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With the development of human civilization, the public infrastructure has been greatly improved, such as the power facilities, telecommunications and cable television, road traffic with GPS monitor, water pipe network, heating pipe networks and etc. In order to provide maintenance, management, and further planning to these large scale infrastructures, computers become the necessity for helping our work. In GIS, these facilities are considered as "network system", which is a network-shape system consisted by many connected line segments. The network model is an abstraction of this system about real life. For instance, in the city traffic network, roads are represented by line segments, named as network arcs; similarly, road intersections and stops are taken as points, named as network nodes, etc. In the network model, resources and information can go from one point to another.

The network analysis is a process to solve the practical problems by analyzing on the network model, like path analysis, service zone analysis, closest facility analysis, etc. Currently, network analysis has been widely applied in electric navigation, traffic tourism, urban planning and management, logistic distribution, power industry, telecommunication, as well as layout design and query of various pipe line networks.

The following contents are introduced in this section:

1) General Introduction of Network Model
2) Basic Concepts of Network Analysis
3) Summary of Network Analysis Functionality
4) Building Network Analysis
5) Functionality of Traffic Network Analysis
6) Facility Network Analysis
Network Model Introduction

Network Model: it stores data which has network topology relationship with each other, including network line datasets, network point datasets as well as their spatial topology relationship. The line datasets are main datasets, while the point datasets are sub datasets.
There are two type network models in GIS, traffic network model and public pipeline facilities network model.

### 2.1 Traffic Network Model

In traffic network model, the traveling pedestrians and transported resources inside the network can have various directions, speed and destinations, although the lines have been set direction in the model. For instance, a driver is able to turn and drive in any direction, choosing the parking time; while on a one-way road, he is not allowed to turn around. And this is totally different from the public pipeline facilities network situation.

### 2.2 Public Pipeline Facilities Network

Public pipeline facilities network has directions to represent the water stream, electric current, or any other mediums, which flow in the network according to particular principles. For instance, the water routes are designed beforehand, but the flow of the water could be different by changing some switches which work as the circulation principles in the network.
Network model not only has abstract topology relationship between edges and notes, but also has the geometry positions and geography property features of GIS spatial data. Topology relationship is the spatial position between the geographic objects, such as points between lines, lines between regions, etc. The followings are the basic concepts of network model.

Diagram 2 Network Illustration

**Node**

A node is the connection place of two edges, please see Diagram one. Nodes are used to represent the crossroads, river meeting points in real life. The property tables of nodes and edges are used to record their adjacent relations.

**Edge**

An edge is the section line between two nodes. An edge connects with the rest of edges by nodes, please see Diagram one. It is used to deputy the high express, railway, transport lines of electric network, and rivers of hydrology network. There is topology structure between the edges.
Network

The network consists of a group of related edges, points and their properties, shown in Diagram one. Network represents the roads and pipelines in our life. The following factors should be defined to produce information such as demands, requirements, and centre points and so on.

Impendence

In real life, the cost of a journey could be measured by distance, time, and cost. The cost on nodes or edges is abstracted into network impendence which is stored in the impendence field in the property table.

Center

Center is the discrete facilities which have functions to receive or supply resources, locating on the nodes. Facilities represent substance, resources, information, management, and cultural environment. For instance, in a school, the education resources are necessary for students who have to go for study; in a retail warehouse, the goods are stored to distribute to all the retail points. A center is actually a node in the network.

Barrier Nodes and Barrier Edges

The traffic jam is not rare in city life at all. Since it is a dynamic procedure and always happens randomly, there are no regulations to follow. In order to display the traffic conditions in real time, the edge in the traffic jam must be defined with property that is able to temporarily ban the trip and then free the edge when the traffics flow freely. Barrier nodes and barrier edges are designed to meet this requirement, which have comparatively independent features from the current network environment parameters.

Turn Table

Turning is a trip from one edge, passing a central node, to another edge. The cost of turning is the consumption during this trip, which stores in the turn table. All the turning directions of a crossroad should be listed in the turn table. Usually, there are four fields, related with the fields of nodes and edges, used to record the turning information, the initial edge field (FromEdgeID), terminal edge field (ToEdgeID), node annotation field (NodeID), and the cost of the turning (TurnCost). Each record lists the turning cost for one turning possibility. The minus cost value means forbidden turning.

There are many crossroads and divergences in the road network analysis. The turn table should be used for them to record the turning cost, please refer to Diagram three. The left diagram is a crossroad, and its turn table is the right table.
Diagram 3 the Structure of a Turn Table
Summary of Network Analysis Functionality

The network analysis functions offered by SuperMap Objects Java are path finding, service area analysis, traveling salesman problem analysis, closest facility analysis, allocation and location, logistics vehicle routing analysis, as well as related analysis functions of facility network analysis. Facility network analysis is used to trace upstream and downstream analysis, routes analysis of the facility network, and connectivity analysis.

These powerful functions provided by SuperMap GIS are widely used in the following practical questions:

Place B is short of water, and in order to transmit water from Place A to Place B, the connectivity situation of the pipeline between the two places must be checked first. If it is in good shape, water will be switched on. This problem requires the connectivity function.

The tracing analysis is able to locate the pollution source according to local polluted areas.

The salesman path finding is extremely useful to delivers of the express delivery companies. A suitable shortest route can pass by all the delivery destinations. The fire fighting truck needs to choose a route that takes the least time to the accident place, and path finding is the best analysis method for them.

The service area analysis of SuperMap GIS can help to find a suitable location for a new post office in a city.

The police station receives a crime report, and they want the patrol car which is nearest to the accident place to deal with it. The closest facility analysis can give them satisfied answer.

A snack bar has M branches, and there are N customers order the take-out. The dispatcher of the snack bar can work out the most convenient routes for all the deliverers by using logistics vehicle routing analysis of SuperMap GIS.
Building Network Analysis

In order to conduct the network analysis functions offered by SuperMap Objects Java, you have to build network datasets. First, you have to abstract the analyzing objects into lines and points, and then build the topology relationship between them; finally, a model containing the objects to imitate the relations between things in the real world will be built.

Building network datasets use the function BuildNetwork () of the NetworkBuilder class of the SuperMap Objects Java. This is a reloading method. It can establish a network datasets by given a line dataset, building the topology relationship. Alternatively, it can build option parameters through a network datasets, controlling the topological transaction content during the building procedure of network datasets. Besides, to build a network dataset by using multiple point datasets and line datasets is the third way. We are going to introduce two building methods in the following sections.

**Method One: building a network model dataset according to specified line datasets, datasources and datasets names.**

**Syntax:**

```java
public static DatasetVector buildNetwork(DatasetVector lineDataset, Datasource outputDatasource, String networkDatasetName)
```

**Parameters:**

- lineDataset: the line datasets that is used to build network datasets.
- outputDatasource: storing datasources of the established network datasets.
- networkDatasetName: names of the specified network datasets.

**Return Value:**

Returns the established datasets, which is vector dataset.

**Method Two: building network datasets by using the line dataset array and point dataset array.**

**Syntax:**

```java
public static DatasetVector buildNetwork(DatasetVector[] lineDatasets, DatasetVector[] pointDatasets, Datasource outputDatasource, String networkDatasetName, NetworkSplitMode networkSplitMode, double tolerance)
```
**Parameters:**

- lineDatasets: the line dataset array that is used to build network datasets. This array includes one or more line datasets to establish network datasets.

- pointDatasets: the point dataset array that is used to build network datasets. This array includes one or more point datasets to establish network datasets.

- outputDatasource: storing the datasource of the established network datasets.

- networkDatasetName: names of the specified network datasets.

- networkSplitMode: specified split mode.

- tolerance: the tolerance value of points in the point dataset that could be considered as the points on the network.

**Return Value:**

Returns the established network dataset, which is vector dataset.
Functions of Traffic Network Analysis

Functions of traffic network analysis includes: path finding, service area analysis, traveling salesman problem analysis, the closest facility analysis, allocation and location, and logistics vehicle routing analysis.

These stated analyses should be achieved through three steps: environment configuration of the traffic network analysis, loading environment configuration of the traffic network analysis, and setting parameters of the traffic network analysis.

6.1 Environment Configuration of Traffic Network Analysis

All the functions of traffic network analysis are achieved by functions provided by class TransportationAnalyst. The functions of the class require environment configurations to get the necessary parameter information. Environment configuration could be done by setting an method `setAnalystSetting` (`TransportationAnalystSetting` value) of the class `TransportationAnalyst`. In a word, to set environment configuration is actually to set methods in the class `TransportationAnalystSetting`. Please note that the environment configuration will affect the analysis result very much.

