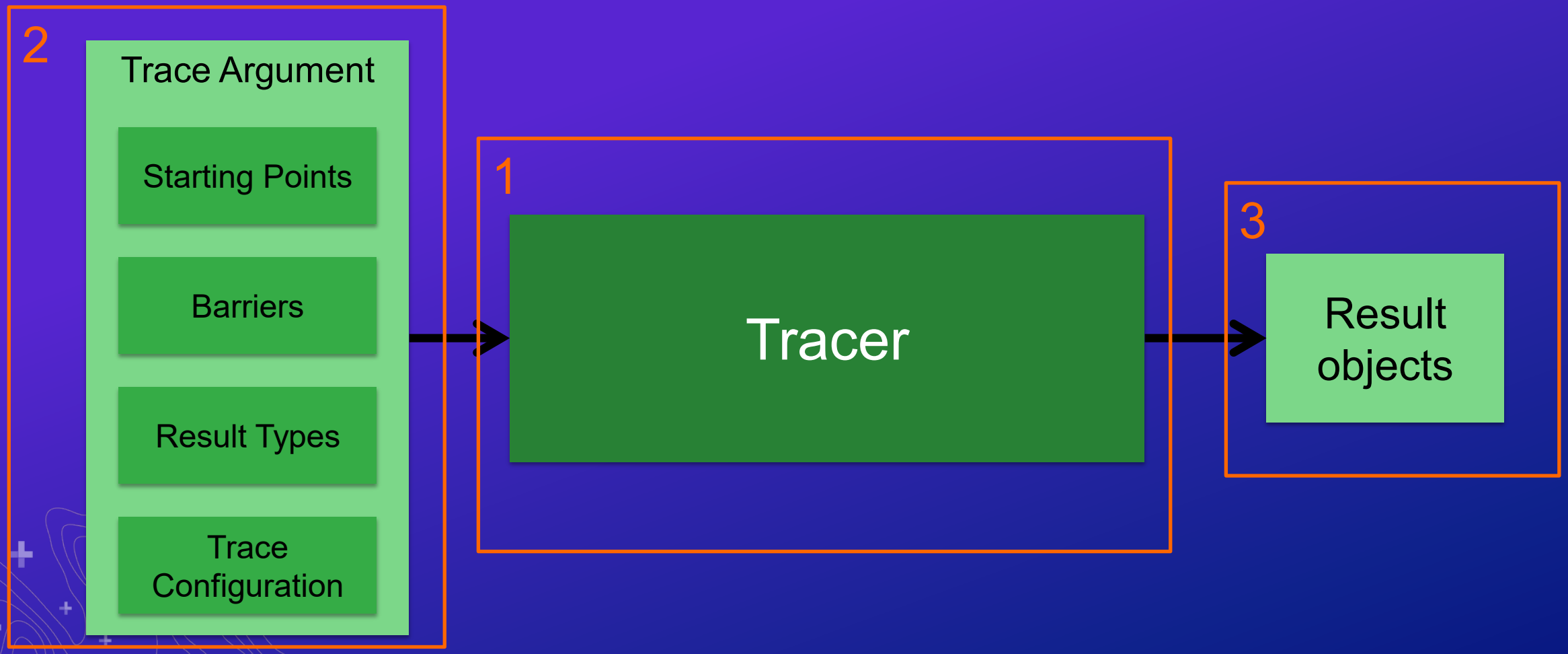
- The `FunctionOutputResult` class contains a list of `FunctionOutput` objects
- The `FunctionOutput` class is a set of Function-Value pairs
  - `Function : Function`
  - `Value : object`



Future: Additional Result Types

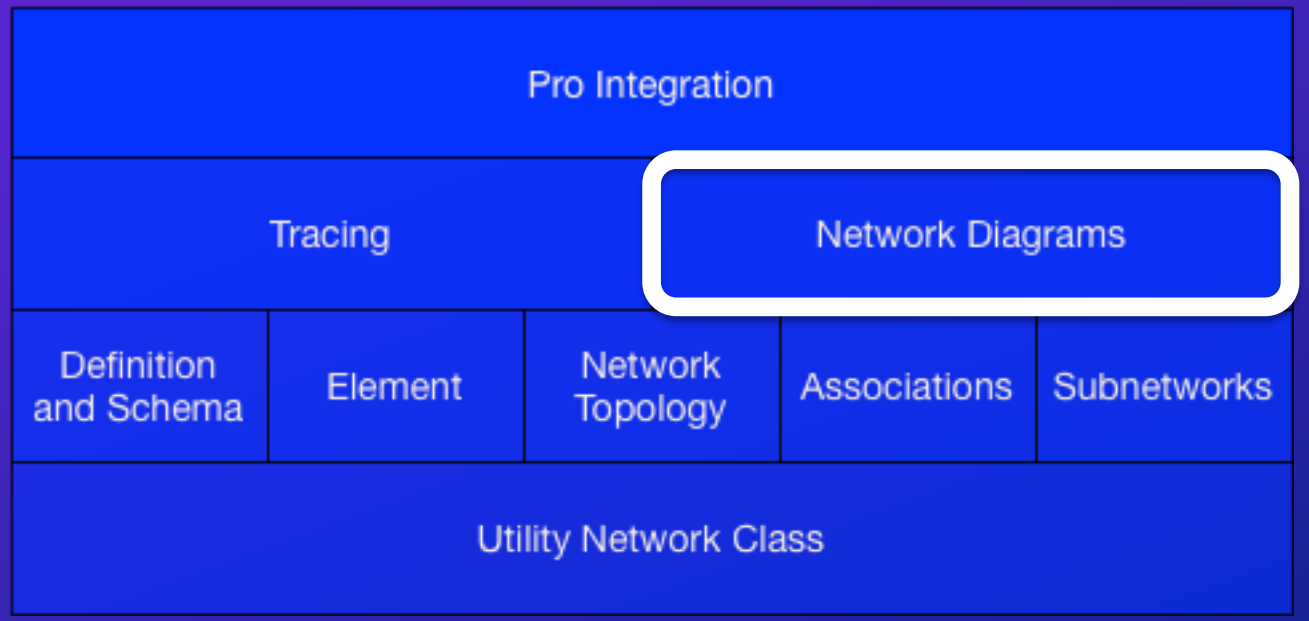
- Future software versions may implement additional result types.
- Some possible result types that might be supported in the future are
  - Geometry
  - Connectivity information
  - Network Diagram
  - Propagator values per row
  - Additional network attributes
- Each result type will add a value to the `ResultType` enum and a new concrete subclass of `Result`

