TIBCO® Spotfire®
Network Analytics 1.1

User's Manual

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TIBCO Spotfire is covered by U.S. Patent No. 6,014,661 and U.S. Patent No. 7, 216,116. Other patent(s) pending.

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Contents

1   Introduction

Welcome to TIBCO® Spotfire® Network Analytics!

Network Analytics is a tool that is integrated into TIBCO® Spotfire® and is useful when you need to get an overview of, and analyze, the existing relations in your data.

Note: This user's manual contains information about the functionality in TIBCO® Spotfire® Network Analytics. For information about functionality within the main Spotfire product, please consult the TIBCO® Spotfire® User's Manual.
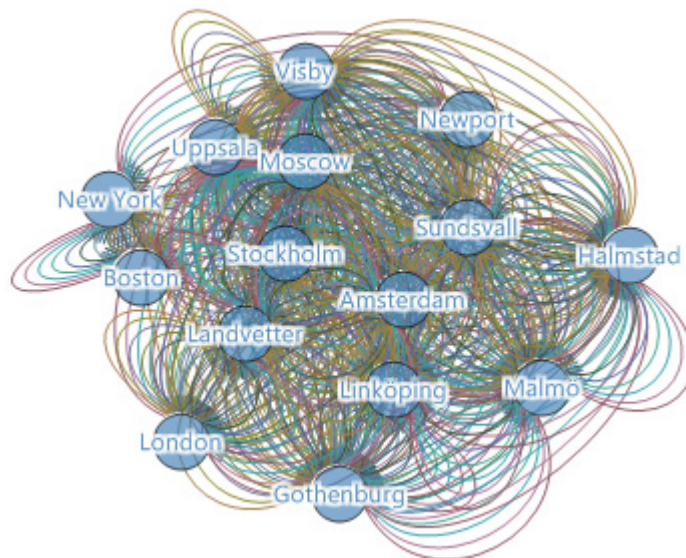
2 What is a Network Graph?

Network graphs are useful when you need to see relations between items, or groups of items, in your data. A network graph consists of nodes (sometimes called vertices) and edges. A node is similar to what is called a marker in a scatter plot, and each node in a network graph represents a row in a data table (in some cases a node may represent a group of rows). An edge is a collection of relations between two nodes (the start and end point of the edge) and is displayed as lines between the nodes. Two nodes connected by an edge is called a node pair.

Example of a network graph with five nodes and six edges:
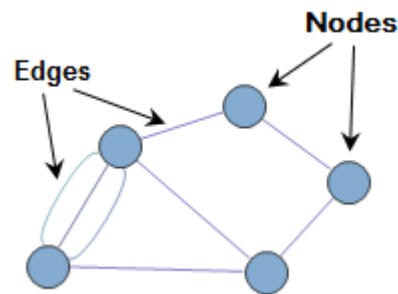

A network graph can display any kind of relation. In the example below each node represents a city, and each edge represents persons travelling between the cities:

By adjusting the network graph settings and filtering out information, you can more easily look at the aspects of the data that you are interested in. You can for example color and size nodes by a column

in your node table and thus add another dimension to the network graph. The graph below is an example of this:
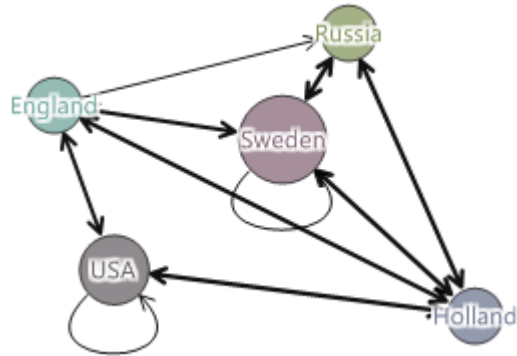
The nodes have been grouped together to represent countries instead of cities. Each edge is displayed as one single line instead of one line for each person. But the width of the line still gives an indication of the number of travels between the countries, and the size of the nodes indicates the number of cities located in each country.

You can also add background images, such as maps, to your network graph, for example to add a context to the data in the graph.

3 How to Use the Network Graph

3.1 Setting up a Network Graph

Network graphs are based on two data tables, one edge data table and one node data table. You can use the file formats TXT, CSV and Microsoft Excel (XLS, XLSX) for your data tables. To learn more about how to open files and add data tables in TIBCO Spotfire see TIBCO® Spotfire® - User's Manual.

To create a new network visualization it is necessary to provide an edge data table. It is optional to add a node data table since the application can generate a node table from your edge table as soon as you have made the necessary settings for the edges. The edge table must contain at least two columns, but usually more than two columns are needed for the network graph to give any useful insight into the data. The table should also contain a meaningful relation between the columns. For example, persons travelling to or from cities or, friendship relationships.

The example below shows a simple data table that can be used as an edge data table:

Name	Means of transport	From	To
Mr A.	by bus	Boston	New York
Mr A.	by train	New York	Boston
Mr A.	by bus	Boston	New York
Mr A.	by airplane	New York	Amsterdam
Mr A.	by airplane	Amsterdam	Boston
Ms B.	by airplane	London	Amsterdam
Ms B.	by airplane	Amsterdam	Moscow
Ms B.	by airplane	Moscow	Stockholm
Ms B.	by airplane	Stockholm	London
Mr C.	by car	Stockholm	Gothenburg
Mr C.	by car	Gothenburg	Stockholm

The table contains data about persons travelling between cities as well as the means of transport they used. You can use the cities in the columns From and To as start and end point respectively for the edges in the network graph. That is, the cities should be used as nodes in the

network graph. Hence, if you let Spotfire generate a node table with these edge settings, it will look like the table below:

Node ID
Boston
New York
Amsterdam
Moscow
Stockholm
Gothenburg
London

Each city appearing in the columns From or To in the edge data table becomes a unique row in the Node ID column of the generated node data table.

Although you do not have to provide a node data table, more features will be available if you do. For example, if you provide a node table with locations along with longitude and latitude, as in the example below, you can add a map to the background. To read more about how to add background images, see "Background Images" on page 14.

City	Longitude	Latitude	Country
Boston	-71.06	42.36	USA
Gothenburg	11.93	57.70	Sweden
Moscow	37.67	55.77	Russia
Stockholm	18.07	59.32	Sweden
London	-0.13	51.50	England
Amsterdam	4.90	52.37	Holland
New York	-74.00	40.18	USA

This table has an additional column named Country, which can be used for grouping nodes. That is, instead of representing a city, each node can represent the country where the city is located. See "Node Groups" on page 11 to learn more about how to apply node grouping.

When creating a network graph you should always start by adjusting the edge settings before you either generate a node table, or set up the nodes based on a data table of your own.