Syntax:

`TransportationAnalystSetting TransportationAnalyst .AnalystSetting`

Table 1 The methods of traffic Network Analysis Environment Configuration Class

(TransportationAnalystSetting Class)

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getBarrierEdges()</td>
<td>Obtaining or setting the ID list of barrier edges.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td><code>setBarrierEdges(int[] value)</code></td>
<td>One edge was set as barrier edge, means that it is not allow to pass in the analysis process. The barrier edge could be dynamic setting in the analysis process, and doesn’t affect the efficiency.</td>
</tr>
<tr>
<td><code>getBarrierNodes()</code></td>
<td>Obtaining or setting the ID list of barrier nodes.</td>
</tr>
<tr>
<td><code>setBarrierNodes()</code></td>
<td></td>
</tr>
<tr>
<td><code>getEdgeIdField()</code></td>
<td>Obtaining or setting the ID fields of network edges.</td>
</tr>
<tr>
<td><code>setEdgeIdField(String value)</code></td>
<td>This parameter must be set, and take effective in the entire analysis process.</td>
</tr>
<tr>
<td><code>getEdgeNameField()</code></td>
<td>Obtaining or setting names of fields that stores the edge names.</td>
</tr>
<tr>
<td><code>setEdgeNameField(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getFNodeIdField()</code></td>
<td>Obtaining or setting the ID field of initial node of an edge.</td>
</tr>
<tr>
<td><code>setFNodeIdField(String value)</code></td>
<td>This parameter must be set.</td>
</tr>
<tr>
<td><code>getFTSingleWayRuleValues()</code></td>
<td>Obtaining or setting the arrays that represent the positive single way string. Exactly speaking, if the value of attribute RuleField is one of the strings in the array, the correspondent edge is a positive single way road.</td>
</tr>
<tr>
<td><code>setFTSingleWayRuleValues(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getNetworkDataset()</code></td>
<td>Obtaining or setting the analysing network datasets.</td>
</tr>
</tbody>
</table>

**SuperMap Objects Java Technology Documents**
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>setNetworkDataset(DatasetVector value)</td>
<td>The Network Dataset must be built, before load the model of Network Analyst.</td>
</tr>
<tr>
<td>getNodeIDField()</td>
<td>Obtaining or setting the ID fields of network nodes.</td>
</tr>
<tr>
<td>setNodeIDField(String value)</td>
<td></td>
</tr>
<tr>
<td>getNodeNameField()</td>
<td>Obtaining or setting the names of fields that stores the node names.</td>
</tr>
<tr>
<td>setNodeNameField(String value)</td>
<td></td>
</tr>
<tr>
<td>getProhibitedWayRuleValues()</td>
<td>Obtaining or setting string arrays that represent the prohibited lines; i.e. if the value of attribute RuleField is one of the strings in the array, the correspondent network edge is prohibited line.</td>
</tr>
<tr>
<td>setProhibitedWayRuleValues(String value)</td>
<td></td>
</tr>
<tr>
<td>getRuleField()</td>
<td>Obtaining or setting the fields that represent the traffic principles of the edges.</td>
</tr>
<tr>
<td>setRuleField(String value)</td>
<td></td>
</tr>
<tr>
<td>getTFSingleWayRuleValues()</td>
<td>Obtaining or setting string arrays that represent the reverse single way. Exactly speaking, if the value of attribute RuleField is one of the strings in the array, the correspondent edge is a negative single way road.</td>
</tr>
<tr>
<td>getTFSingleWayRuleValues(String[] value)</td>
<td></td>
</tr>
<tr>
<td>getTNodeIDField()</td>
<td>Obtaining or setting the ID field of terminal node of an edge.</td>
</tr>
<tr>
<td>setTNodeIDField(String value)</td>
<td></td>
</tr>
<tr>
<td>getTolerance()</td>
<td>Obtaining or setting the tolerance between nodes and</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>or</code></td>
<td></td>
</tr>
<tr>
<td><code>setTolerance(double value)</code></td>
<td></td>
</tr>
<tr>
<td>edges.</td>
<td></td>
</tr>
<tr>
<td>Principle, Any point in the Network could</td>
<td>be set as a node in the Network Analysis process, and the node must</td>
</tr>
<tr>
<td>be near the Network. If this point is</td>
<td>neither in the node nor on the edge, this method could add the point as a</td>
</tr>
<tr>
<td>neither in the node nor on the edge,</td>
<td>node of Network according the distance tolerance.</td>
</tr>
<tr>
<td>this method could add the point as a node</td>
<td></td>
</tr>
<tr>
<td>of Network according the distance tolerance.</td>
<td></td>
</tr>
<tr>
<td><code>getTurnDataset()</code></td>
<td>Obtaining or setting datasets of turn table.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td><code>setTurnDataset(DatasetVector value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getTurnFEdgeIDField()</code></td>
<td>Obtaining or setting the ID field of the initial turning edge.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td><code>setTurnFEdgeIDField()</code></td>
<td></td>
</tr>
<tr>
<td><code>getTurnNodeIDField()</code></td>
<td>Obtaining or setting the ID field of the turning node.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td><code>setTurnNodeIDField(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getTurnTEdgeIDField()</code></td>
<td>Obtaining or setting the ID field of the terminal turning edge.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td><code>setTurnTEdgeIDField(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getTurnWeightFields()</code></td>
<td>Obtaining or setting the field set of turning weight.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td><code>setTurnWeightFields(String[] value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getTwoWayRuleValues()</code></td>
<td>Obtaining or setting string arrays that represent the double-way road,</td>
</tr>
<tr>
<td>or</td>
<td>which means if the value of attribute RuleField is one of the strings in the</td>
</tr>
<tr>
<td><code>setTwoWayRuleValues(String[] value)</code></td>
<td>array, the correspondent network edge is a double-way road.</td>
</tr>
<tr>
<td><code>getWeightFieldInfos()</code></td>
<td>Obtaining or setting weight fields' information set object. WeightFieldInfos</td>
</tr>
<tr>
<td>or</td>
<td>is the set of WeightFieldInfo. In the WeightFieldInfo, the fields of</td>
</tr>
<tr>
<td><code>getWeightFieldInfos()</code></td>
<td>positive weight</td>
</tr>
</tbody>
</table>
setWeightFieldInfos(WeightFieldInfos value) | value and negative weight value, which represent the cost of the network analysis, could be set.
---|---
WeightFieldInfos is the set of WeightFieldInfo. In the WeightFieldInfo, the fields of positive weight value and negative weight value, which represent the cost of the network analysis, could be set.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getFTWeightField() or setFTWeightField(String value)</td>
<td>Forward Resistance Field</td>
</tr>
<tr>
<td>getTFWeightField() or setTFWeightField(String value)</td>
<td>Reverse Resistance Field</td>
</tr>
<tr>
<td>getName() or setName(String value)</td>
<td>Names of Weight Field information</td>
</tr>
</tbody>
</table>

### 6.2 Loading Environment Configuration of Traffic Network Analysis

After you finish the setting of traffic network analysis environment, the next step is to load your configuration by calling Load () method in class TransportationAnalyst. This method will make your custom settings effective.

**Syntax:**

```java
public boolean load()
```

**Return Value:**

Returns True if the loading activity is achieved, otherwise returns False.
6.3 Setting Parameters of Traffic Network Analysis

TransportationAnalystParameter class is used as parameters in many network analyses, such as path finding, traveling salesman problem analysis, closest facility analysis, service area analysis. Hence, we can set the methods of the class object transportationAnalystParameter to provide traffic network analysis function to corresponding network analysis functions. It allows setting barriers in nodes or lines, name mark of weight field information, turning weight field. Meanwhile, you may also able to get a desired result by setting if the node set, arc set, and route object set and station set are shown in the outcome. The following table is an introduction of class transportationAnalystParameter methods.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getBarrierEdges()</td>
<td>Obtaining or setting of network barrier edge set</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>setBarrierEdges(int[] value)</td>
<td></td>
</tr>
<tr>
<td>getBarrierNodes()</td>
<td>Obtaining or setting network barrier point set.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>setBarrierEdges(int[] value)</td>
<td></td>
</tr>
<tr>
<td>isEdgesReturn()</td>
<td>Obtaining or setting if contain the past edges set in the result</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>setEdgesReturn(boolean value)</td>
<td></td>
</tr>
<tr>
<td>isNodesReturn()</td>
<td>Obtaining or setting if contain the past points set in the result.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>setNodesReturn(boolean value)</td>
<td></td>
</tr>
<tr>
<td>isPathGuidesReturn()</td>
<td>Obtaining or setting if contain driving guide set in the result.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>setPathGuidesReturn(boolean value)</code></td>
<td>Obtaining or setting if contain any route object (i.e. set of GeoLineM) set in the result.</td>
</tr>
<tr>
<td><code>isRoutesReturn()</code></td>
<td></td>
</tr>
<tr>
<td><code>setRoutesReturn(boolean value)</code></td>
<td></td>
</tr>
<tr>
<td><code>isStopIndexesReturn()</code></td>
<td>Obtaining or setting if contain index set of past stops in the result.</td>
</tr>
<tr>
<td><code>setStopIndexesReturn(boolean value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getNodes()</code></td>
<td>Obtaining or setting the ID set of past nodes. Mutual exclusion with attribute Points. Only one could be used in each time.</td>
</tr>
<tr>
<td><code>setNodes(int[] value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getPoints()</code></td>
<td>Obtaining or setting the past points set. Mutual exclusion with attribute Nodes. Only one of them could be used in each time.</td>
</tr>
<tr>
<td><code>setPoints(int[] value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getTurnWeightField()</code></td>
<td>Obtaining or setting the turning weight field.</td>
</tr>
<tr>
<td><code>setTurnWeightField(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getWeightName()</code></td>
<td>Obtaining or setting name mark of weight field information, i.e. the value of Name of a weight field information object (WeightFieldInfo) in weight field information set (WeightFieldInfos), which is in network analysis environment configuration (NetworkAnalystSetting).</td>
</tr>
<tr>
<td><code>setWeightName(String value)</code></td>
<td></td>
</tr>
</tbody>
</table>

We are going to introduce you, together with the components products of SuperMap Objects Java, all these functions and how to achieve them.
6.4 Path Finding

Path finding is looking for a route between two nodes in the network that has the least resistance. The route should be accessed by the selecting sequence of nodes. The "least resistance" at here means a lot, according to your practical situation it could be any simple factors, for instance, the least time to use, the lowest cost to pay, the most enjoyable scenery along the road, the best traffic to go, the fewest bridges and toll gates in the total journey, or the most villages to pass by. For instance, we want to visit four nodes 1, 2, 3, 4 in order of their number. The first thing that needs to be done is obtaining the optimum path R1_2 between node 1 and 2. Second, the optimum path R2_3 between node 2 and node 3 should be located. Third, the optimum path R3_4 between node 3 and 4 should be found. Finally, the best route visiting the four nodes from number 1 is R = R1_2 + R2_3 +R3_4.