Tracing Summary



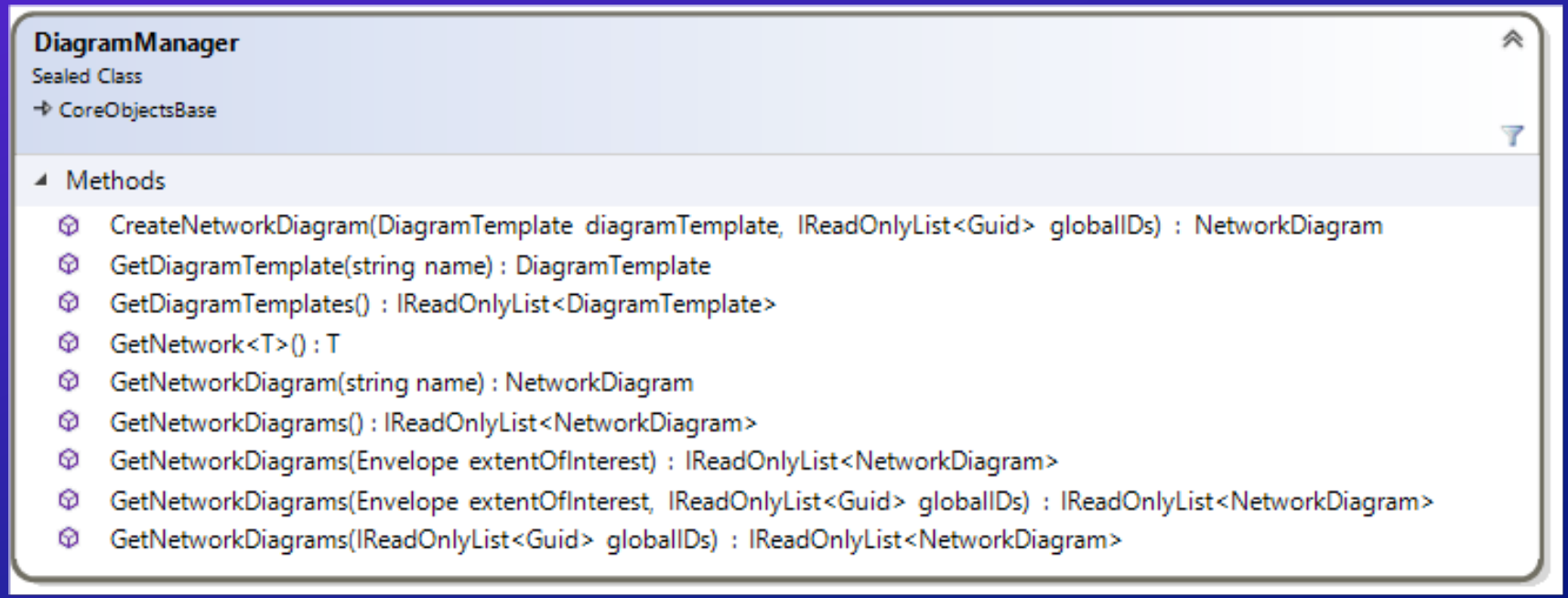
Organization of the Utility Network API

- Network Diagrams allows the developer to query and edit network diagrams



The DiagramManager Class

- The `DiagramManager` class serves as the core class in the network diagrams API
- Use the `DiagramManager` class to:
  - Create network diagrams
  - Retrieve diagram templates
  - Retrieve network diagrams
  - Retrieve the related network



The NetworkDiagram Class

- This class represents a diagram generated from a portion of the utility network
- Some key routines:
  - Update
  - Append
  - Overwrite
  - Store
  - Delete
  - ApplyLayout

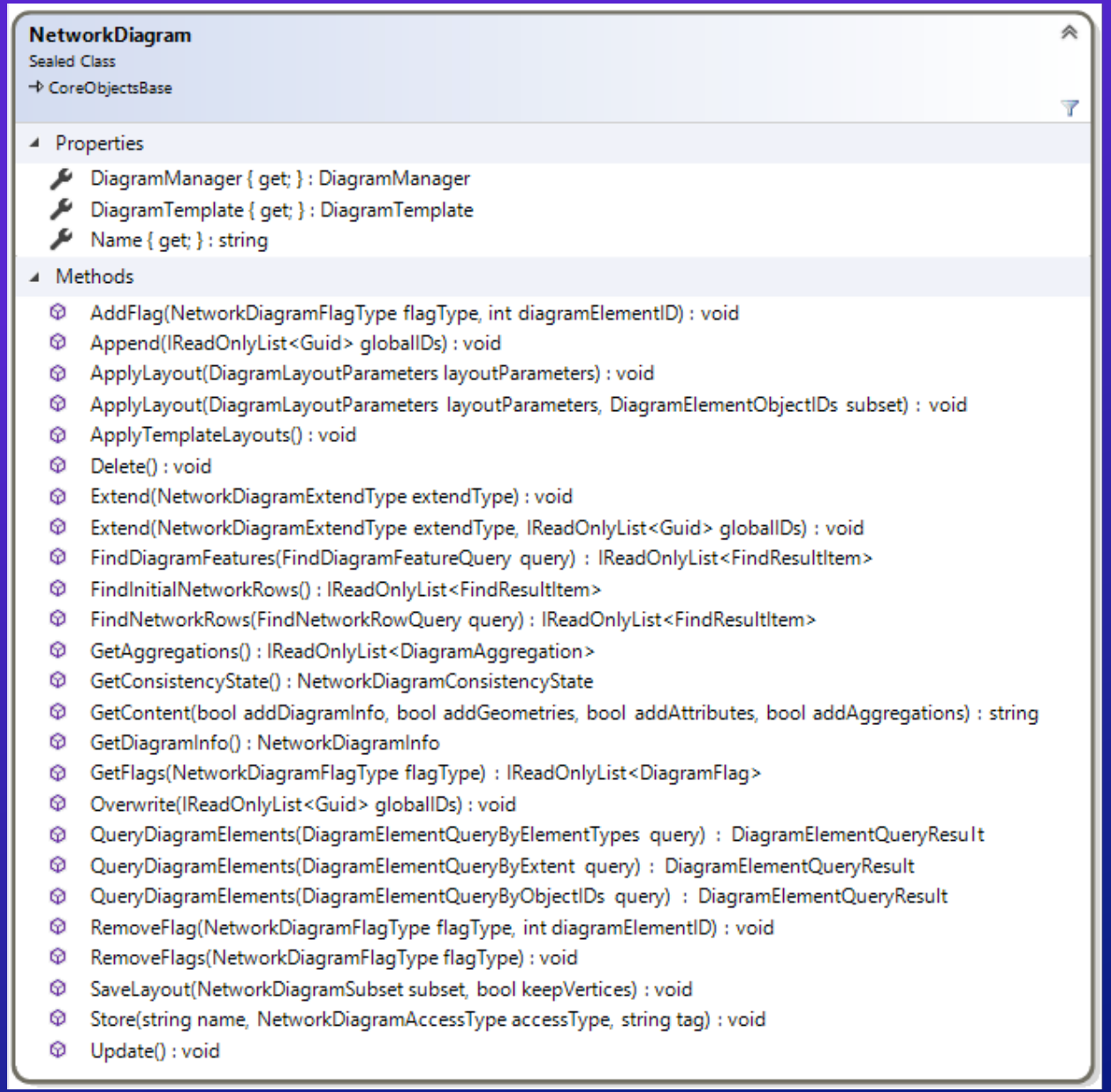
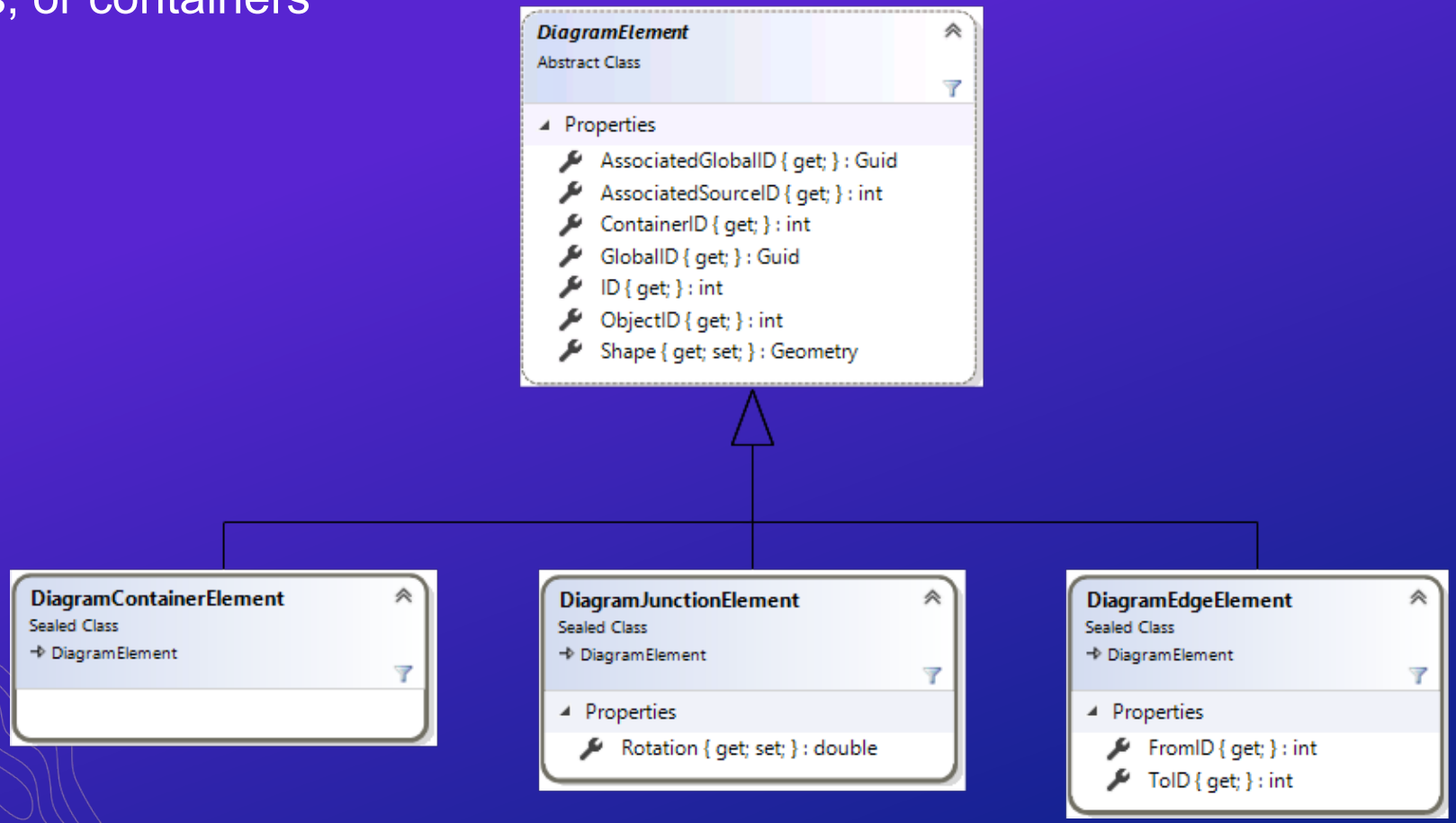