▶ **To set up a new network graph:**

1   Click on the New Network Graph button on the toolbar, ⬚.

Comment: You can also select **Insert > New Visualization > Network Graph** from the menu.

Response: A first attempt to set up a suitable network graph is made by the application.

2   Adjust the Network Graph to display the nodes and edges of your choice by right-clicking in the visualization to display the pop-up menu, select **Properties**, and select the **Data** page.

3   In the **Data table** drop-down list in the **Edges** part of the dialog, select the data table that you want to use for the edges in the network graph.

4   In the drop-down lists **From** and **To**, select the two columns in the edge data table that you want to use as start and end points for the edges.

5   Click the **Refresh** button to generate a new node table based on the settings for the edge data table if you do not want to provide a node data table of your own. If you are going to use your own node data table, continue to the second part of the dialog to make the settings for the nodes.

       Note: Every time either one of the drop-down lists **From** or **To** is changed you must click the **Refresh** button if you wish to use an automatically created node data table.

6   In the **Data table** drop-down list in the **Nodes** part of the dialog, select the data table that you want to use for the nodes in the network graph.

7   In the **Node column** drop-down list, select a column to represent the nodes in the graph.

8   If you want to apply node grouping, choose a column to group by from the **Group column** drop-down list.

9   If your node table has X and Y coordinates, select the corresponding columns from the **X-axis by** and **Y-axis by** dropdown lists.

3.2   Markings

Marking nodes and edges in the network graph works in the same way as in other visualizations in TIBCO Spotfire. That is, click on a node or an edge to mark it. Alternatively, drag a rectangle around a group of items to mark many items. The marked items will then have another color until you unmark them. If you mark items in another visualization that is based on the edge data table, then the edges in the network graph corresponding to the marked items will also be marked. Marking items in another visualization that is based on the node data table works in the same way for the nodes.

You can limit the data shown in a visualization by markings. This is a feature for advanced users and should be used with care. Since the network graph is based on two data tables there are more possible combinations to limit the data by than in other visualizations.

▶   **To limit the data to show in a visualization:**

1   Right-click in the network graph and select **Properties** from the pop-up menu, and click to display the **Markings** page.

2   Under **Limit data to show in visualization**, select the marking that you want to limit the data by from the list of markings.

Note: If you select to limit the data by both the marking in the edge table and the marking in the node table, only items that are marked in both the edge table **and** the node table will be visible.

Each network graph in an analysis will also be available (by the title of the network graph) as a marking in the list of markings on the Data page of the properties dialogs for every visualization, see below.
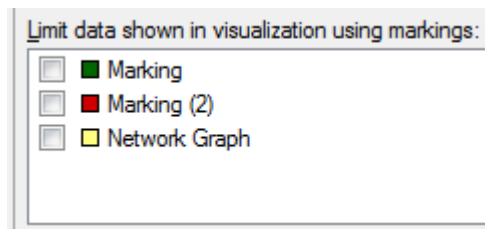

By selecting the network graph check box you can use the graph in the same way as a marking to limit data. This is useful when you want to limit data in other visualizations to data shown in a specific network graph. If your analysis includes more than one network visualization, it will also be possible to limit data in one network graph by another network graph. This is not recommended since it means that if you choose to limit the data in Network Graph 1 by Network Graph 2. Only the data that is currently visible in Network Graph 2 will be visible in Network Graph 1.

3.3   Color

Applying colors to the nodes and edges can give an extra dimension to the data and help clarifying which nodes and edges that are associated in some way.

In the example below, each node represents a city, but is colored by the country that the city is located in. Each edge represents a person

travelling between two cities and the edges are also colored by person.
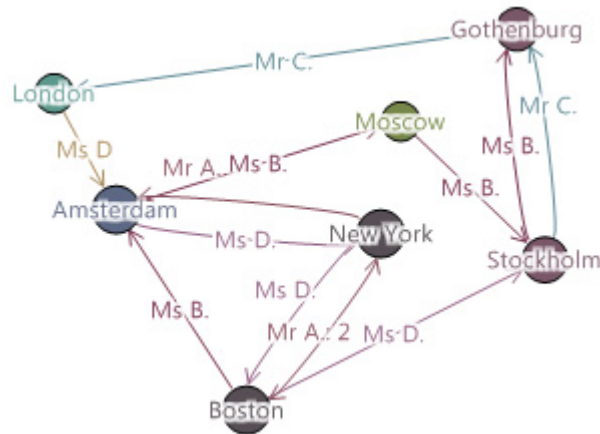
▶   **To apply color to nodes:**

1   Right-click in the network graph and select **Properties** from the pop-up menu. Click to display the **Nodes** page.

2   Under **Node color**, select a column to color the nodes by in the **By column** drop-down list.

Response: The nodes will be colored with one color for each category in the selected column.

▶   **To apply color to edges:**

1   Right-click in the network graph and select **Properties** from the pop-up menu. Click to display the **Edges** page.

2   Select a column to color the edges by in the **Edge category by** drop-down list.

Response: The edges will be colored with one color for each category in the selected column.

Comment: For more information about edge categories, see "Edge Categories and Tooltips" on page 12.

3.4   Node Groups

It can be useful to group nodes that belong together to see patterns in the data more clearly, for example if the network graph contains a

large amount of nodes. The example below shows how node grouping can be used:
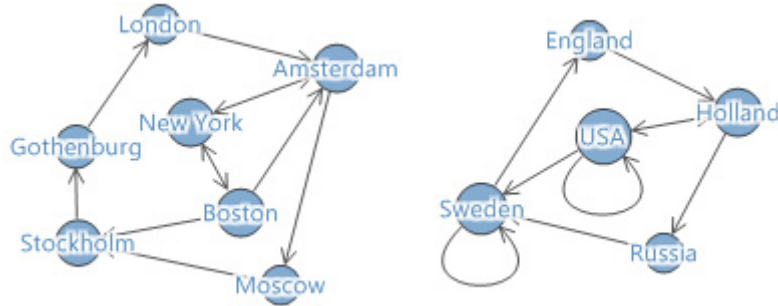
In the graph on the left each node represents a city. In the graph on the right, the nodes have been grouped and each node now represents a country.