6.4.1 Steps to Achieve Path Finding

1. Create Network Dataset. If there is no network dataset used to analyze, we should use buildNetwork() method in NetworkBuilder class to create network dataset.

2. Set traffic network analysis environment, namely set setAnalystSetting(TransportationAnalystSetting value) method in TransportationAnalyst class.

3. Set traffic network analysis parameter class object, namely set parameter object of TransportationAnalystParameter class.

4. Call path analysis method to implement Path Analysis and get the analysis result.

6.4.2 How to Call the Path Finding

Syntax:

public TransportationAnalystResult
findPath(TransportationAnalystParameter parameter, boolean hasLeastEdgeCount)

Parameters:

parameter: traffic network analysis parameter object.
Through setting parameter of TransportationAnalystParameter type in the method, N points in the analysis and their sequence are set. There are two modes:

(1) Use method `setNodes(int[] value)` of TransportationAnalystParameter type's parameter object to specify points Path Analysis passes through in the form of nodes ID array of network dataset. So points Path Analysis passes through are the corresponding network nodes, and the sequence of the points are the sequence of the nodes in the nodes ID array;

(2) Use method `setPoints(Point2Ds value)` of TransportationAnalystParameter type's parameter object to specify points Path Analysis passes through in the form of coordinate points string of the past points. Method `setPoints(Point2Ds value)` of TransportationAnalystParameter type's parameter object is corresponding to coordinate points set, so the sequence of the points Path Analysis passes through is the sequence of coordinate point in the points set.

Besides setting the points Path Analysis passes through, some information required in Path Analysis can also be set in the parameter of TransportationAnalystParameter type.

`hasLeastEdgeCount`: whether number of arcs is smallest. True represents that it will query according to the smallest arcs. Small arcs don't represent short arcs, so the query result may not be the shortest path.

**Return Value:**

Returns the result of Path Analysis, which is saved in the class of TransportationAnalystResult.

### 6.4.3 The Outcome of the Path Finding

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>getRoutes()</code></td>
<td>Obtaining the route set of the analyst result, that is, the set of the GeoLineM class.</td>
</tr>
<tr>
<td><code>getNodes()</code></td>
<td>Obtaining the array of the past node ID in the result of analysis.</td>
</tr>
<tr>
<td><code>getEdges()</code></td>
<td>Obtaining the array of the past edge ID in the result of analysis.</td>
</tr>
<tr>
<td><code>getPathGuides()</code></td>
<td>Obtaining PathGuide array.</td>
</tr>
<tr>
<td><code>getStopIndexes()</code></td>
<td>Obtaining the two-dimensional arrays of the stop index. The values in this array indicate the order of the stops</td>
</tr>
</tbody>
</table>
after analyzing. The first array number is 1 if the analyze has a result, otherwise 0.

Notes:

(1) The node mode of FindPath analysis: If the array of node id we set is \{1, 3, 5\}, as the result order of passed nodes id should be the same to the node order we set, so the value of the StopIndexes will be \{0, 1, 2\}, it is the index order of result node in the initial node array.

(2) The point mode of FindPath analysis: The result node id passed has no relations to the point index we set, so the value of StopIndexes has not any meanings.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getWeights()</td>
<td>Obtaining the array of the analyst weights. The number in the array is 1 if the analyze has a result, otherwise 0, that is, Weights[0] indicates the total weight while analyzing.</td>
</tr>
<tr>
<td>getStopsWeights()</td>
<td>Obtaining the weight in each stop, that is, the cost in each stop.</td>
</tr>
</tbody>
</table>

6.5 The Closest Facility Analysis

The closest facility analysis aims to find a route between an event node to a group of facilities points with the least cost. The outcome displays the optimum routes, the lowest cost, and the best driving directions between the event location and one or more facilities.

**Facility point**: the basic elements of the closest facility analysis. Usually, the service facilities such as school, supermarket, and gas station are the facility points.

**Event point**: another basic element of the closest facility analysis, which is the event place that requires the service facility.

**Scene**: there is a traffic accident reported on the event point, requiring a hospital which must be within ten minutes driving distance. The hospitals around are the facility points; while the accident happened place is an event point. Since the closest facility analysis is a route analysis, the route with barrier points and edges will not be included in the results.
6.5.1 Steps to Achieve the Closest Facility Analysis

1. Create Network Dataset. If there is no network dataset used to analyze, we should use `buildNetwork()` method in NetworkBuilder class to create network dataset.

2. Set traffic network analysis environment, namely set method `setAnalystSetting(TransportationAnalystSetting value)` in TransportationAnalyst class.

3. Set traffic network analysis parameter class object, namely set parameter object of TransportationAnalystParameter class.

4. Call Finding Closest Facility analysis method to implement Finding Closest Facility Analysis and get the analysis result.

6.5.2 How to Call the Closest Facility Analysis

**Syntax:**

```java
public TransportationAnalystResult findClosestFacility(TransportationAnalystParameter parameter, int eventId, int facilityCount, boolean isFromEvent, double maxWeight)
public TransportationAnalystResult findClosestFacility(TransportationAnalystParameter parameter, Point2D eventPoint, int facilityCount, boolean isFromEvent, double maxWeight)
```

**Parameters:**

- `parameter`: traffic network analysis parameter object.

Through setting parameter of TransportationAnalystParameter type in the method, facility points are set. There are two modes:

Use method `setNodes(int[] value)` of TransportationAnalystParameter type's parameter object to specify facility points in the form of node ID array of network dataset. So the facility points in the process of analysis are the corresponding network nodes.

Use method `setPoints(Point2D[] value)` of TransportationAnalystParameter type's parameter object to specify facility points in the form of coordinate points string of the facility points. Method `setPoints(Point2D[] value)` of TransportationAnalystParameter type's parameter object is corresponding to coordinate points set.

Besides setting the facility points, some information required in Finding Closest Facilities Analysis can also be set in the parameter of TransportationAnalystParameter type.
eventPoint/ eventide: specify event point.

In Finding Closest Facilities Analysis event point can be specified in two methods. One is through coordinate point, that is, eventPoint parameter in mode; the other is through node ID in network dataset, regarding network nodes as event points, that is, eventID parameter in mode 1.

facilityCount: count of facility points to query.

isFromEvent: whether to query from event point to facility point.

maxWeight: Search radius. In the same unit of the impedance. If you want to search all the network, set the radius to 0.

Return Value:

Returns the result of Finding Closest Facilities Analysis, which is saved in TransportationAnalystResult class.

6.5.3 The Outcome of the Closest Facility Analysis

Table 5 Methods of transportationAnalystResult class

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getRoutes()</td>
<td>Obtaining the GeoLineM object which contains the routes in the analysis result.</td>
</tr>
<tr>
<td>getNodes()</td>
<td>Obtaining the array of the past node ID in the result of analysis.</td>
</tr>
<tr>
<td>getEdges()</td>
<td>Obtaining the array of the past edge ID in the result of analysis.</td>
</tr>
<tr>
<td>getPathGuides()</td>
<td>Obtaining PathGuide array.</td>
</tr>
<tr>
<td>getStopIndexes()</td>
<td>Obtaining the two-dimensional arrays of the stop index. The values in this array indicate the order of the stops after analyzing. The first array number is 1 if the analyze has a result, otherwise 0.</td>
</tr>
<tr>
<td>getWeights()</td>
<td>Obtaining the array of the analyst weights. The number in the array is 1 if the analyze has a result, otherwise 0, that is, Weights[0] indicates the total weight while analyzing.</td>
</tr>
</tbody>
</table>
6.6  Traveling Salesman Problem Analysis

Salesman path finding is looking for a route passing by a group of nodes, with the custom visiting order to achieve as low travelling cost sum as possible.