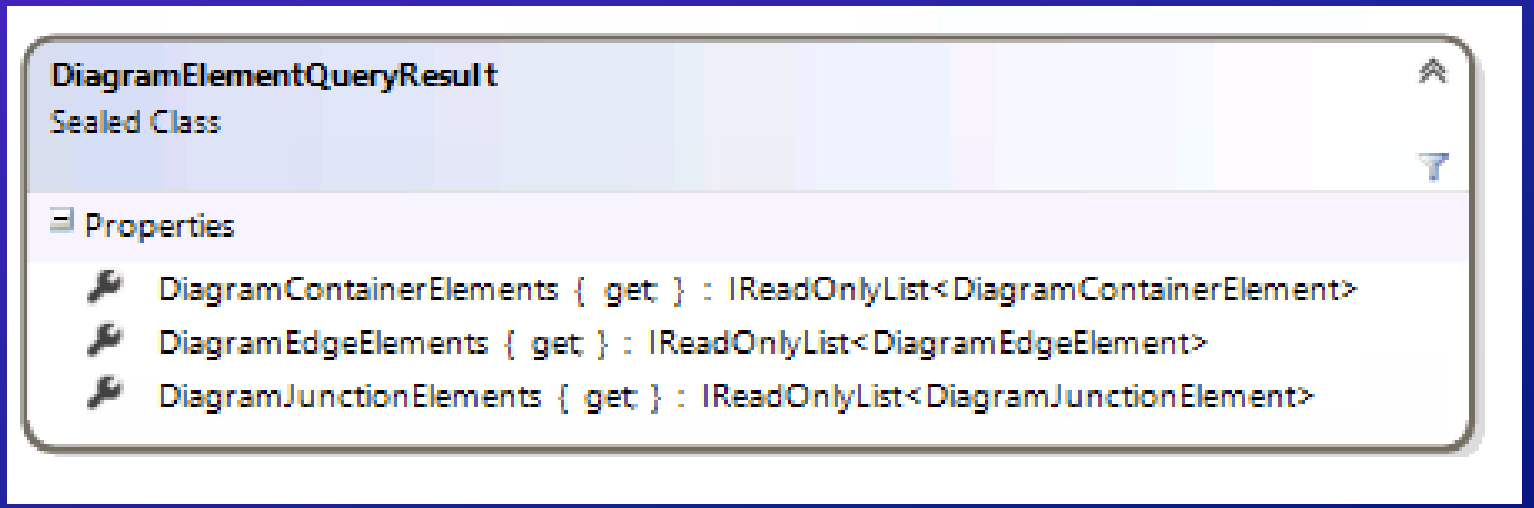
Diagram Element Classes

- A network diagram consists of a set of diagram elements which are either junctions, edges, or containers