To use node groups you must provide a node data table that includes some column that you can group by.
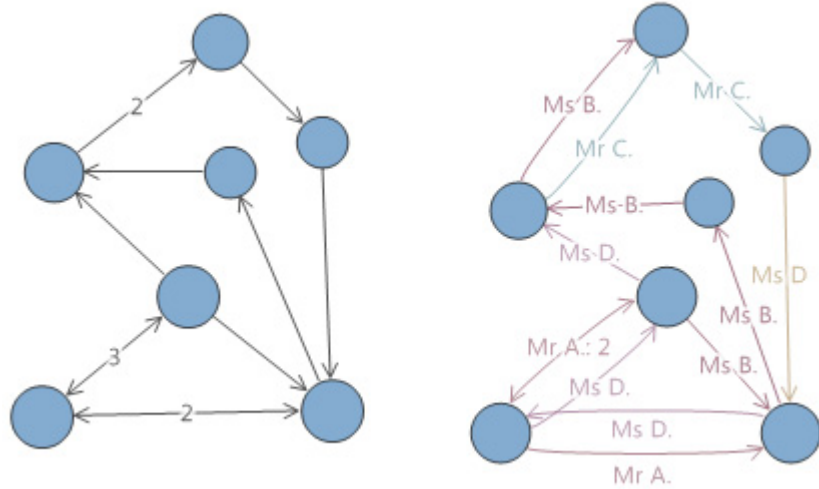
▸   **To apply node grouping:**

1   Right-click in the network graph and select **Properties** from the pop-up menu. Click to display the **Data** page.

2   Select a column to group the nodes by from the **Group column** drop-down list in the **Nodes** part of the dialog.

Response: The nodes are grouped so that a single node is shown for each category in the selected column.

3.5   Edge Categories and Tooltips

Edge categories can be used to decide how the edges should be displayed in the visualization. If you do not select an edge category column, only one single edge line will appear in each node pair. If you choose an edge category, every node pair will get one edge line for each of the different values in the chosen category column. The

example below, displaying persons travelling between cities, shows how selecting an edge category affects a network graph:

In the leftmost graph, no edge category was chosen. The edge labels indicate that some of the edges represent more than one value. That is, more than one travel has occurred between the cities. In the rightmost graph, the edge category "Name" was chosen, and each edge line now represents a unique person.

Note: The lines represent persons. That means that if a person has travelled between two cities more than once, only one line will appear between the two cities.

▶ **To select edge category:**

1 Right-click in the network graph and select **Properties** from the pop-up menu. Click to display the **Edges** page.

2 Select a column from the **Edge Category by** dropdown list.

   Response: In every node pair, one edge will be displayed for each value in the chosen column.

   Selecting an edge category also affects the edge tooltips. If you select an edge category column, settings for the tooltips will also be available. You can decide whether the information in the tooltip should be displayed by node pair, as in graph number 1 in the example below, or by category, as in graph number 2. Graph number

3 shows a tooltip as it will appear if no edge category column is chosen.
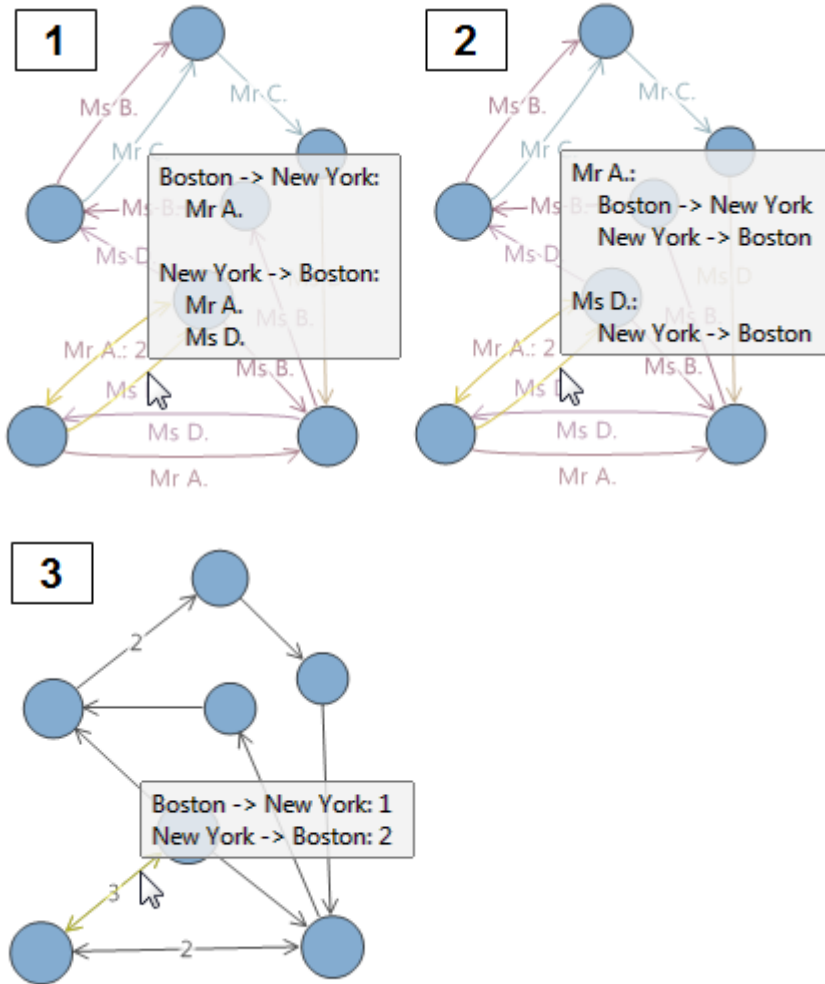
3.6   Background Images

Background images can add meaning to your analysis by providing a context for the data. For example, you can use a map as a background image for a network graph showing relations between cities or countries. If you want to add a map image to the background and match it to locations, you must use a node data table with at least three columns: a Node ID column, an X coordinate column and a Y coordinate column. The node ID column could for example contain cities while the X and Y coordinate columns contain longitude and latitude respectively for the locations.

The example below shows a network graph where the nodes represent cities and the background image is a map.

See "Setting up a Network Graph" on page 7 if you are unsure how to set up a node data table with X and Y coordinates.

▶ **To add an image background:**

1   Right-click in the network graph and select **Properties** from the pop-up menu. Click to display the **Backgrounds** page, click the **Add** button and choose **Image**.

Response: New options will appear in the lower part of the dialog.

2   Type a path and a file name, or click on **Browse...** to locate the interesting background image.

Comment: You can use the following file formats for your background image: BMP, EXIF, GIF, JPG, PNG and TIF.

3   Adjust the **Image position** by typing the coordinates for the image in the spaces provided.

4   If desired, make any other changes in the Properties dialog and click **Close** when finished.

3.7   Layouts

The arrangement of the nodes in the network graph can add meaning to the data. There are four different layouts to choose from in Network Analytics: Circle layout, Force-Directed layout, From-To layout, and Random layout.

