Networks of Florentine Families — A tutorial for the analysis and visualization of networks using visone and the Padgett dataset

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Introduction

In this tutorial you will visualize and explore the network between elite Florentine families in the early 15th century. This was a time of political conflict and turmoil, which eventually led to the rise of the Medici family.

The context for this tutorial is a study by Padgett and Ansell[1], who used the descriptions of family relations in an earlier work by Kent[2] to understand their network power.

A subset of this data was subsequently used by Breiger and Pattison[3], after which their dataset was made publicly available as part of UCINET[4] as well as online through other channels. The dataset originally consists of two UCINET DL files (PADGM and PADGB):

- PADGM is an overview of marriage alliances, presented in the datafiles of this tutorial as PadgettM.csv
- PADGB is an overview of business ties, in particular recorded financial ties such as loans, credits, and joint partnerships, presented in the datafiles of this tutorial as PagdgettB.csv

Both files represent one-mode networks with undirected and unweighted ties.

The dataset also contains a node attribute file (PadgettAttrib.csv), which includes data from PADGW, which provides information on (1) each family's net wealth in 1427 (in thousands of lira) and (2) the number of priorates (seats on the civic council) held between 1282- 1344.[5] To this, longitudinal and latitudinal coordinates were also added, which refer to the (likely) palazzi of the families.

For this practical, the original files have been adapted to .csv files and some additional attribute data has been provided. All data that were part of the original dataset have been indicated by column and row headers in CAPITALS.

In this practical you will learn how to:

- Part 1
    - create networks by drawing them directly.
    - read network data.
    - work with attribute data in networks.
    - visualize networks and change node properties based on different attribute data.

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[1] Padgett, J., & Ansell, C. (1993). Robust Action and the Rise of the Medici, 1400-1434. *American Journal of Sociology, 98*(6), 1259-1319. Retrieved from http://www.jstor.org/stable/2781822

[2] Kent D. (1978). The rise of the Medici: Faction in Florence, 1426-1434. Oxford: Oxford University Press.

[3] Breiger R. and Pattison P. (1986). Cumulated social roles: The duality of persons and their algebras. Social Networks, 8, 215-256.

[4] Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). *Ucinet for Windows: Software for Social Network Analysis.* Harvard, MA: Analytic Technologies.

[5] Dataset and descriptions taken from a webpage of the Center for Computational Analysis of Social and Organizational Systems.

    - save networks as images as well as data files.
    - read network data.
- Part 2
    - import existing network datasets.
    - compare the structure of different networks.
    - understand and calculate network metrics such as network density and degree and betweenness centralities.
    - visualize networks based on the data resulting from their analysis using different layouting techniques and visual patterning.
- Part 3
    - import attribute data into existing networks.
    - visualize attribute data together with network data.
    - understand the key difference between network and attribute data.
    - bonus: layout networks in geographic space.

All of this we will do in visone. Visone (VISualization Of NEtworks, also Italian for mink) is a free to download network visualization and analysis tool, developed by Konstanz University's Centre for Algorithmics. [6]

Visone can be downloaded at http://visone.info

[6] Brandes U., Wagner D. (2004) Analysis and Visualization of Social Networks. In: Jünger M., Mutzel P. (eds) Graph Drawing Software. Mathematics and Visualization. Springer, Berlin, Heidelberg

Part 1, getting to know visone

Step 1

Make a folder in an easy to navigate to place. I suggest the desktop.

Open visone from Start. We are using version 2.17.

Visone should be available on any PC in Lipsius 126 and 127. You can also download it from visone.info or start it in your browser. Visone runs on java, so if it does not run on your machine, download the latest version of java (java.com/download).