The start point of the route is the first element in the parameter of `TransportationAnalystParam`. The method `setNodes(int[] value)` of parameter object `TransportationAnalystParameter` could be used to designate the points as a node ID array. Hence, the past points in the analysis are the correspondent nodes in the network. If there is a point selected as the terminal point, this point is the last node in the node ID array.

The following steps are able to help you achieve the salesman path finding:

First, building a network dataset. You need a network dataset to be used in the analysis. Please use the method `buildNetwork()` in class `NetworkBuilder`.

Setting analysis environment of traffic network, i.e. setting the method `setAnalystSetting(TransportationAnalystSetting value)` in class `TransportationAnalyst`.

Setting the objects of parameter class in traffic network analysis, i.e. setting the parameter objects in class `TransportationAnalystParameter`.

Call the traveling salesman problem analysis function to achieve the analysis as well as the outcome.

**Syntax:**

```java
public TransportationAnalystResult findTSPPath(TransportationAnalystParameter parameter, boolean isEndNodeAssigned)
```

**Parameters:**

- `parameter`: parameters objects in traffic network analysis.
- `isEndNodeAssigned`: indicates terminal point.

To designate the nodes which are going to be passed by salesmen is set in the parameter "parameter" of `TransportationAnalystParameter` parameter objects. There are two methods to designate the nodes to pass:

1. The method `setNodes(int[] value)` of parameter object `TransportationAnalystParameter` could be used to designate the points as a node ID array. Hence, the past points in the analysis are the correspondent nodes in the network. If there is a point selected as the terminal point, this point is the last node in the node ID array.
2. If you have the coordinate information of the points that the route is going to pass, the method `setPoints(Point2Ds value)` of the `TransportationAnalystParameter` could be used. This method is a set of coordinates. If there is a point selected as the terminal point, this coordinate of this point would be the last one in `Points`.

There are more parameters in `TransportationAnalystParameter`, which are necessary in the salesman path finding analysis.

`hasLeastEdgeCount`: it has value True if you set a terminal point which should be the last point for salesmen to visit. The visiting order of the rest points could be decided by the salesmen.

**Return Value:**

Returns the result of traveling salesman problem analysis, which saves in the class of `TransportationAnalystResult`.

The Outcome of Traveling Salesman Problem Analysis List

Table 6 The methods Table of Class `TransportationAnalystResult`

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getRoutes()</td>
<td>Obtaining the object set of the outcome routes. This object set is named GeoLineM.</td>
</tr>
<tr>
<td>getNodes()</td>
<td>Obtaining the node ID set along the analysing outcome route.</td>
</tr>
<tr>
<td>getEdges()</td>
<td>Obtaining the edge set contributed to the outcome route.</td>
</tr>
<tr>
<td>getPathGuides()</td>
<td>Obtaining driving guidance set.</td>
</tr>
<tr>
<td>getStopIndexes()</td>
<td>Obtaining the two dimension array of nodes' index, it represents the order of the nodes. If there is any outcome, the first dimension is 1, otherwise, it is zero.</td>
</tr>
</tbody>
</table>

**Notes:**

1. The node mode of `FindTSPPath` analysis: If the array of node id we set is `{1, 3, 5}`, as the result order of passed nodes id is `{3, 5, 1}`, so the value of the `StopIndexes` will be `{1, 2, 0}`, it is the index order of result node in the initial node array.

2. The point mode of `FindPath` analysis: If the array of...
points we set is \{Pnt1, Pnt2, Pnt3\}, as the result order of passed points is \{Pnt2, Pnt3, Pnt1\}, so the value of the StopIndexes will be \{1, 2, 0\}, it is the index order of result point in the initial point array.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getWeights()</td>
<td>Obtaining the weight array that represents cost. If there is any outcome,</td>
</tr>
<tr>
<td></td>
<td>the length of the array is 1, otherwise, it is zero. In a word, the Weights [0]</td>
</tr>
<tr>
<td></td>
<td>is the total cost.</td>
</tr>
<tr>
<td>getStopsWeights()</td>
<td>Obtaining weights of the past stops.</td>
</tr>
</tbody>
</table>

### 6.7 Service Area Analysis

Service area analysis displays the service scope of a service centre on the network.

**Relative Concepts:**

Service area: a zone displays all the reachable borders and points, restricted by certain resistance, from a specified center. Simply speaking, service area analysis tells us the service scope of a service center with certain restriction.

Service area analysis calculates the service scope of a specified position on the network. For instance, to display the 30-minute driving service area centered by a node on the network. In the outcome, a zone with the node as a center is illustrated. Starting from the central node, you are able to drive to any place within the zone in 30 minutes.

Mutex of multiple service area: we will apply mutex operation to the overlapped areas of adjacent service areas.

Where to start the analysis: there are two ways to conduct the analysis. Sometimes, it is necessary to analyze from the central point, which means the service centre should deliver their service to the destination, for instance a dairy station has to sent milk to nearby neighborhoods, the analysis should use the dairy station as a centre. In other cases, it is necessary to analyze from the destination, which indicates the service could only be obtained in the service center, for instance, in order to know the service scope of a school, the analysis should be conducted from students' neighborhoods, as every student has to go to school to have classes.

### 6.7.1 Steps to achieve the Service Area Analysis

1. Create Network Dataset. If there is no network dataset used to analyze, we should use `buildNetwork()` method in NetworkBuilder class to create network dataset.
2. Set traffic network analysis environment, namely set method
   `setAnalystSetting(TransportationAnalystSetting value)` in TransportationAnalyst class.

3. Set traffic network analysis parameter class object, namely set parameter object of
   TransportationAnalystParameter class.

4. Call Service Area analysis method to implement Service Area Analysis and get the analysis result.

### 6.7.2 How to Call the Service Area Analysis

**Syntax:**

```java
public ServiceAreaResult findServiceArea(TransportationAnalystParameter parameter, double[] weights, boolean isFromCenter, boolean isCenterMutuallyExclusive)
```

**Parameters:**

- **Parameter:** traffic network analysis parameter object.

  In Service Area analysis, through setting parameter of TransportationAnalystParameter type, service center is set, and we can set multi service center points. There are two modes:

  Use method `setNodes(int[] value)` of TransportationAnalystParameter type's parameter object to specify service center point in the form of node ID array of network dataset. So service center point in the process of analysis is the corresponding network nodes.

  Use method `setPoints(Point2Ds value)` of TransportationAnalystParameter type's parameter object to specity service center point in the form of coordinate point’s string of the service center points. Method `setPoints(Point2Ds value)` of TransportationAnalystParameter type's parameter object is corresponding to coordinate points set.

  Some information required in Service Area Analysis can also be set in the parameter of TransportationAnalystParameter type.

- **Weights:** cost array.

- **isFromCenter:** whether to start analyzing from center.

- **isCenterMutuallyExclusive:** whether center points are exclusive, that is, judge whether to make exclusive disposal according to the distance of center points. If analyzed service areas overlap, the parameter is set to make exclusive disposal. For example, the left graph doesn't make exclusive disposal, and the right does. Notice: centers exclusive analysis isn't supported for the moment.
Return Value:

Returns the result of Service Area Analysis, which is saved in ServiceAreaResult class.

### 6.7.3 The Outcome of the Service Area Analysis

Result class of Service Area analysis: ServiceAreaResult class, inherits from TransportationAnalystResult class, so it owns all properties of TransportationAnalystResult class.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getRoutes()</td>
<td>Obtaining the GeoLineM object which contains the routes in the analysis result.</td>
</tr>
<tr>
<td>getNodes()</td>
<td>Obtaining the array of the passed node ID in the result of analysis.</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>getEdges()</td>
<td>Obtaining the array of the passed edge ID in the result of analysis.</td>
</tr>
<tr>
<td>getPathGuides()</td>
<td>Obtaining PathGuide array.</td>
</tr>
<tr>
<td>getStopIndexes()</td>
<td>Obtaining the two-dimensional arrays of the stop index. The values in this array indicate the order of the stops after analyzing. The first array number is 1 if the analyze has a result, otherwise 0.</td>
</tr>
<tr>
<td>getWeights()</td>
<td>Obtaining the array of the analyst weights. The number in the array is 1 if the analyze has a result, otherwise 0, that is, Weights[0] indicates the total weight while analyzing.</td>
</tr>
<tr>
<td>getStopsWeights()</td>
<td>Obtaining the weight in each stop, that is, the cost in each stop.</td>
</tr>
<tr>
<td>getServiceRegions()</td>
<td>Obtaining the set of the service region objects.</td>
</tr>
<tr>
<td>getServiceRouteCounts()</td>
<td>Obtaining the count array of the route of each service region in ServiceAreaResult.</td>
</tr>
</tbody>
</table>

The following graph shows what problem Service Area analysis will resolve and what information the analysis result provides. Blue points represent service center providing service, and regions with kinds of colors represent service area within the limit of specified resistance centered on the relevant service center.
6.8 Logistics Vehicle Routing Analysis

Logistic vehicle routing analysis aims to deliver goods to N destinations from M distribution centers (M and N are positive integer) by providing economic and effective distribution routes, as well as the correspondent travelling route.

Logistic vehicle routing analysis is helpful to reasonably distribute the send-out order and sending routes, containing the cost of a center or the sum of the total distribution cost within the lowest scale.