▶ **To apply a layout to the network graph:**

1   Right-click in the network graph and select **Layouts** from the pop-up menu.

2   Select the layout you want to apply.

Response: The nodes and edges in the visualization are rearranged according to the selected layout type.

3.7.1   Circle Layout

If you apply circle layout to the network graph, the nodes will be spread out to form a circle in the visualization, see below.
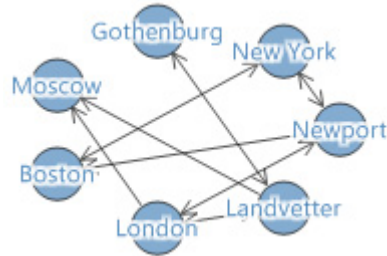
3.7.2   Force-Directed Layout

The Force-Directed layout strives for bringing nodes that are directly connected by an edge close, and separating all non-directly connected nodes. Thus the structure of the network is generally more clearly visualized. Below is an example of Force-Directed layout on a graph where the nodes represent cities and the edges represent a person's travels between the cities.
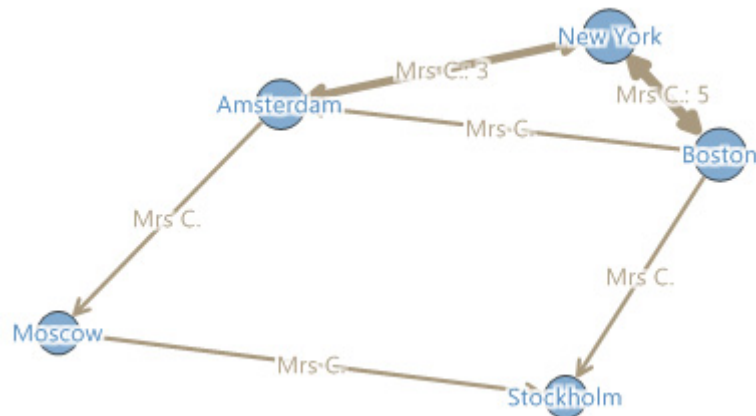
The example shows that the cities the person has travelled between many times are placed closer together in the visualization than the cities she has travelled between fewer times.

The layout algorithm works by arranging the nodes using a physical analogy. Imaginary forces attract nodes that are directly connected by an edge, and repel all pairs of nodes from each other. The attractive forces increase with increased distance and the repulsive forces decrease with increased distance. The node positions change gradually according to the net force on each node until ideally equilibrium is reached. If the layouting is cancelled by the user, the positions reached at that point will be used.

The Force-Directed layout in Network Analytics uses a modified version of the Fruchterman-Reingold algorithm (Fruchterman and Reingold, 1991).

3.7.3 From-To Layout

The From-To layout arranges the nodes in two groups, one group containing the nodes that are the start point of the edge, and one group containing nodes that are the end points of the edge.

This type of layout is useful when the two edge columns have different kinds of values. In the example below the nodes represent persons travelling and the means of transport they used.
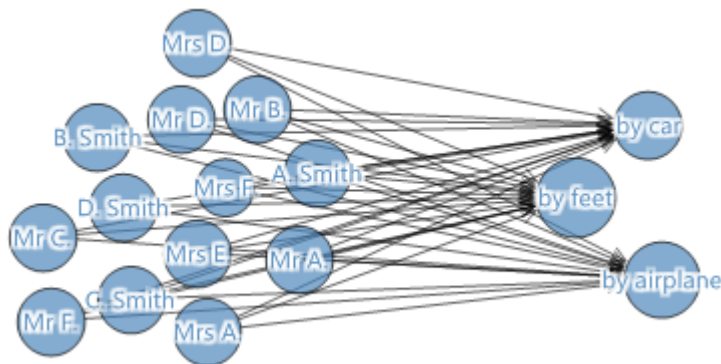
3.7.4 Random Layout

The Random Layout places the nodes on randomly selected positions on the area inside an ellipse, see below.
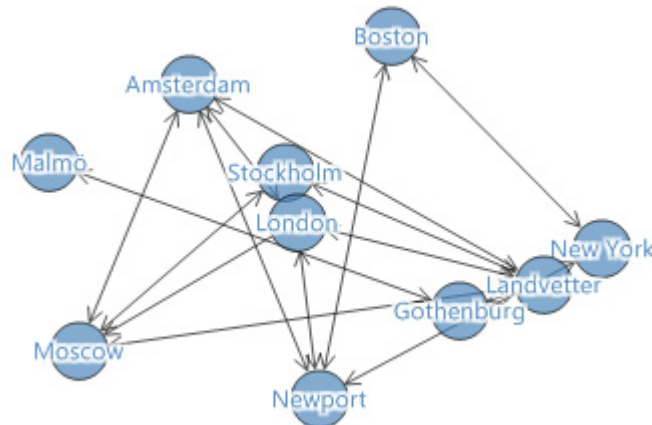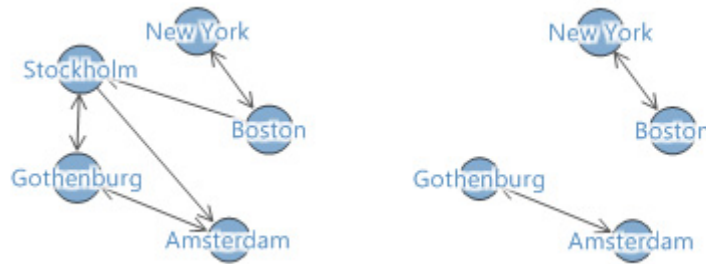
3.8   Calculations

You can perform four different kinds of calculations on a network graph in Network Analytics: **Betweenness**, **Connected Components**, **Degree**, and **Distance to/from Marked**.

Degree calculates the number of visible edges connected to each of the nodes in the graph.

Distance calculates the distance to the other nodes in the graph by counting the nodes between them.

Betweenness calculates a value indicating how important a node is for the flow between all other pairs of nodes, or groups of nodes. More specifically, for each pair of connected nodes (or groups of nodes) an imaginary unit flow is divided equally between all shortest paths between the nodes, counting parallel edges as different paths and taking directionality into account. The betweenness of a node is then defined as the total flow through that node.

Connected Components calculates the number of isolated groups of connected nodes in a network graph. The leftmost network graph below consists of one component, while the rightmost network graph consists of two components, since the node representing Stockholm was filtered out.

If you perform the calculation **Connected Components** on the rightmost graph, the two components will be listed in the filter panel, making it possible to filter out either of the two entire components separately.

To learn more about the different calculations, see for example chapter 3 in Network Analysis (Brandes and Erlenbach, 2005).