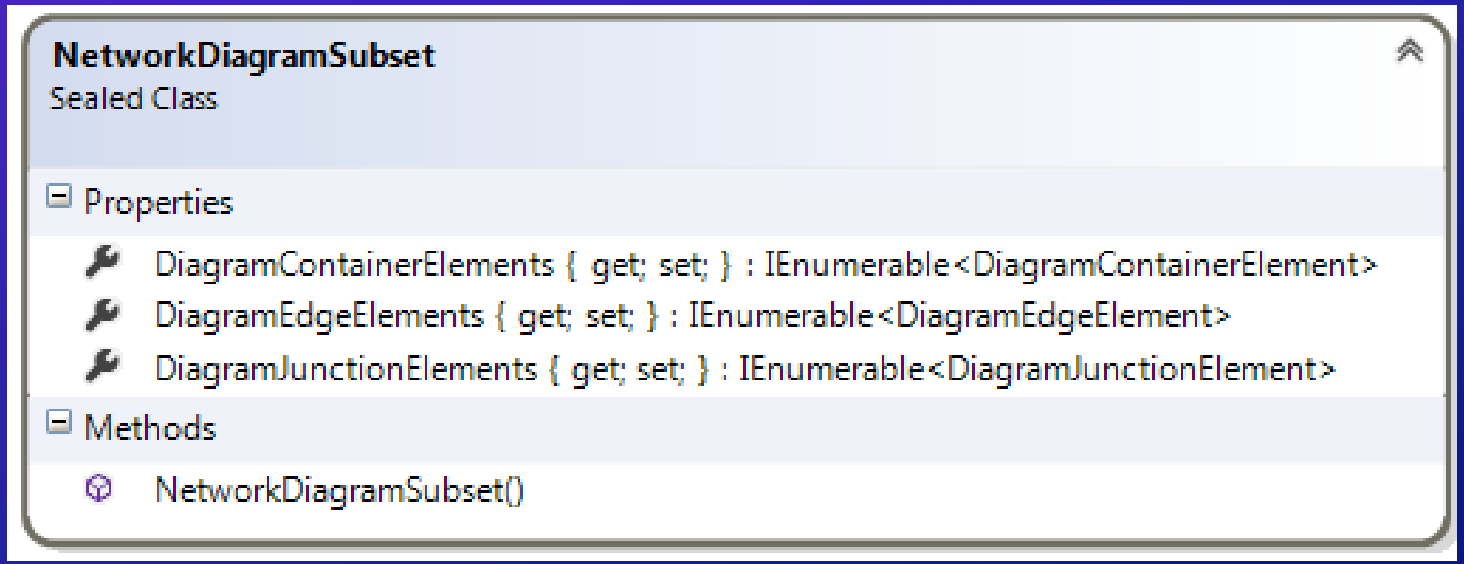
Retrieving Diagram Elements

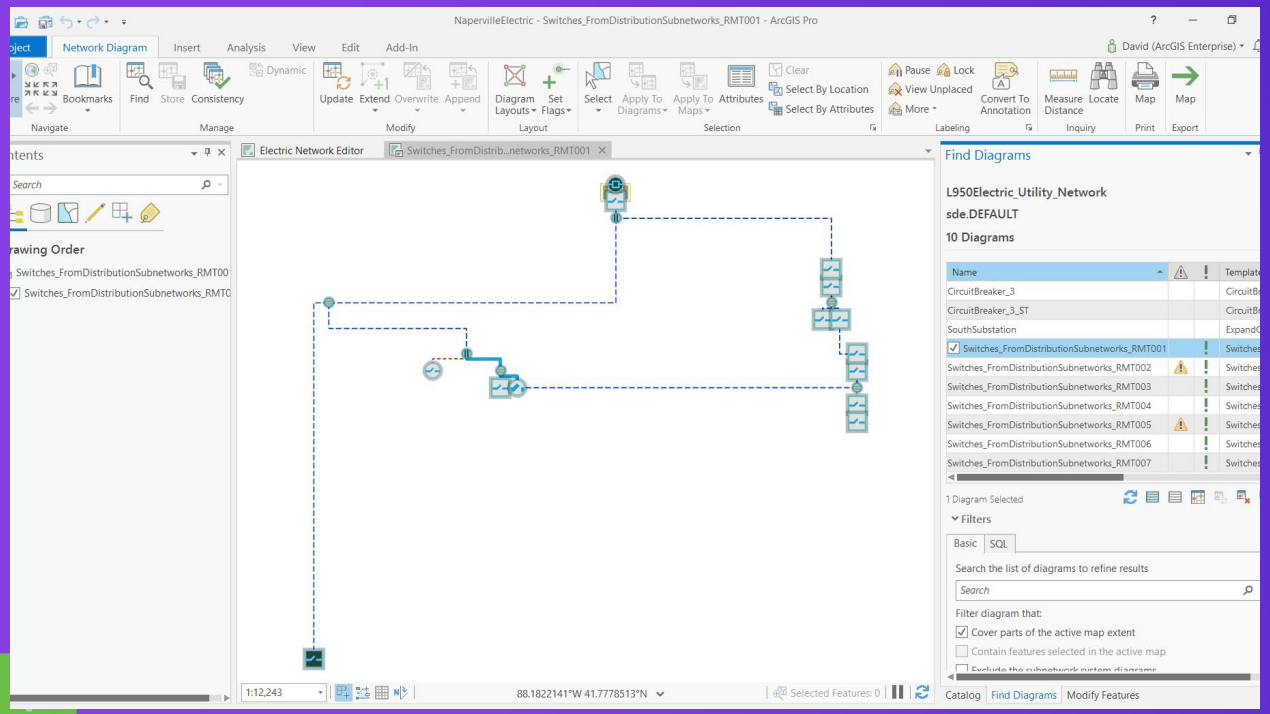
- By Type (edge, junction, container)
  - `DiagramElementQueryByElementTypes` class
- By Extent
  - `DiagramElementQueryByExtent` class
- By set of ObjectIDs
  - `DiagramElementQueryByObjectIDs` class



Custom Layouts

1. Query for set of diagram elements
2. Change the shape of those elements
3. Add the diagram elements to a `NetworkDiagramSubset` object
4. Pass that as an argument to `NetworkDiagram.SaveLayout()`



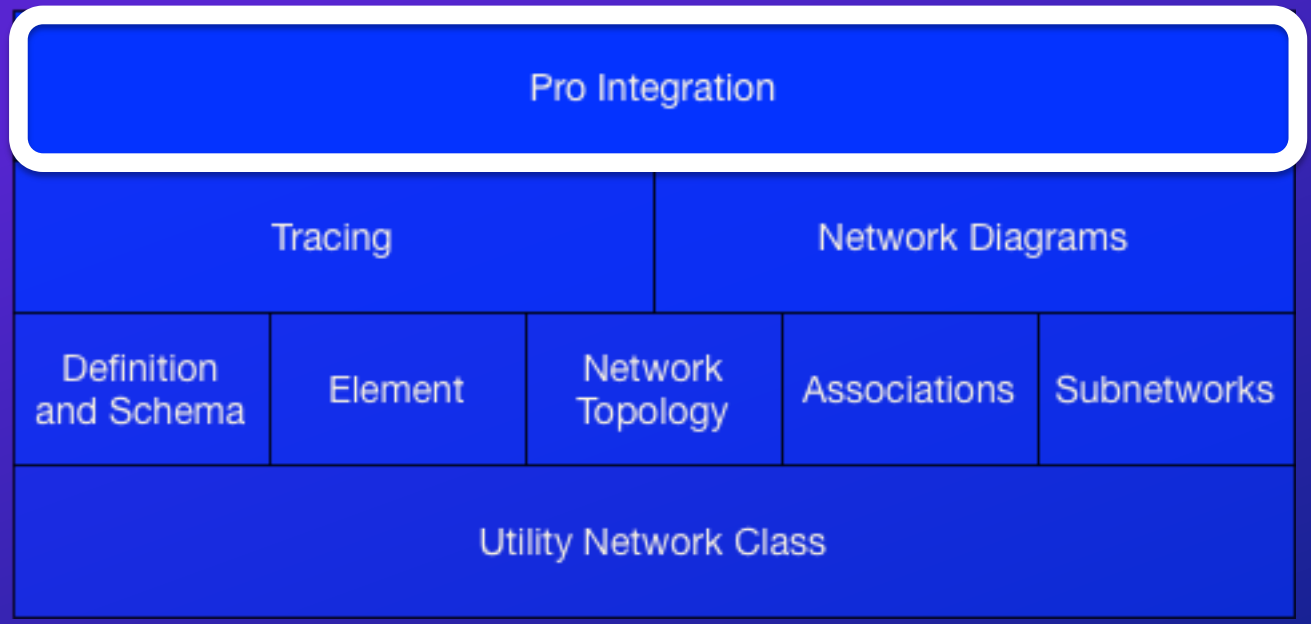


Network Diagrams

David Crawford

Organization of the Utility Network API

- Finally, Pro Integration describes how the utility network API integrates with other parts of the Pro SDK

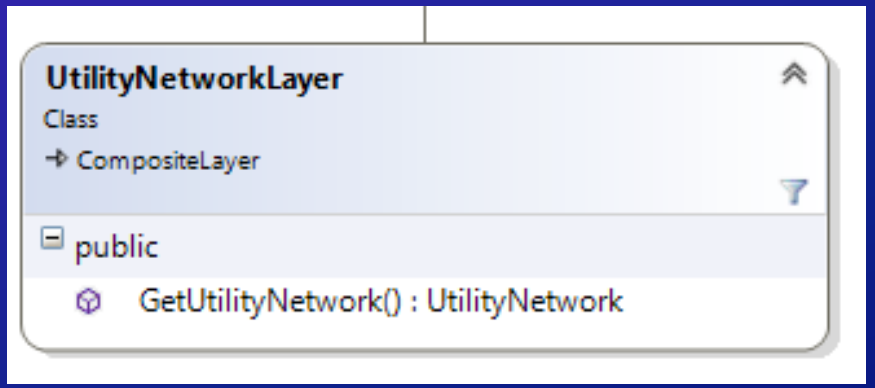


The UtilityNetworkLayer Class

- The `UtilityNetworkLayer` class represents a utility network layer in a map
- The `UtilityNetworkLayer` class inherits from `CompositeLayer`, which can be used to iterate through the dirty area and error sublayers