Logistic vehicle routing analysis outcome will display all the destinations of each distribution centre, the order of the destinations to deliver, and the correspondent travelling road. As a result, the cost of a center or the sum of the total distribution cost will be the lowest one.

6.8.1 Steps to Achieve the Logistic Vehicle Routing Analysis

1. Create Network Dataset. If there is no network dataset used to analyze, we should use
method **buildNetwork()** in NetworkBuilder class to create network dataset.

2. Set traffic network analysis environment, namely set method
   **setAnalystSetting(TransportationAnalystSetting value)** in TransportationAnalyst class.

3. Set traffic network analysis parameter class object, namely set parameter object of
   TransportationAnalystParameter class.

4. Call Logistics Analysis method to implement Logistics Analysis and get the analysis result.

**6.8.2 How to Call the Logistic Vehicle Routing Analysis**

**Syntax:**

```
public TransportationAnalystResult findMTSPPath(TransportationAnalystParameter parameter, int[] centerNodes, boolean hasLeastTotalCost)

public TransportationAnalystResult.findMTSPPath(TransportationAnalystParameter parameter, Point2Ds centerPoints, boolean hasLeastTotalCost)
```

**Parameters:**

parameter: traffic network analysis parameter object.
Through setting parameter of TransportationAnalystParameter type in Logistics Analysis method, destinations are set. There is two modes:

Use method **setNodes(int[] value)** of TransportationAnalystParameter type's parameter object to specify destinations in the form of nodes ID array of network dataset. So destinations in the process of analysis are the corresponding network nodes.

Use method **setPoints(Point2Ds value)** of TransportationAnalystParameter type's parameter object to specify destinations in the form of coordinate point’s string of the destinations. Method **setPoints(Point2Ds value)** of TransportationAnalystParameter type's parameter object is corresponding to coordinate points set.

Some information required in Logistics Analysis can also be set in the parameter of TransportationAnalystParameter type.

centerNodes/ Point2Ds centerPoints : specify distribution center.
The necessary parameters in Logistics Analysis are distribution center and distribution destination. Two modes are used to specify distribution center.

1. It's set by centerNodes parameter in Logistics Analysis method 1, which is a network node ID array, so the relevant network node is set to be distribution center.

2. It's set by centerPoints parameter in Logistics Analysis method 2, which is a coordinate point set, so the relevant coordinate point is set to be distribution center.

   hasLeastTotalCost: whether the distribution mode is the least cost scheme. If true, it will distribute according to the least cost, when the result may be that some distribution centers spend more and others spend less. If false, it represents the partially best, which will control how much every distribution center spends to make the cost relatively even, when the total cost may be not the least. The parameter is set False by default.

Return Value:

Returns the result of Logistics Analysis, which is saved in the class of TransportationAnalystResult.

### 6.8.3 The Outcome of the Logistic Vehicle Routing Analysis

Result information of Logistics Analysis is saved in relevant properties of TransportationAnalystResult class object. The following is a detailed introduction to the meaning of every method in TransportationAnalystResult class, combining the result of Logistics Analysis, as shown in the table below.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getRoutes()</td>
<td>Obtaining the route set of the analyst result, that is, the set of the GeoLineM class.</td>
</tr>
<tr>
<td>getNodes()</td>
<td>Obtaining the array of the past node ID in the result of analysis. The property is corresponding to a two-dimensional array, which represents storing the past nodes according to the distribution program of every destination got by the analysis result, that is, the array's demension 1 marks distribution program number of</td>
</tr>
</tbody>
</table>
### Functions of Traffic Network Analysis

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getEdges()</td>
<td>Obtaining the array of the past edge ID in the result of analysis. The property is corresponding to a two-dimensional array, which represents storing the past edges according to the distribution program of every destination got by the analysis result, that is, the array's demension 1 marks distribution program number of distribution destination which is used to differentiate distribution programs of different destinations; demension 2 stores edge ID number of the relevant distribution program.</td>
</tr>
<tr>
<td>getPathGuides()</td>
<td>Obtaining PathGuide array.</td>
</tr>
<tr>
<td>getStopIndexes()</td>
<td>Obtaining a two-dimensional array of stop index, which reflects the sequence of stops after analysis. The property is corresponding to a two-dimensional array, which represents storing indexes of the past stops (that is, distribution destinations) according to the distribution program of every destination got by the analysis result, that is, the array's demension 1 marks distribution program number of distribution destination which is used to differentiate distribution programs of different destinations; demension 2 stores indexes of the passed stops (that is, distribution destinations) of the relevant distribution program.</td>
</tr>
</tbody>
</table>

**Notes:**

1. The node mode of FindMTSPPath analysis: It is similar to the node mode of FindTSPPath analysis. The result of FindMTSPPath analysis is more than one index cluster.

2. The point mode of FindMTSPPath analysis: It is similar to the point mode of FindTSPPath analysis. The result of FindMTSPPath analysis is more than one index cluster.
<table>
<thead>
<tr>
<th>getWeights()</th>
<th>Obtaining the array of the cost weights.</th>
</tr>
</thead>
<tbody>
<tr>
<td>getStopsWeights()</td>
<td>Obtaining the weight of the past stops in analysis.</td>
</tr>
</tbody>
</table>

**Example:** There are 50 book retailers (distribution destinations), and 4 book distribution centers. We now want to find the best route for each of these 4 distribution centers to distribute books to the book retailers. This is a logistics analysis problem, which is illustrated in the figures below.

Figure 1 shows the result of the logistics analysis. The 4 big spots represent the book distribution centers, and the 50 smaller spots represent book retailers. The route found for each center has been highlighted in a different color.
6.9 Allocation and Location

Location selection and location analysis is able to find the most optimum or best location for one or more facilities to build to provide service in the most economic and effective way. Allocation
and location analysis does not only include selecting address procedure but also the partition process which means to locate reasonable demands into these new facilities.

**Concepts in the Allocation and Location Analysis:**

The resource supply center: the node data that is used to hold the relative information of the resource supply center (resource amount, the resistance limits, the type and the ID of resource supply center, and so on), which prepare for the analysis.

Resource amount: the largest amount of service or the number of goods could be offered by the center

Resistance limits: to limit the cost between the supply center and the demand points during delivery. The points, which are outside of the reach from the centre even with the largest cost, will be excluded. In a word, the center supply cannot provide service to the excluded points.

Resource supply center type: permanent center, optional center, and improper center. The permanent center is the established facilities (the resource supply sides); optional centers are the location options for building a new center; the improper center will be excluded at all in the analysis.

**The delivery modes:**

The "deliver" mode (from supply side to demand side):

The power station, as the network centre, generates electric to clients by electricity network which is the edges in the network model. In this situation, the energy is distributed from the supply side to the demand side.

The "fetch" mode (from demand side to supply side):

Schools offer education service to school-age children who are the demand sides. Children are allocated along the neighborhood network, requiring the enrollment places from the school.

### 6.9.1 Steps to Achieve Allocation and Location Analysis

1. Create Network Dataset. If there is no network dataset used to analyze, we should use method `buildNetwork()` in NetworkBuilder class to create network dataset.

2. Set traffic network analysis environment, namely set method `setAnalystSetting(TransportationAnalystSetting value)` in TransportationAnalyst class.
3. Set location-allocation analysis parameter class object, namely set parameter object of LocationAnalystParameter class.

4. Call location-allocation analysis method to implement the Analysis and get the analysis result.

### 6.9.2 Parameters Configuration for the Allocation and Location Analysis

Through LocationAnalystParameter class set location-allocation analysis methods to provide the necessary parameter information for location-allocation analysis. The detailed methods information is as shown as the following table:

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>getSupplyCenters()</code></td>
<td>Obtaining the supply centers. SupplyCenters class is SupplyCenter class set. Property of SupplyCenter, see in table 11.</td>
</tr>
<tr>
<td><code>getNodeDemandField()</code></td>
<td>Setting or obtaining the field representing the demand of the nodes which are regarded as the demand centers in the network dataset.</td>
</tr>
<tr>
<td><code>getExpectedSupplyCenterCount()</code></td>
<td>Setting or obtaining the number of the supply centers which will be used to build some establishments. If the parameter is set to zero, the minimal number of required supply centers will be computed to cover the whole analysis area.</td>
</tr>
<tr>
<td><code>isFromCenter()</code></td>
<td>Setting or obtaining whether to analyze from the supply centers or not. If true it represents from the supply centers; if false it doesn’t.</td>
</tr>
<tr>
<td><code>getBarrierEdges()</code></td>
<td>Setting or obtaining ID set of the barrier edges in the network.</td>
</tr>
</tbody>
</table>

**Table 9 The methods table of LocationAnalystParameter class**
6.9.3 How to Call the Allocation and Location Analysis

When calling location-allocation analysis method to realize location-allocation, the demand sides used in the process of location-allocation analysis are all network nodes, that is, except network nodes corresponding to kinds of centers other network nodes are all regarded as resource demand points in location-allocation analysis. If we want to exclude some nodes, we can set them as barrier points.

Syntax:

```java
public LocationAnalystResult findLocation(LocationAnalystParameter parameter)
```

Parameters:

- `parameter`: location-allocation analysis parameter class object. It provides the necessary parameter information for location-allocation analysis.