▶   **To perform a calculation on a network graph:**
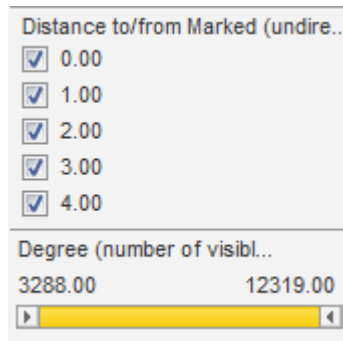
1   Right-click in the network graph and select **Calculations** from the pop-up menu.

2   Select the calculation you want to perform.

When a calculation is performed on a network graph, a new column containing the calculated values is created in the node data table. The example below shows a node table after the calculations Distance To/
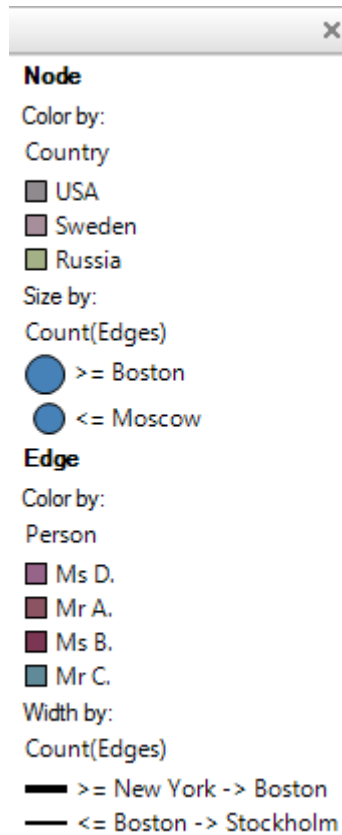
From Marked and Degree was performed. The marked row contains the node that was marked when Distance was calculated.

Node ID	Distance to/from...	Degree (number...
Boston	4.00	5515.00
New York	4.00	3288.00
Newport	3.00	8959.00
Amsterdam	2.00	12319.00
Moscow	2.00	7993.00
Stockholm	2.00	6035.00
Landvetter	1.00	10676.00
Gothenburg	0.00	11376.00
Halmstad	1.00	10021.00
Uppsala	1.00	9643.00
Malmö	1.00	9808.00
Visby	1.00	9890.00
Linköping	1.00	9887.00
Sundsvall	1.00	9818.00
London	2.00	5842.00

When a calculation is performed, a new filter is also created in the filter panel. The filter works like any other filter and lets you filter your data according to the calculations you have performed. The two filters created from the calculations above can be seen in the example below.

Distance to/from Marked (undire...
- ☑ 0.00
- ☑ 1.00
- ☑ 2.00
- ☑ 3.00
- ☑ 4.00

Degree (number of visibl...

3288.00   12319.00

3.9 Legend

The legend helps you identify what the graphics in the visualization represent. It can show what parameter in the visualization is represented by which color for the nodes and edges separately. It can also display which parameter the nodes are sized by, which parameter decides the width of the edges, as well as settings for the background renderer.

There are no column selectors in the network graph legend. To change what is shown in the legend, open the **Legend** page of the properties dialog.
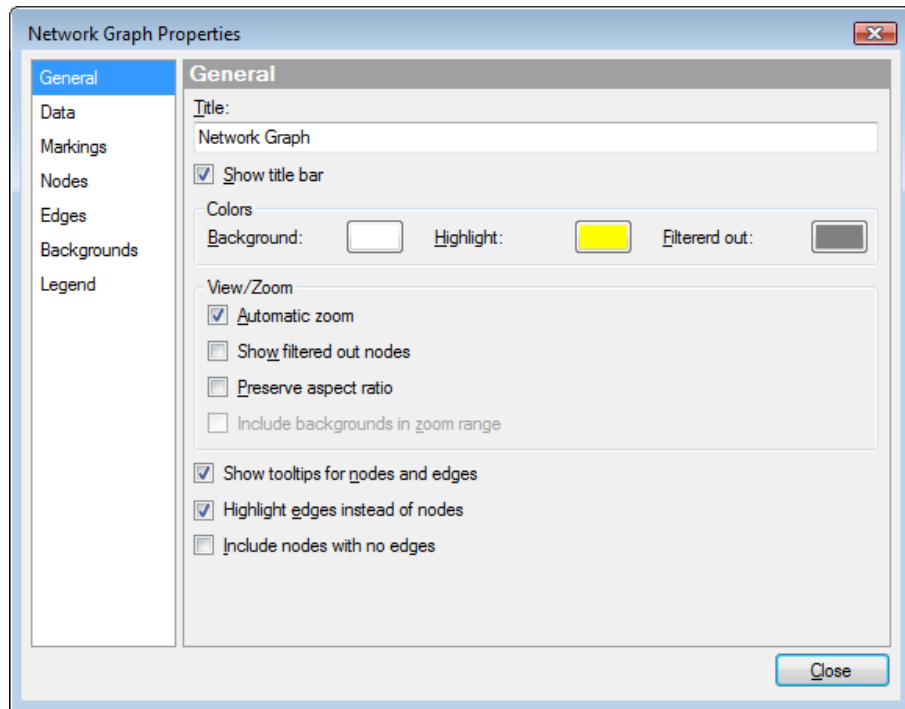
4 Network Graph Properties

The Network Graph Properties dialog consists of several pages:

- General

- Data

- Markings

- Nodes

- Edges

- Backgrounds

- Legend

▶ **To reach the Network Graph Properties dialog:**

1 Right-click on the network graph visualization.
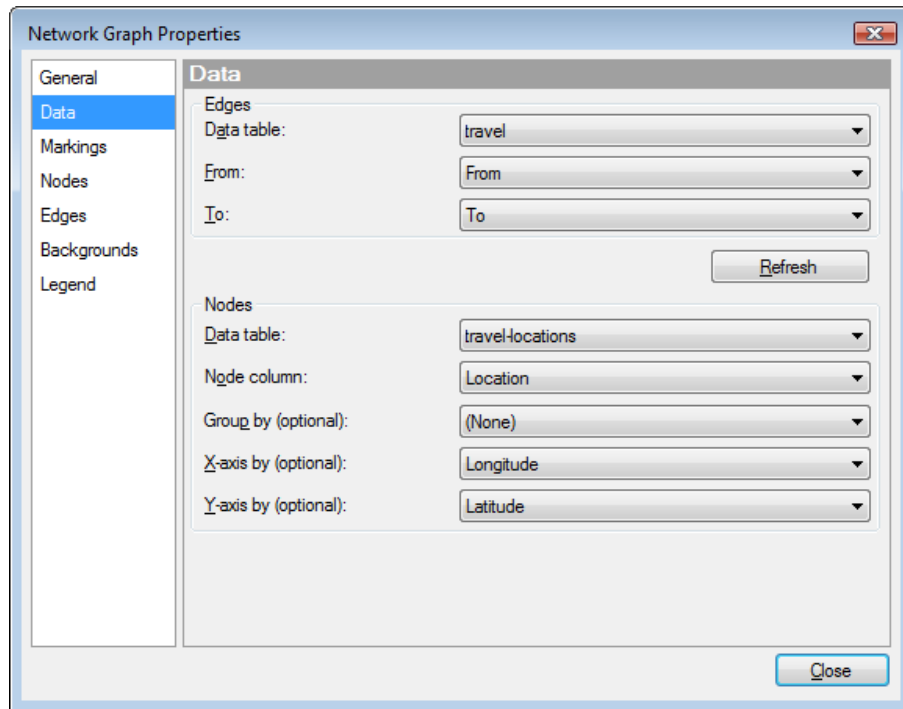
2 Select **Properties** from the pop-up menu.