`GetUtilityNetwork() : UtilityNetwork`

- Returns the `UtilityNetwork` class pointed at by this layer
- Used with ArcGIS Pro add-ins to obtain the underlying geodatabase object from the selected layer



Ribbon Integration

- When you are writing a button or tool to appear on the ribbon, the config.daml file is used to configure when the object is enabled
  - As described by the Pro SDK documentation
- We provide a new utility network condition that enables items if a utility network layer is in the active map

```
condition="esri_mapping_utilityNetworkCondition"
```

Editor Integration

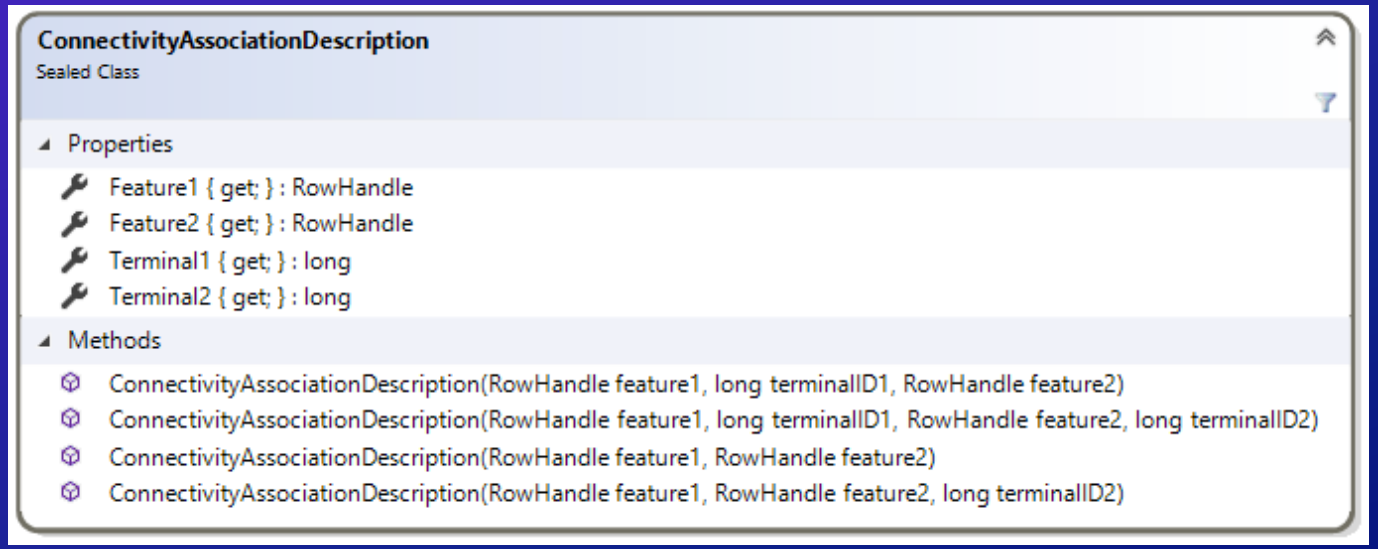
- The preferred technique for editing is to use the high level EditOperation class
  - This class includes a number of high-level editing routines like Create(), Delete(), Move()
  - These routines queue up edits
  - EditOperation.Execute() fires off the actual edits
- The EditOperation was extended in 2.1 to support utility network edits

Read the Editor Conceptual Documentation for more information

Creating and Deleting Associations

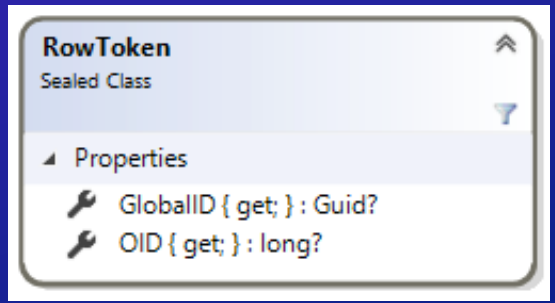
- New set of AssociationDescription classes created
  - `ConnectivityAssociationDescription`
  - `ContainmentAssociationDescription`
  - `StructuralAttachmentAssociationDescription`

- New `Create()` and `Delete()` overloads created on `EditOperation` class



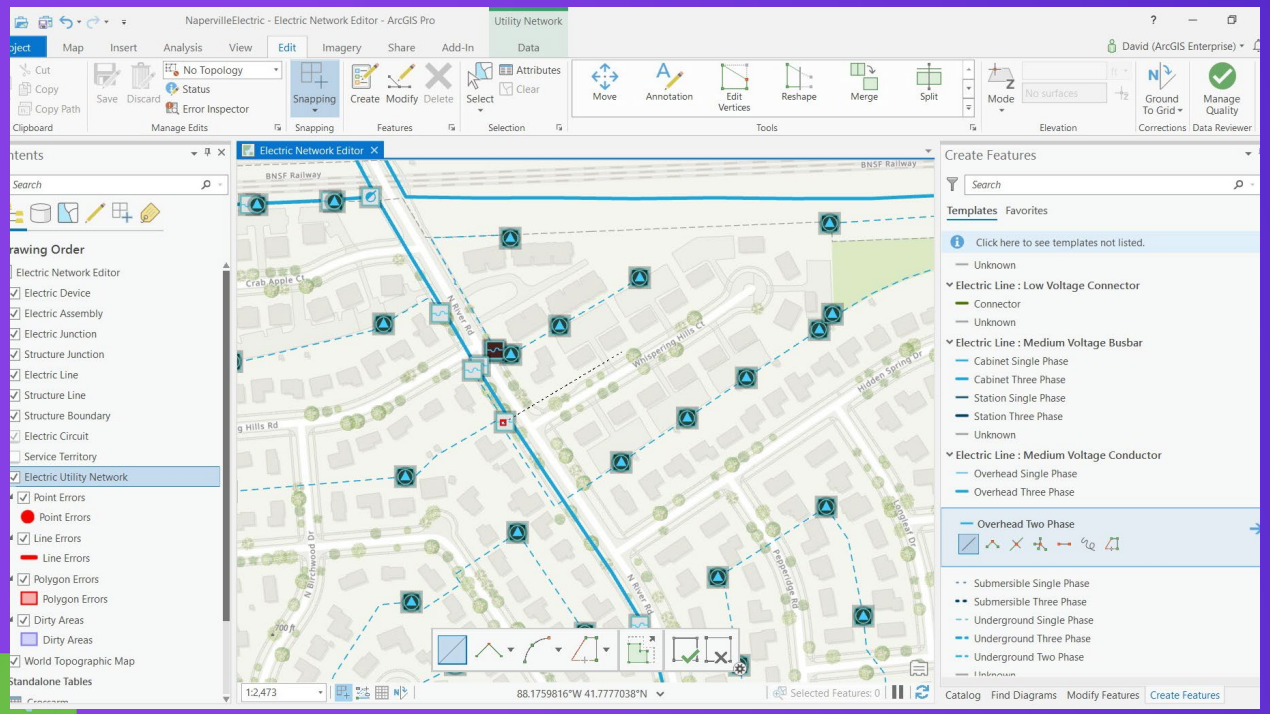
Creating Features and Associations in the Same Edit Operation