Return Value:
Returns the result of location-allocation analysis, which is saved in location-allocation analysis result class.

### 6.9.4 The Outcome of the Allocation and Location Analysis

The result of location-allocation analysis is saved in location-allocation analysis result class, that is, `LocationAnalystResult` class object. We can get result information from relevant methods of `LocationAnalystResult` class object. The methods are shown as the following table:

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>getSupplyResults()</code></td>
<td>Setting or obtaining the array of the <code>SupplyResult</code> objects.</td>
</tr>
<tr>
<td><code>getDemandResults()</code></td>
<td>Setting or obtaining the array of the <code>DemandResult</code> objects.</td>
</tr>
</tbody>
</table>

In which, supply center result class, that is, `SupplyResult` class provides type, ID, the maxima impedance, resource value, etc.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>getType()</code> or <code>setType(SupplyCenterType type)</code></td>
<td>Setting or obtaining the type of <code>SupplyCenterType</code>.</td>
</tr>
<tr>
<td><code>getID()</code></td>
<td>Obtaining the ID of <code>SupplyCenter</code>.</td>
</tr>
<tr>
<td><code>getMaxWeight()</code></td>
<td>Obtaining the maximum impedance of <code>SupplyCenter</code>. If cost from demand point (edge or node) to the center is bigger than the maximum impedance, the demand point is filtered.</td>
</tr>
<tr>
<td><code>getResourceValue()</code></td>
<td>Setting or obtaining the resource’s value of <code>SupplyCenter</code>.</td>
</tr>
</tbody>
</table>
or
setResourceValue(double value)

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getTotalWeights()</td>
<td>Obtaining the total weight of SupplyCenter.</td>
</tr>
<tr>
<td>getDemandCount()</td>
<td>Obtaining the count of demand points which the supply center provides service for.</td>
</tr>
<tr>
<td>getActualResourceValue()</td>
<td>Obtaining the actual resource supply value from supply center.</td>
</tr>
<tr>
<td>getActualResourceValue()</td>
<td>Obtaining the average weight of the supply center.</td>
</tr>
</tbody>
</table>

Table 12 The methods table of DemandResult class

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getID()</td>
<td>Obtaining the network node ID corresponding to the demand node.</td>
</tr>
<tr>
<td>getSupplyCenterID()</td>
<td>Obtaining the ID of the supply center. It represents which supply center resources got by the demand point are from.</td>
</tr>
<tr>
<td>getActualResourceValue()</td>
<td>Obtaining the actual allocated resource value for the demand side.</td>
</tr>
<tr>
<td>isEdge()</td>
<td>Represents whether the demand side type is edge or not. If the property is set true it represents edge; if false, it represents node. (Here, it's the result of location-allocation analysis, so only consider node demand)</td>
</tr>
</tbody>
</table>

Example: As shown in Figure 1, we want to set up a number of post offices for the region. There are 15 candidate locations for the post offices (As shown in Figure 1, the blue boxes represent the candidate locations), and we want to select 7 target locations based on the following conditions: the residents in the region should have access to at least one post office within 30 minutes' walk, and each post office has a maximum number of residents it can serve. The Location and Allocation analysis will locate these 7 post offices and outline the area that can be served by each post office (as shown in Figure 2, the red points are the post offices located).
**Notes:** In the following two figures, all the nodes in the network are considered as the residents involved in the Location and Allocation analysis.

Diagram 6 Network and Candidate Locations

Diagram 7 The Result of Location and Allocation Analysis
Facility Network Analysis

Using functions offered by class FacilityAnalyst to achieve correspondent network analysis functions. We are going to introduce all the facility network analysis functions provided by class FacilityAnalyst in the flowing sections, as well as their relative concepts.

7.1 Steps to Achieve Facility Network Analysis

1. Build network datasets

2. Build flow direction or class for network data. Facility network analysis needs a network dataset designed for itself. As a result, a network dataset must be built at the very beginning. Finally, use the method `buildFacilityNetworkDirections()` in the class NetworkBuilder to plant the specific data information for facility network analysis into the network dataset, i.e. building the flow direction for the network dataset which is the basic condition for the facility network analysis. At this stage, you are able to use various functions in the facility network analysis. The method `buildFacilityNetworkHierarchies()` of the class NetworkBuilder also allows you to add your class information.

3. The configuration of facility network analysis is to set the method `FacilityAnalyst.setAnalystSetting(FacilityAnalystSetting facilityAnalystSetting)`.


5. Use various facility network analysis methods offered by class FacilityAnalyst.
7.2 Building Network Dataset Flow Direction and Class

There are three parts in this chapter to illustrate the procedures of building flow direction and class for the network dataset:

7.2.1 Building Network Dataset Flow Direction

Creating direction for network dataset is realized by `buildFacilityNetworkDirections()` method in `NetworkBuilder` class:

**Syntax:**

```java
public static boolean buildFacilityNetworkDirections(FacilityAnalystSetting facilityAnalystSetting, int[] sourceIDs, int[] sinkIDs, String weightName, String nodeTypeField)
```

**Parameters:**

- `FacilityAnalystSetting facilityAnalystSetting`: Facility network analysis environment sets the class object. The parameter is `FacilityAnalystSetting` class object. For contents of the parameter setting, see table 18 which lists the property information.

- `sourceIDs`: The array of network node ID corresponding to sources. Sources and sinks are used to establish the flow of network datasets. The flow of network datasets is determined by positions of sources and sinks.

- `sinkIDs`: The array of network node ID corresponding to sinks. Sources and sinks are used to establish the flow of network datasets. The flow of network datasets is determined by positions of sources and sinks.

- `weightName`: The name of the specified `WeightFieldInfo` object, that is, `WeightFieldInfo.Name`.

- `nodeTypeField`: The name of node type field. Types of nodes contain source node, sink node, common node. The field exists in network node dataset. If it doesn't exist, we should create the field.

**Table 13 The methods table of `FacilityAnalystSetting` class**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>getNetworkDataset()</code></td>
<td>Setting or obtaining the network dataset.</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
</tbody>
</table>
### Remarks:

The NetworkDataset will represent different network dataset in different steps of the facility analysis. As follows:

1. **When building the dataset for the facility analysis:**

   - **buildFacilityNetworkDirections()** and **buildFacilityNetworkHierarchies()** in NetworkBuilder class both use parameter of FacilityAnalystSetting type, so they relate to the setting of setNetworkDataset() method in FacilityAnalystSetting type parameter. When creating flow the property is corresponding to the ordinary network dataset; when creating grade the property corresponding to network dataset with flow information.

2. **When using kinds of methods in FacilityAnalyst class to conduct facility analysis:**

   Before using kinds of methods in FacilityAnalyst class to conduct facility analysis, we need set network analysis environment through setAnalystSetting() method of FacilityAnalyst which is type of FacilityAnalystSetting, so it relates to the setting of NetworkDataset. Here, NetworkDataset represents network dataset which has created flow or has created flow and grade.

### Table: Node and Edge ID Field Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>getFNodeIDField()</code></td>
<td>Setting or obtaining the ID field indicating the start node of an edge in the network dataset.</td>
</tr>
<tr>
<td><code>setFNodeIDField(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getTNodeIDField()</code></td>
<td>Setting or obtaining the ID field indicating the end node of an edge in the network dataset.</td>
</tr>
<tr>
<td><code>setTNodeIDField(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getNodeIDField()</code></td>
<td>Setting or obtaining node ID field.</td>
</tr>
<tr>
<td><code>setNodeIDField(String value)</code></td>
<td></td>
</tr>
<tr>
<td><code>getEdgeIDField()</code></td>
<td>Setting or obtaining edge ID field.</td>
</tr>
<tr>
<td><code>setEdgeIDField(String value)</code></td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>getWeightFieldInfos()</code> or <code>setWeightFieldInfos(WeightFieldInfos)</code></td>
<td>Setting or obtaining the WeightFieldInfos object. WeightFieldInfos is the set of WeightFieldInfo. You can set the weight filed, which represents the cost in the analysis, in the WeightFieldInfo. Two weight fields are provided in the WeightFieldInfo, they are FTWeightField and the TFWeightField. The FTWeightField represents the cost from the start to the end of the edge while the TFWeightField indicates the cost from the end to the start of the edge.</td>
</tr>
<tr>
<td><code>getTolerance()</code> or <code>setTolerance(double value)</code></td>
<td>Setting or obtaining the distance tolerance from the point to the edge.</td>
</tr>
<tr>
<td><code>getBarrierNodes()</code> or <code>setBarrierNodes(int[] value)</code></td>
<td>Setting or obtaining the ID list of the BarrierNodes.</td>
</tr>
<tr>
<td><code>getBarrierEdges()</code> or <code>setBarrierEdges(int[] value)</code></td>
<td>Setting or obtaining the ID list of the BarrierEdges.</td>
</tr>
<tr>
<td><code>getDirectionField()</code> or <code>setDirectionField(String value)</code></td>
<td>Setting or obtaining the DirectionField.</td>
</tr>
</tbody>
</table>

**Return Value:**

Build a direction for the specified network dataset by this method. Returns True if successful, else returns False.
7.2.2 The Result of Building Network Dataset Flow Direction

After building the network dataset direction successfully, the network dataset has a direction. Two kinds of information will be added to the network dataset.