4.1 Network Graph Properties - General

Option	Description
Title	The title of the visualization.
Show title bar	Specifies whether or not to show the visualization title.
Colors	Determines which color to use for the background as well as the highlighted and filtered out nodes and edges in the visualization.
View/Zoom	
Automatic zoom	Use this option if you want the visualization to automatically zoom in on the remaining nodes and edges when you use filters.
Show filtered out nodes	Use this option to keep filtered out nodes in the visualization visible. The nodes will have a different color.
Preserve aspect ratio	Determines whether the aspect ratio of the visible nodes should be kept when you filter and zoom.
Include backgrounds in zoom range	If you select this check box you can zoom out further than the outer visible nodes in the graph to see the entire background. **Note:** Only applicable when automatic zoom is deselected.
Show tooltips for nodes and edges	Determines whether to show tooltips with details about an item when you mouseover it.

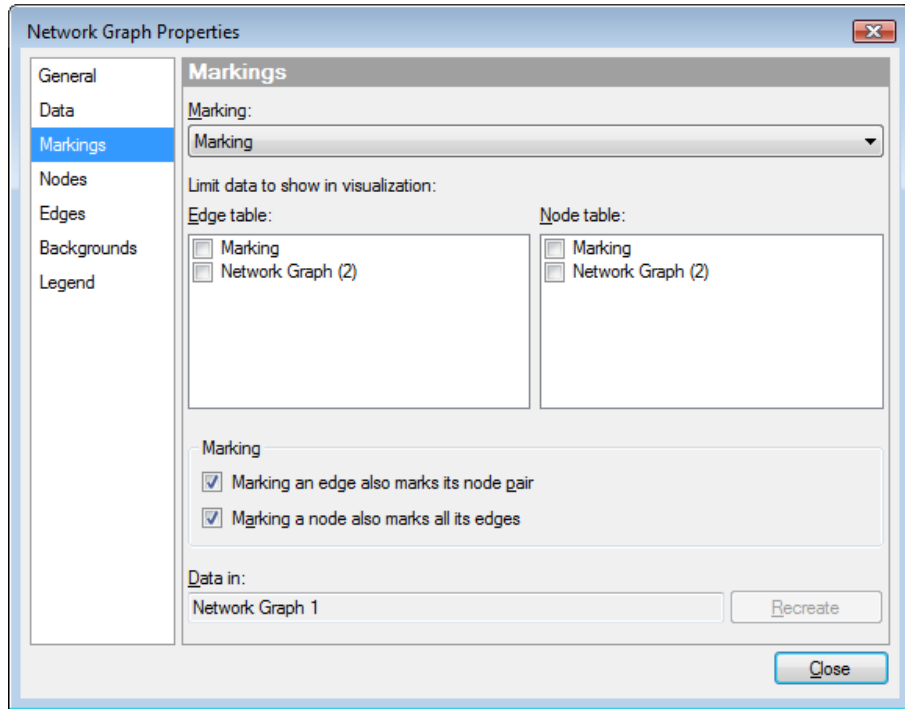| **Highlight edges instead of nodes**	Highlights the edges connected to a node instead of the actual node that you mouseover. **Note:** Both edges going to and from a node are highlighted.
Include nodes with no edges	Use this option to see nodes that are not connected to any edges in the network graph.

4.2   Network Graph Properties - Data

Option	Description
Edges	
Data table	Specifies the data table from which the edges in the visualization collects its values.
From **To**	Specifies which two columns in the edge data table that you want to see relations between. The values in the specified columns will become nodes in the node data table.
Refresh	Click this button to generate a new node table after you have changed the settings for the edges or when you set up a network graph for the first time. **Note:** In some cases, depending on which changes you make to the edges settings, the table is redrawn automatically in the visualization. You should still click the **Refresh** button since it is possible that the old node table is not valid for the new settings.
Nodes	
Data table	Specifies the data table from which the nodes in the visualization collects its values. **Note:** It is optional to provide a node data table. A node data table is created automatically each time the **Refresh** button is clicked.

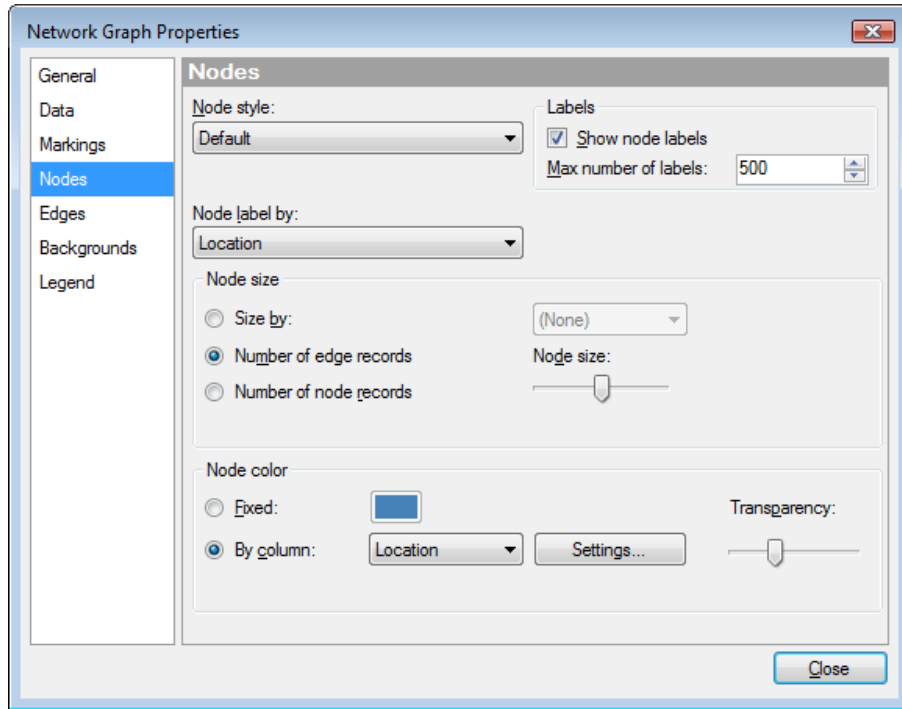|	
Node column	Specifies which column in the node data table that the nodes collects their values from.
Group column (optional)	Specifies a column in the node data table that you want the nodes to be grouped by. **Note:** This option is only available if you have created a grouping of your own or if you use a node data table of your own. See "Node Groups" on page 11to learn more.
X-axis by (optional) **Y-axis by (optional)**	Specifies which two columns in the node data table, if any, that contain X and Y coordinates. By specifying these columns the nodes will have fixed positions in the visualization. **Note:** Only applicable if you provide a node data table of your own and if the table has two columns with X and Y coordinates respectively.