- How do you specify an association between two features when the features haven't been created yet?
  - You don't have an ObjectID or GlobalID
- New `CreateEx()` methods on `EditOperation` return a `RowToken`
  - This token can be passed into AssociationDescription classes



Editing with low-level Geodatabase Routines

- We also provide low-level geodatabase objects for editing
- This is the only way to edit in a stand-alone application
- Not recommended in an ArcGIS Pro Add-in
  - The Map is not refreshed
  - The Undo/Redo stack is not modified



Editing

David Crawford

What’s New

ArcGIS Pro 2.4 and 2.5

New Since DevSummit 2019

- Isolation tracing with the IsolationTracer class 2.4
- And and Or operator precedence 2.5
- New TraceConfiguration properties 2.4
  - IgnoreBarriersAtStartingPoints
  - IncludeIsolatedFeatures
- Support attribute substitution with propagation 2.4
- Support subnetwork retrieval by name 2.4
- Enhancements to Attribute Rule APIs (Geodatabase) 2.4
  - Execute attribute rules within an edit operation

The Road Ahead

The Road Ahead

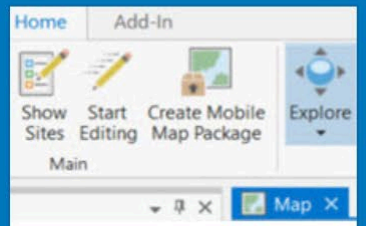
- Non-spatial object support (telecom and underground electric)
- Filter barriers
- More control on how features are updated using Update Subnetwork

Learning More

Conceptual Doc

https://pro.arcgis.com/en/pro-app/sdk/

Learn key concepts



Framework

Build add-ins which extend the Pro UI and leverage asynchronous programming.

Read the topic

Editing

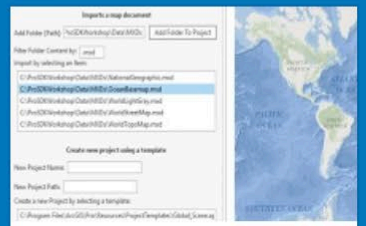
Create custom tools to construct and edit feature classes with your unique logic.

Read the topic

Map exploration

Create capabilities to navigate and explore the map in 2D and 3D.

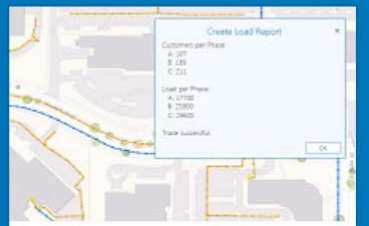
Read the topic



Content

Manage Pro project content items such as maps, layouts, styles, and more.

Read the topic



Utility Network

Develop custom network traces, editing tools and diagrams.

Read the topic

Conceptual Doc

ProConcepts Utility Network

Uma Harano edited this page 27 days ago · 4 revisions

The utility network is a comprehensive framework of functionality in ArcGIS for modeling utility systems such as electric, gas, water, storm water, wastewater, and telecommunications. This topic provides an introduction to the utility network API. It details the classes and methods that query and edit the utility network. The utility network API is commonly used in conjunction with the geodatabase and editing.

```
Language:      C# and Visual Basic
Subject:       Utility Network
Contributor:   ArcGIS Pro SDK Team <arcgisprosdk@esri.com>
Organization:  Esri, http://www.esri.com
Date:          1/7/2019
ArcGIS Pro:    2.3
Visual Studio: 2015, 2017
```

In this topic

- Introduction
  - Overview
  - Resource Management
  - Namespaces and Extension Methods

Samples

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- ProSnippets

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- Installing ArcGIS Pro SDK for .NET
- Getting started
- ProGuide: ArcGIS Pro Extensions NuGet
- ProConcepts: Migrating to ArcGIS Pro
- ProSnippets
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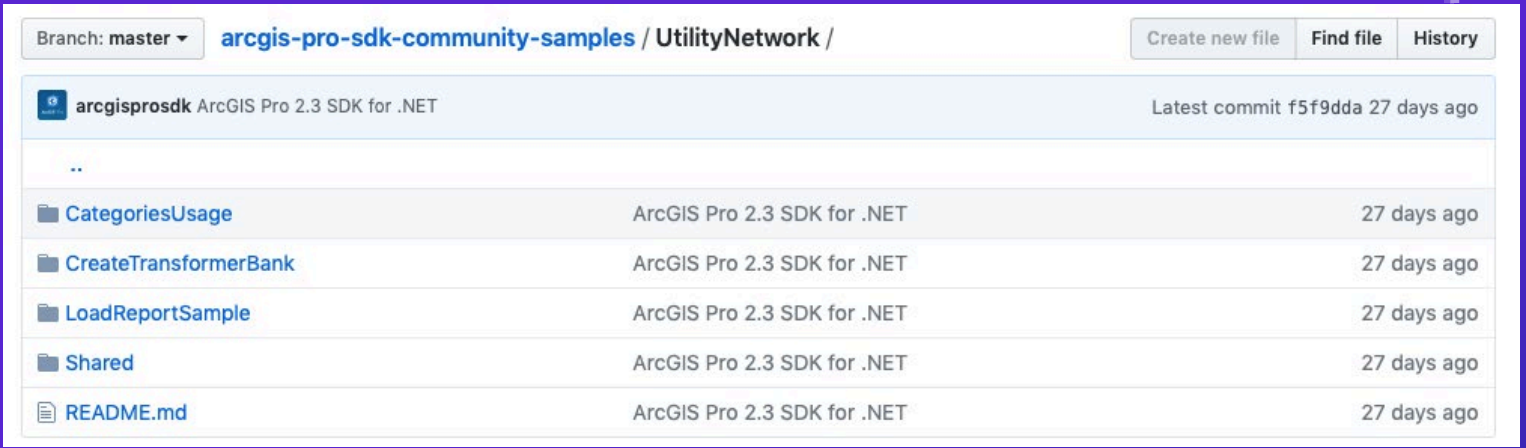
- Release notes
- Resources

Samples



- Categories Usage
  - Demonstrates using the schema classes to list all of the asset types that support a given category
- Load Report Sample
  - Does a downstream trace from a starting point and creates a report that sums the load and counts the customers per phase
- Place a Transformer Bank
  - Shows how to create a transformer bank assembly (including the contents and associations)
- Suggestions?
- Write your own?