The node type information will be written into the network dataset. There are three types of nodes. They are the source node, sink node and general node. The following table lists the node types and the corresponding values.

<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>It is neither a source node nor a sink node.</td>
</tr>
<tr>
<td>1</td>
<td>Source node</td>
</tr>
<tr>
<td>2</td>
<td>Sink node</td>
</tr>
</tbody>
</table>

The flow direction will be written into the network node dataset. The flow direction information is recorded in the flow direction field and represents a certain direction. The numbers and meanings are shown in the following table:

<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Same with the line direction in digitalization</td>
</tr>
<tr>
<td>1</td>
<td>Opposite to the line direction in digitalization</td>
</tr>
<tr>
<td>2</td>
<td>Loop(it is also called the invalid direction)</td>
</tr>
<tr>
<td>3</td>
<td>Uninitialized direction(it is also called unconnected direction)</td>
</tr>
</tbody>
</table>

The system sets the flow direction of the network dataset according to the source and sink. The flow direction information is automatically built and written into the specified fields. The range of the values is shown in the table above.
Digitalization direction:

Figure 1: There are two points A (1, 1) and B (2, 2). The digitalization direction of line AB is northeastern. The digitalization direction of line BA is southwest. The digitalization direction is the order direction of the coordination points along the line. The digitalization direction of line AB is A→B, and the digitalization direction of line BA is B→A.

Diagram 8 the definition of digitalization direction

Figure 2: Take line AB as an example. If A is the source point, the flow direction (suppose the facility is a river) is A→B, so it is the same with the digitalization direction (A→B) of line AB. If A is the sink node, the flow direction is B→A, it is opposite to the digitalization direction (A→B).

Diagram 9 The flow direction and the digitalization direction

Loop

Figure 3: take line AB as an example. If A is the source point, the flow direction (suppose the facility is a river) is A→B; If B is the source point, the flow direction (suppose the facility is a river) is B→A;
If A and B are both source nodes, the flow direction could be A→B or B→A. This is an invalid flow direction, it is also called loop.

**Diagram 10 Loop**

**Unconnected edge:**

Figure 4: If edge AB is not connected with the source node or sink node, it is called unconnected edge.

**Diagram 11 unconnected edge**

### 7.2.3 Building Network Dataset Hierarchy

If the data used for facility analysis has the hierarchy, based on the flow direction, you can use the `buildFacilityNetworkHierarchies()` method of the NetworkBuilder class to add the hierarchy data to the network dataset.

**Syntax:**
public static boolean buildFacilityNetworkHierarchies(FacilityAnalystSetting facilityAnalystSetting,int[] sourceIDs,int[] sinkIDs,String weightName,String hierarchyField,boolean isLoopValid)

Parameters:

FacilityAnalystSetting facilityAnalystSetting: The properties of this object have been introduced when building the flow direction, the difference is the network dataset set by FacilityAnalystSetting have built the direction in advance.

sourceIDs: The source network node ID array. Source and sink are used to build the flow direction of the network dataset. The flow direction is defined by the position of the source and sink.

csinkIDs: The sink network node ID array. Source and sink are used to build the flow direction of the network dataset. The flow direction is defined by the position of the source and sink.

weightName: The specified name of the weightFieldInfo object, namely WeightFieldInfo.Name.

hierarchyField: The specified name of hierarchy field. The hierarchy information of the network dataset will be recorded in this field after the hierarchy is built.

isLoopValid: Specifies whether the loop is valid. When the loop is valid this parameter is True, otherwise false.

Return Value:

Returns True, if successful; otherwise, returns False.

After building the hierarchy, the hierarchy information of the network dataset will be recorded in the hierarchy field. The field value is integer. The higher hierarchy, the smaller value. For example, building the river hierarchy, the first level river is recorded as 0, the second level river is recorded as 1 and so on.

7.3 Environment Configuration of the Facility Network Analysis

The environment configuration of the network analysis will directly affect the outcome of the analysis. Parameters used in facility network analysis includes datasets, ID field of nodes, ID field of edges, ID field of the starting point of an edge, ID field of the end point of an edge, weight information, distance tolerance between the point and edge, barrier nodes, barrier edges, flow direction field.

The environment configuration of facility network analysis achieved through method setAnalystSetting(FacilityAnalystSetting facilityAnalystSetting) in the class FacilityAnalyst. This method setAnalystSetting(FacilityAnalystSetting facilityAnalystSetting) is correspondent to class FacilityAnalystSetting. The method of FacilityAnalystSetting have been introduced in the previous
sections. It should be noted that the attribute NetworkDataset in the class FacilityAnalystSetting must be network datasets that have flow direction or network datasets that have both flow direction and class.

### 7.4 Loading the Facility Network Analysis

After setting the environment configuration of the facility network analysis, you have to call the `Load()` method in `FacilityAnalyst` class to load the facility network data, making your configuration in effect.

### 7.5 A List of Facility Network Analysis Functions

The following are the detail instructions of all the facility network analysis functions offered by class `FacilityAnalyst`, as well as the relative concepts.

#### 7.5.1 Checking Network Loop

**Syntax:**

```java
public int[] checkLoops()
```

**Return value:**

Returns the ID array of the network loop edges.

#### 7.5.2 Finding Interlinked Loop

There are two methods to search the connected loops:

Method one: Based on the array of the specified network node IDs, search the loops that connect with these nodes.

**Syntax:**

```java
public int[].findLoopsFromNodes(int[] nodeIDs)
```

**Parameters:**

- `nodeIDs`: The array of the specified network node IDs.
Return value:

Returns the array of the corresponding network edge IDs of loops that connect with the network nodes.

Method Two: Based on the array of the specified network edge IDs, search the loops that connect with these edges.

Syntax:

public int[] findLoopsFromEdges(int[] edgeIDs)

Parameters:

edgeIDs: The array of the specified network edge IDs.

Return value:

Returns the array of the corresponding network edges of loops that connect with the specified network edges.

### 7.5.3 Finding Unconnected Edges

The methods of searching the unconnected edges:

Method One: Based on the array of the specified network node IDs, search the edges that do not connect with these nodes.

Syntax:

public int[] findUnconnectedEdgesFromNodes(int[] nodeIDs)

Parameters:

nodeIDs: The array of the specified network node IDs.

Return Value:

Returns the network edges that do not connect with the specified network nodes.

Method Two: Based on the array of the specified network edge IDs, search the edges that do not connect with these nodes.

Syntax:

public int[] findUnconnectedEdgesFromEdges(int[] edgeIDs)

Parameters:
edgeIDs: The array of the specified network edge IDs.

**Return value:**

Returns the network edges that do not connect with the specified network edges.

### 7.5.4 Finding Connected Edges

The methods of searching the connected edges:

Method One: Based on the array of the specified Network node IDs, search the edges that connect with these nodes.

**Syntax:**

```java
public int[] findConnectedEdgesFromNodes (int[] nodeIDs)
```

**Parameters:**

- nodeIDs: The array of the specified network node IDs.

**Return value:**

Returns the network edges that connect with the specified network nodes.

Method Two: Based on the specified network edge IDs, search the edges that connect with these nodes.

**Syntax:**

```java
public int[] findConnectedEdgesFromEdges (int[] edgeIDs)
```

**Parameters:**

- edgeIDs: The array of the specified network edge IDs.

**Return value:**

Returns the network edges that connect with the specified network edges.

### 7.5.5 Upstream Tracing

**Concept——Upstream:**

As shown in the illustration: Suppose water flows in the network along the specified flow direction. Q is a sink and water from Node A, B, C, L, E, F, and G all goes to Q, so these nodes are called the
upstream (nodes) of Q. Similarly, Edge AB, BC, CL, LQ, EB, FG, and GL are all upstream (edges) for Q.

For Edge LQ, Node A, B, C, L, E, F, and G are all its upstream nodes; and Edge AB, BC, CL, EB, FG, and GL are all upstream edges for Edge LQ.

Diagram 12 Upstream

Upstream Tracing Analysis Method one: Get and return all the upstream edges for the specified node.

Syntax:

public int[] traceUpFromNode(int nodeID, String weightName, boolean isLoopValid)

Parameters:

nodeID: The ID of the specified node.
weightName: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
isLoopValid: Specifies whether the loop is valid or not.

Return value:

Returns the ID array of upstream edges for the specified node.

Example: As shown in the illustration, when Q is specified as the sink node for the upstream tracing analysis, the ID array for Edge AB, BC, CL, LQ, EB, FG and GL will be returned as the result.
Upstream Tracing Analysis Method 2: Get and return all the upstream edges for the specified edge.

**Syntax:**

```java
public int[] traceUpFromEdge(int edgeID, String weightName, boolean isLoopValid)
```

**Parameters:**

- `edgeID`: The ID of the specified edge.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
- `isLoopValid`: Specifies whether the loop is valid or not.

**Return value:**

Returns the ID array of upstream edges for the specified edge.