4.3 Network Graph Properties - Markings

Option	Description
Marking	Specifies the marking (that is, the color and relationships to other marked items) that shall be used to mark items in this visualization.
	Note: You can create new markings in the **Document properties** dialog which can be reached from the **Edit** menu.
Limit data to show in visualization	Lists the available markings that can be used to limit what is shown in this network graph. **This is a feature for advanced users** that allows you to use the current visualization similarly to the Details-on-Demand, which displays data that has been marked in some other visualizations only. This means that if nothing is marked, the current visualization will not contain any data at all.
	If more than one marking is selected, then the resulting details visualization shows the union of the markings.
	Note: Each network graph is also a marking representing all visible items in that graph.
	Note: If you use the same marking to limit a visualization as specified above you may end up with a situation where the visualization limits itself upon marking.

| Edge table	Lists the markings to be used for limiting edges in the visualization.
	Note: If you have selected a marking to limit the edges by, you must mark items in a visualization based on the edge data table to see any effect.
Node table	Lists the markings to be used for limiting nodes in the visualization.
	Note: If you have selected a marking to limit the nodes by, you must mark items in a visualization based on the node data table to see any effect.
Marking	
Marking an edge also marks its node pair	Determines whether marking an edge should also mark the two nodes that the edge is a connection between.
Marking a node also marks all its edges	Determines whether marking a node should also mark the edges that are connected to the node.
Data in	Shows which marking this network graph concerns.
	Note: If you delete a marking that represents the visible nodes of a network graph you have to click on the **Recreate** button to get a new marking to represent that graph. Otherwise it will not be possible to use that graph to limit data in other visualizations. See "Markings" on page 9 to learn more.

4.4 Network Graph Properties - Nodes

Option	Description
Node style	Determines which drawing method that should be used for the nodes.
Labels	
Show node labels	Specifies whether to show labels on the nodes in the visualization.
Max number of labels	Specifies the maximum number of labels to be shown. **Note:** If the number is smaller than the available number of nodes in the visualization, no labels will be visible.
Node label by	Specifies the column (in the node data table) whose values should be presented as labels in the visualization.
Node size	
Size by	Use this option to size the nodes according to the sum of the values for a specific column. You select which column to size by in the drop-down list to the right. **Note:** Only applicable if you have provided a node data table of your own.

|	
Number of edge records	Use this option if you want the number of edge records connected to the nodes in your data to decide node size.
Number of node records	Use this option if you want the number of node records that one node consists of to decide node size. **Note:** Only meaningful if there are node groupings in the graph, otherwise one node is one node record.
Node size	Increases or decreases the overall size of all nodes.
Node color	
Fixed	Use this option to apply a single, fixed color to all nodes. Use the palette to change to a different color.
By column	Use this option to apply a color scheme with different colors for all values in a (categorical) column of your node data table, or a continuous color gradient for numeric columns. **Note:** If you use an automatically generated node table you can only color by Node ID.
Settings	Opens a dialog where you can define if you want the coloring to be categorical or continuous, and select which colors should represent minimum and maximum values respectively on the continuous scale. **Note:** If the column is categorical you cannot change it to continuous.
Transparency	Determines the transparency of the nodes. That is, the degree to which you can see through the nodes. The transparency is strongly connected to the color.

4.5 Network Graph Properties - Edges
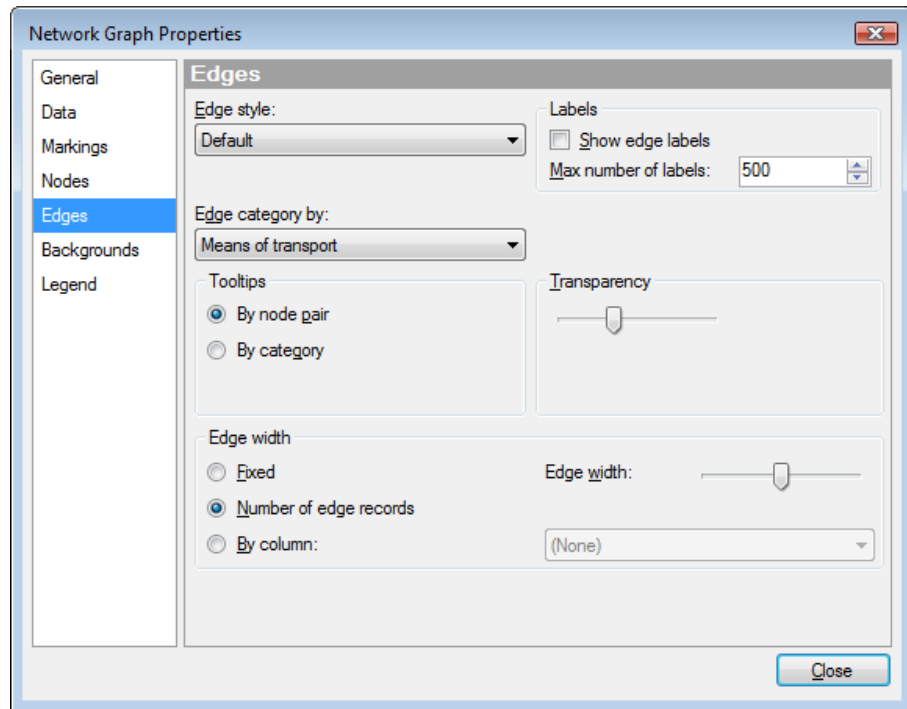
Option	Description
Edge style	Determines which drawing method that should be used for the edges.
Labels	
Show edge labels	Specifies whether to show labels on the edges in the visualization. **Note:** You must also select an **Edge category** column to display labels for the edges.
Max number of labels	Specifies the maximum number of labels to be shown. **Note:** If the number is smaller than the available number of edges in the visualization, no labels will be displayed.
Edge category by	Use this option to see one edge for each value in the category column. **Note:** If no selection is made, only one edge will be displayed for each node pair.
Tooltips	Determines how you want the tooltips to be shown in the visualization. **Note:** Only available if you have selected an edge category column.