Snippets

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Snippets

- Small pieces of code that show how to accomplish a specific task

UtilityNetwork Snippets

- Get a Utility Network from a Table
- Get a Utility Network from a Layer
- Find a Tier given a Domain Network Name and Tier Name
- Update all dirty subnetworks in a tier
- Creating a DownstreamTracer
- Create a Trace Argument
- Create a Condition to compare a Network Attribute against a set of values
- Create a Function
- Create a FunctionBarrier
- Creating an output condition
- Creating a Propagator
- Using Function Results
- Get a list of Inconsistent Network Diagrams
- Retrieving Diagram Elements
- Changing the Layout of a Network Diagram

Get a Utility Network from a Layer

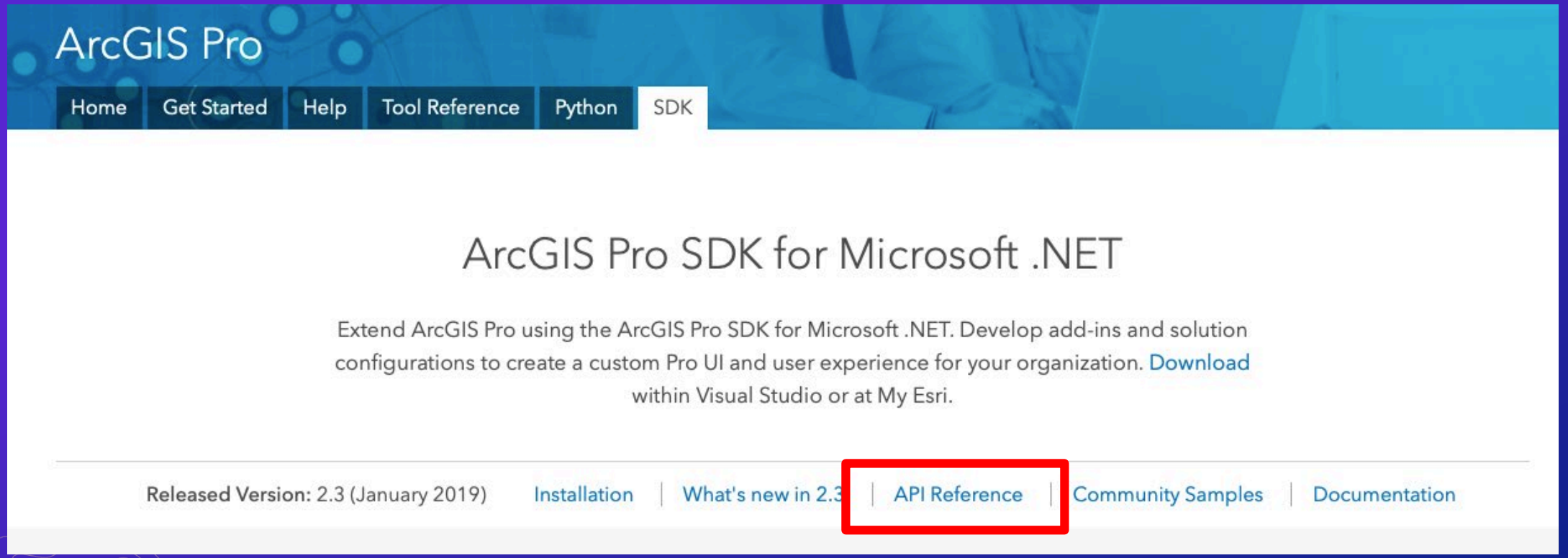
```
// This routine obtains a utility network from a FeatureLayer, SubtypeGroupLayer,
public static UtilityNetwork GetUtilityNetworkFromLayer(Layer layer)
{

  if (layer is UtilityNetworkLayer)
  {
    UtilityNetworkLayer utilityNetworkLayer = layer as UtilityNetworkLayer;
    return utilityNetworkLayer.GetUtilityNetwork();
  }

  else if (layer is SubtypeGroupLayer)
  {
    CompositeLayer compositeLayer = layer as CompositeLayer;
    return GetUtilityNetworkFromLayer(compositeLayer.Layers.First());
  }

  else if (layer is FeatureLayer)
  {
    FeatureLayer featureLayer = layer as FeatureLayer;
    using (FeatureClass featureClass = featureLayer.GetFeatureClass())
    {
      if (featureClass.IsControllerDatasetSupported())
      {
        IReadOnlyList<Dataset> controllerDatasets = featureClass.GetControllerDat
        foreach (Dataset controllerDataset in controllerDatasets)
        {
          if (controllerDataset is UtilityNetwork)
          {
            return controllerDataset as UtilityNetwork;
          }
        }
      }
    }
  }
  return null;
}
```

API Reference



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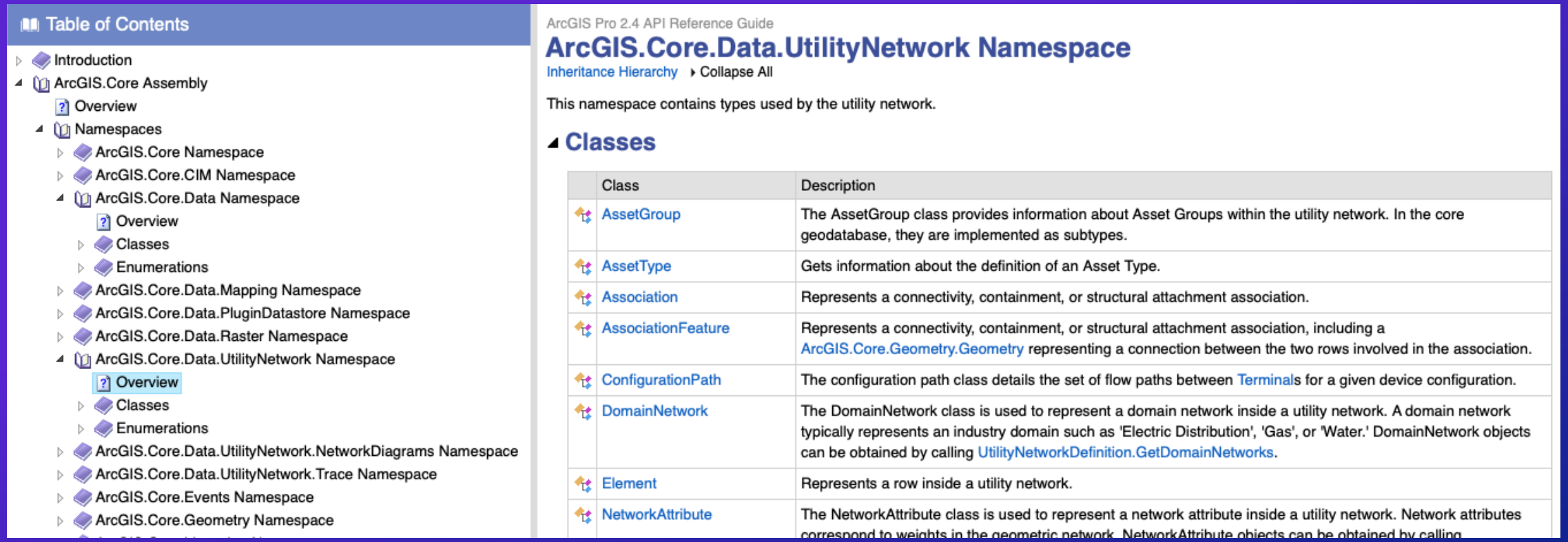


Object Model Diagram

- Finally, Pro integration describes how the utility network API integrates with other parts of the Pro SDK.

An object model diagram of the utility network API is provided on the website.

UtilityNetwork Class

Utility networks are implemented in the geodatabase as controller datasets. Other controller datasets in ArcGIS include network datasets for transportation networks, and topology for managing coincident features.

The `UtilityNetwork` class provides an abstraction of this controller dataset. Methods on this class provide an entry point to the other areas of the utility network API.