**Example:** As shown in the illustration, when LQ is specified as the edge for the upstream tracing analysis, the ID array for Edge AB, BC, CL, EB, FG and GL will be returned as the result.

---

### 7.5.6 Downstream Tracing

**Concept — Downstream:**

As shown in the illustration: Suppose water flows in the network along the specified flow direction. Q is a source node and water from Source Q flows to Node A, B, C, L, E, F, and G. so these nodes are called the downstream (nodes) of Q. Similarly, EdgeBA, CB, LC, QL, BE, GF, and LG are all downstream (edges) for Q.

For Edge QL, Node A, B, C, L, E, F, and G are all its downstream nodes; and Edge BA, CB, LC, BE, GF, and LG are all downstream edges for Edge QL.
Downstream Tracing Analysis Method 1: Get and return all the downstream edges for the specified node.

**Syntax:**

```java
public int[] traceDownFromNode(int nodeID, String weightName, boolean isLoopValid)
```

**Parameters:**

- `nodeID`: The ID of the specified node.
- `weightName`: the name of the WeightFieldInfo object, that is, `WeightFieldInfo.Name`.
- `isLoopValid`: Specifies whether the loop is valid or not.

**Return value:**

Returns the ID array of downstream edges for the specified node.

As shown in the illustration, when Q is specified as the source node for the downstream tracing analysis, the ID array for Edge BA, CB, LC, QL, BE, GF, and LG will be returned as the result.

Downstream Tracing Analysis Method 2: Get and return all the upstream edges for the specified edge.

**Syntax:**

```java
public int[] traceDownFromEdge(int edgeID, String weightName, boolean isLoopValid)
```
Parameters:

edgeID: The ID of the specified edge.

weightName: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.

isLoopValid: Specifies whether the loop is valid or not.

Return value:

Returns the ID array of downstream edges for the specified edge.

As shown in the illustration, when QL is specified as the edge for the downstream tracing analysis, the ID array for BA, CB, LC, BE, GF, and LG will be returned as the result.

7.5.7 Common Upstream Tracing

Common Upstream Tracing Analysis Method 1: Get the common upstream edges for the nodes in the specified ID array.

Syntax:

public int[] findCommonAncestorsFromNodes(int[] nodeIDs, String weightName, boolean isLoopValid)

Parameters:

nodeIDs: The ID of the specified node.

weightName: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.

isLoopValid: Specifies whether the loop is valid or not.

Return value:

Returns the ID array of upstream edges for the specified node.

As shown in the illustration, the ID array for Edge GL and FG will be returned as they are the common upstream edges for Node Q and P.
Common Upstream Tracing Analysis Method 2: Get the common upstream edges for the edges in the specified ID array.

**Syntax:**

```java
public int[] findCommonAncestorsFromEdges(int[] edgeIDs, String weightName, boolean isLoopValid)
```

**Parameters:**

- `edgeIDs`: The ID of the specified edge.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
- `isLoopValid`: Specifies whether the loop is valid or not.

**Return value:**

Returns the ID array of upstream edges for the specified edge.

As shown in the illustration, the ID array for Edge GL and FG will be returned as they are the common upstream edges for Edge LQ and MP.
7.5.8 Common Downstream Tracing

Common Downstream Tracing Analysis Method 1: Get the common downstream edges for the nodes in the specified ID array.

**Syntax:**

```
public int[] findCommonCatchementsFromNodes(int[] nodeIDs, String weightName, boolean isLoopValid)
```

**Parameters:**

- `nodeIDs`: The ID of the specified node.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
- `isLoopValid`: Specifies whether the loop is valid or not.

**Return Value:**

Returns the ID array of common upstream edges for the specified node.

As shown in the illustration, the ID array for Edge BA, CB, LC, BE, LG and GF will be returned as they are the common downstream edges for Node Q and P.

![Diagram 15 Common Downstream](image-url)
Common Downstream Tracing Analysis Method 2: Get the common downstream edges for the edges in the specified ID array.

**Syntax:**

```java
public int[] findCommonCatchmentsFromEdges(int[] edgeIDs, String weightName, boolean isLoopValid)
```

**Parameters:**
- `edgeIDs`: The ID of the specified edge.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
- `isLoopValid`: Specifies whether the loop is valid or not.

**Return Value:**
Returns the ID array of common upstream edges for the specified edge.

As shown in the illustration, the ID array for Edge BA, CB, LC, BE, LG and GF will be returned as they are the common downstream edges for Edge LQ and MP.

### 7.5.9 Upstream Path Analysis

Upstream Path Analysis Method 1: Find the shortest upstream path or the upstream path with the least edges for the node of the specified ID.

**Syntax:**

```java
public FacilityPathResult findPathUpFromNode(int nodeID, String weightName, boolean hasLeastEdgeCount)
```

**Parameters:**
- `nodeID`: The ID of the specified node.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
- `hasLeastEdgeCount`: whether number of arcs is smallest. False represents that the result is the shortest path; True represents that the path is not only the shortest, but also the arcs is the smallest.

**Return Value:**
Returns the result of upstream path analysis which is saved in class of FacilityPathResult.
Methods | Description
---|---
getNodes() | Get the ID array of the nodes that are passed by the result path.
getEdges() | Get the ID array of the edges that are passed by the result path.

As shown in the figure, we want to find the shortest upstream path for Node Q, and return the path. We can find that the upstream paths for Node Q end at Node A, E, and F, and FGLQ is the shortest upstream path.

![Diagram 16 Upstream Path](image)

Upstream Path Analysis Method 2: Find the shortest upstream path or the upstream path with the least edges for the edge of the specified ID.

**Syntax:**

```java
public FacilityPathResult FindPathUpFromEdge(int edgeID, String weightName, boolean hasLeastEdgeCount)
```

**Parameters:**

- `edgeID`: The ID of the specified edge.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
hasLeastEdgeCount: whether number of arcs is smallest. False represents that the result is the shortest path; True represents that the path is not only the shortest, but also the arcs is the smallest.

**Return Value:**

Returns the result of upstream path analysis which is saved in the class of FacilityPathResult.

As shown in the illustration, we want to find the shortest upstream path for Edge LQ, and return the path.

We can find that the upstream paths for Edge LQ end at Node A, E, and F, and FGL is the shortest upstream path.

### 7.5.10 Downstream Path Analysis

Downstream Path Analysis Method 1: Find the shortest downstream path or the downstream path with the least edges for the node of the specified ID.

**Syntax:**

```java
public FacilityPathResult findPathDownFromNode(int nodeID, String weightName, boolean hasLeastEdgeCount)
```

**Parameters:**

- `nodeID`: The ID of the specified node.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
- `hasLeastEdgeCount`: whether number of arcs is smallest. False represents that the result is the shortest path; True represents that the path is not only the shortest, but also the arcs is the smallest.

**Return Value:**

Returns the result of the downstream path analysis which is saved in the class of FacilityPathResult.

As shown in the illustration, we want to find the shortest downstream path for Node Q, and return the path.

We can find that the downstream paths for Node Q end at Node A, E, and F, and QLGF is the shortest downstream path.
Downstream Path Analysis Method 2: Find the shortest downstream path or the downstream path with the least edges for the edge of the specified ID.

Syntax:

```java
public FacilityPathResult findPathDownFromEdge(int edgeID, String weightName, boolean hasLeastEdgeCount)
```

Parameters:

- `edgeID`: The ID of the specified edge.
- `weightName`: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
- `hasLeastEdgeCount`: whether number of arcs is smallest. False represents that the result is the shortest path; True represents that the path is not only the shortest, but also the arcs is the smallest.

Return Value

Returns the result of downstream path analysis which is saved in the class of FacilityPathResult.

As shown in the illustration, we want to find the shortest downstream path for Edge QL, and return the path.

We can find that the downstream paths for Edge QL end at Node A, E, and F, and LGF is the shortest downstream path.
7.5.11 Facility Network Path Analysis

Facility Analysis Method 1: finds the path which is the shortest or has the least edges between the specified from-node and to-node.

Syntax:

public FacilityPathResult findPathFromNodes(int startNodeID, int endNodeID, String weightName, boolean hasLeastEdgeCount)

Parameters:

startNodeID: From-node ID.
endNodeID: To-node ID.
weightName: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
hasLeastEdgeCount: whether number of arcs is smallest. False represents that the result is the shortest path; True represents that the path is not only the shortest, but also the arcs is the smallest.

Return Value:

Returns the result of facility network path analysis which is saved in the class of FacilityPathResult.

Facility Analysis Method 2: finds the path which is the shortest or has the least edges between the specified from-edge and to-edge.

Syntax:

public FacilityPathResult findPathFromEdges(int startEdgeID, int endEdgeID, String weightName, boolean hasLeastEdgeCount)

Parameters:

startEdgeID: From-edge ID.
endEdgeID: To-edge ID.
weightName: the name of the WeightFieldInfo object, that is, WeightFieldInfo.Name.
hasLeastEdgeCount: whether number of arcs is smallest. False represents that the result is the shortest path; True represents that the path is not only the shortest, but also the arcs is the smallest.

Return Value:

Returns the result of facility network path analysis which is saved in the class of FacilityPathResult.