| By node pair	Use this option if you want the tooltips to list the relations between two nodes, and for each relation, every existing category in that relation. See "Edge Categories and Tooltips" on page 12 to learn more.
By category	Use this option if you want the tooltips to list every category and all the relations for each of the categories. See "Edge Categories and Tooltips" on page 12 to learn more.
Transparency	Determines the transparency of the edges. That is, the degree to which the nodes can be seen through it. The transparency is strongly connected to the color.
Edge width	
Fixed	Use this option if you want all edges to have the same width.
Number of edge records	Use this option if you want the number of edge records to decide edge width.
By column	This option will size the edges according to the sum of the values for a specific column. You select which column to size by in the drop-down list to the right. **Note:** The column must have a numeric value.
Edge width	Increases or decreases the overall width of all edges.

4.6   Network Graph Properties - Backgrounds
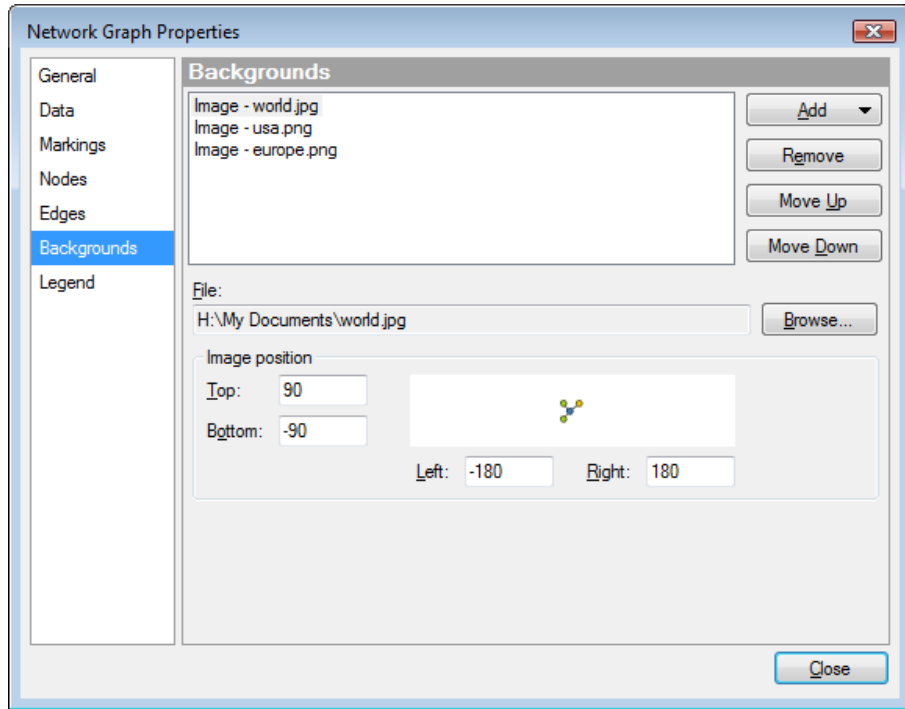
Option	Description
Add	Click this button to add an image to the list of backgrounds.
Remove	Removes the selected item from the list.
Move up	Moves the selected item up in the list.
Move down	Moves the selected item down in the list.
File	Specifies the file to use as background. Click on Browse... to locate a file. **Note:** You can use any of the following file formats: BMP, EXIF, GIF, JPG, PNG and TIF.
Browse...	Opens a dialog where you can select the file of interest.
Image position	Specifies the location of the image in the visualization.

4.7 Network Graph Properties - Legend
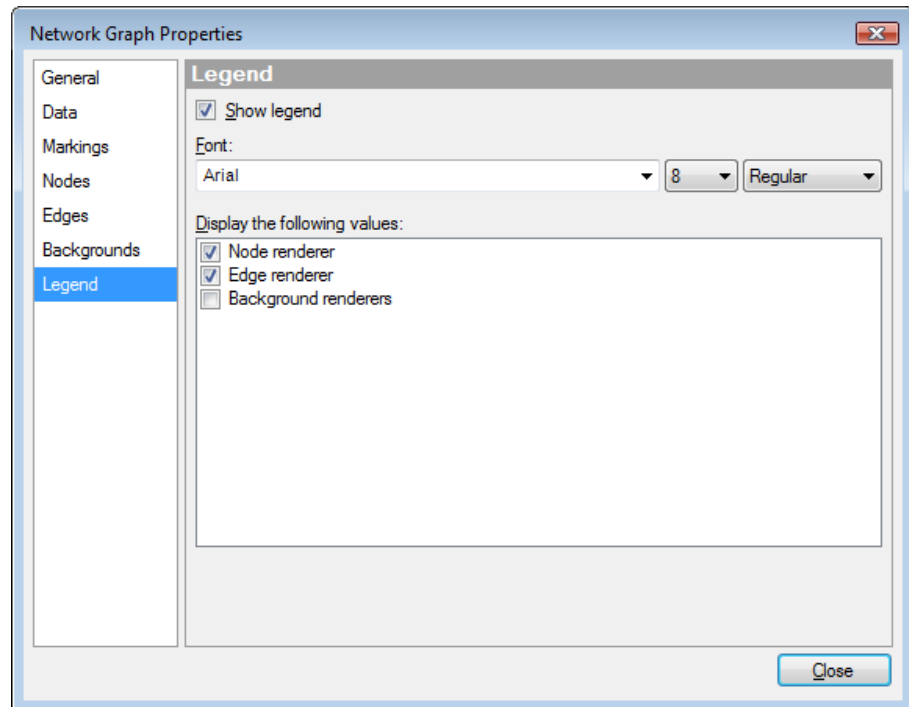
Option	Description
Show legend	Specifies whether or not the legend should be shown in the visualization.
Font	Specifies the font, size and style for the text in the legend.
Display the following values	Specifies what will be shown in the legend.

5 References

Brandes, U., and Erlebach, T. (Eds.). (2005). *Network Analysis. Methodological Foundations.* Berlin Heidelberg: Springer-Verlag.

Fruchterman, T.M.J., and Reingold, E.M. (1991). 'Graph Drawing by Force-directed Placement', *Software – Practice and Experience*, 21(11), 1129-1164.