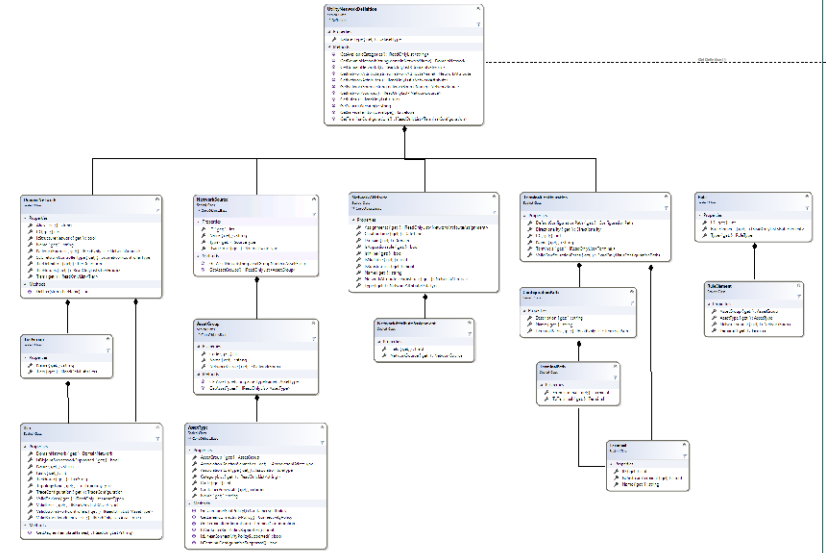
As with other datasets in the geodatabase, a UtilityNetwork object can be obtained by calling `Geodatabase.OpenDataset()`. UtilityNetwork objects can also be obtained from a table or feature class that belongs to a utility network by using `Table.GetControllerDatasets()`. Note that a particular feature class can belong to multiple controller datasets.

> The `Geodatabase.OpenDataset()` routine takes the name of a dataset to open. Remember that when using feature services, the name of the dataset in the feature service workspace does not match the name in the client-server workspace. You typically need to get the

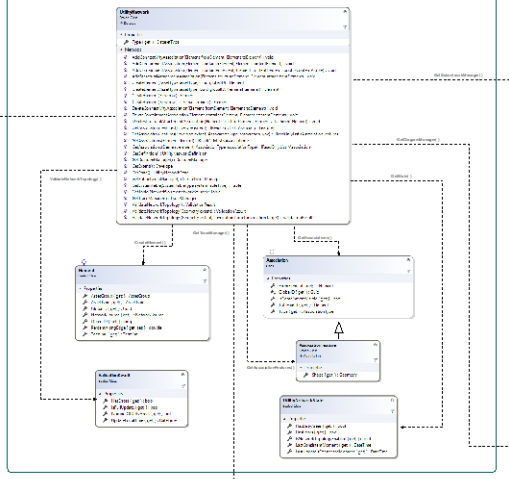
Utility Network Object Model

ArcGIS Pro 2.3

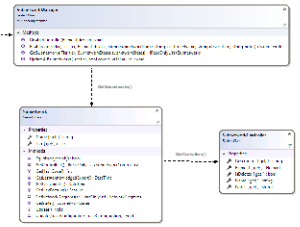
Schema



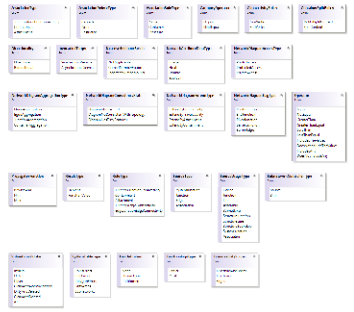
Utility Network Core



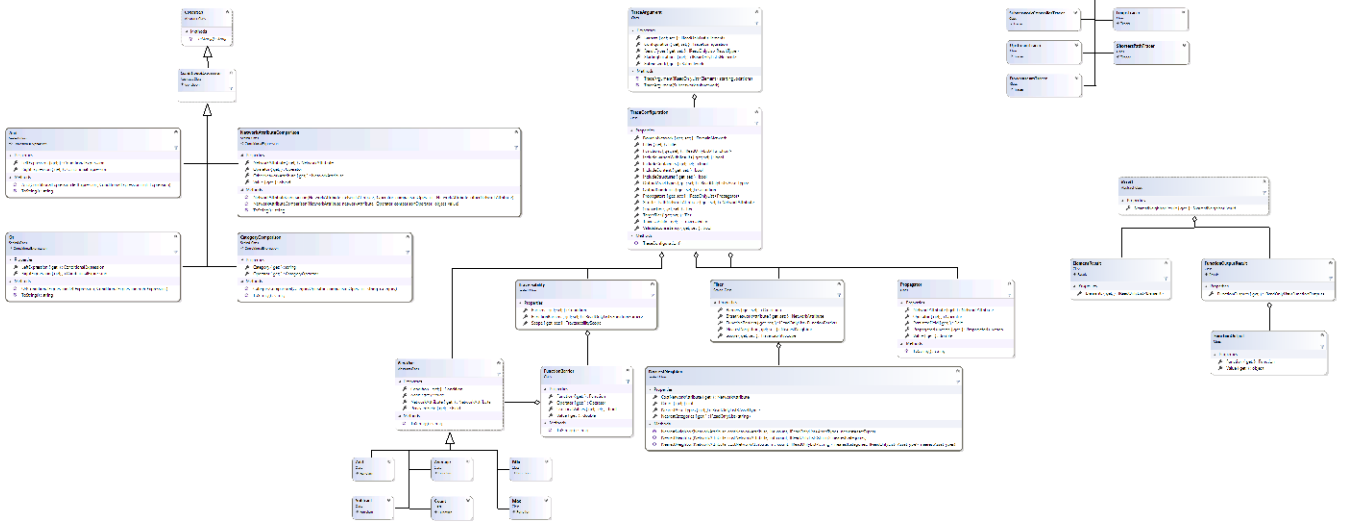
Subnetwork



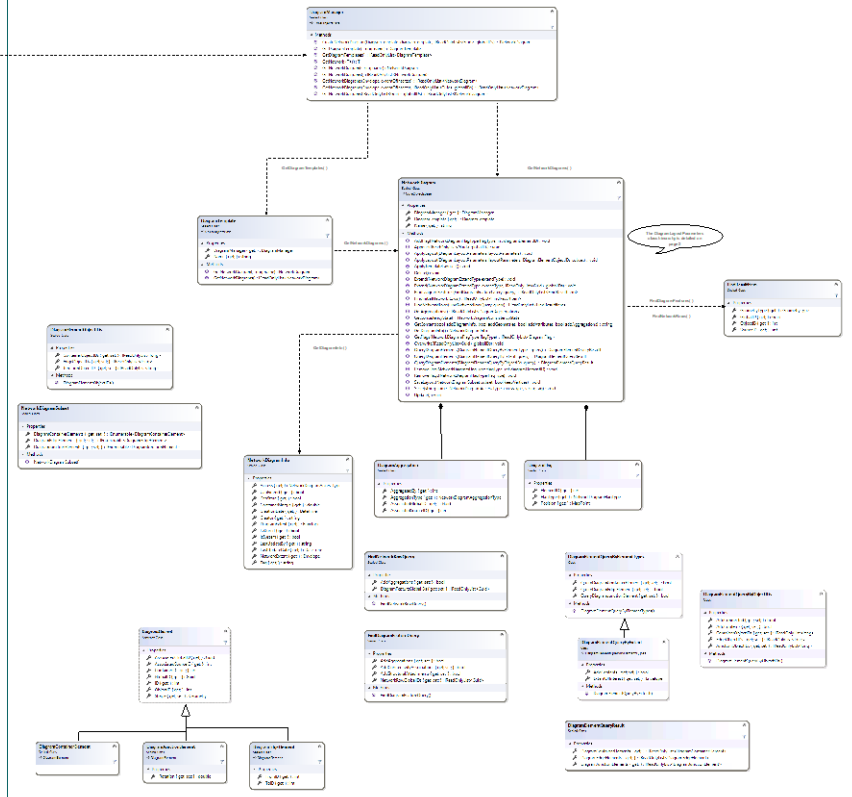
Enumerations



Tracing



Network Diagrams



An Overview of the Utility Network Management API

- **Session materials are available here:**
  - https://github.com/esri/arcgis-pro-sdk/wiki/tech-sessions#2020-palm-springs