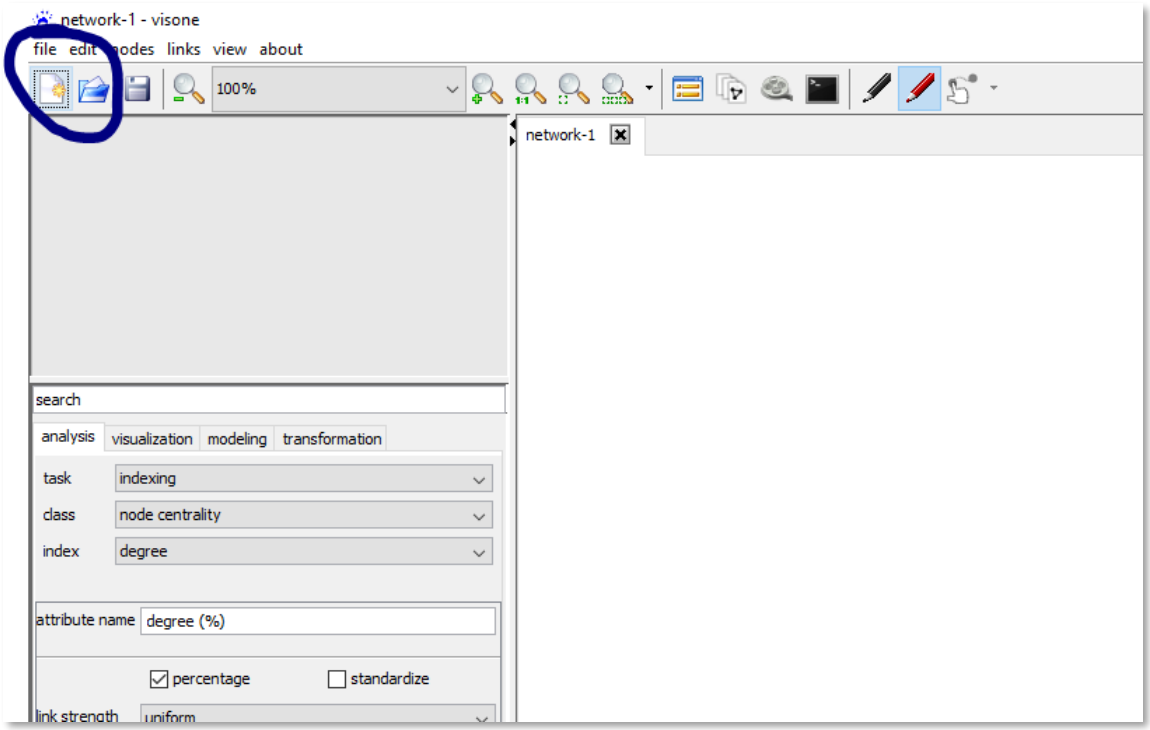
Two VERY important things to remember:

1. **Visone is freeware and although kept up to high standards may occasionally elicit bugs that will cause the program to crash or your network to become corrupted.**
2. **Visone does NOT have an undo button. Any change you make to a network is permanent, unless you go back to a previous save.**

In short, when working with visone SAVE OFTEN and make back-ups and/or copy networks before you make big changes to them (see below on how to copy networks)**!**

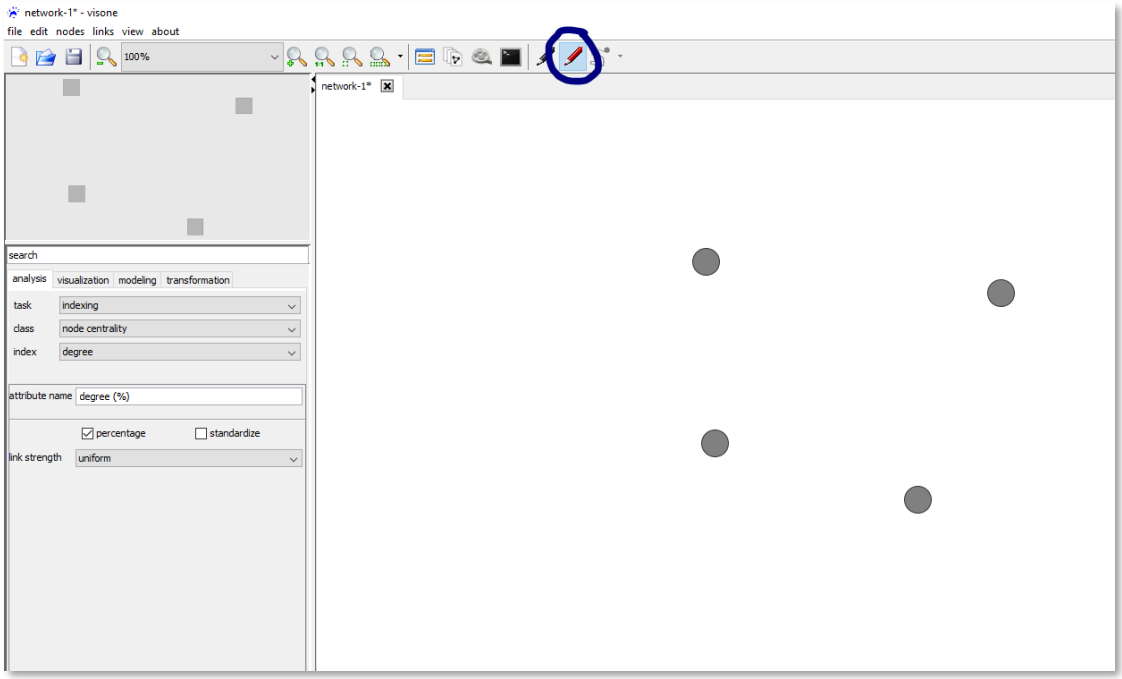
Step 2

Open a new empty network from the menu bar (for this and following steps, see the blue markings in the screen captures) alternatively you can open a new network with *file -> new*



Step 3

You can draw networks directly in visone. Make sure the Pencil menu item is selected and create some nodes by clicking on the empty network space.



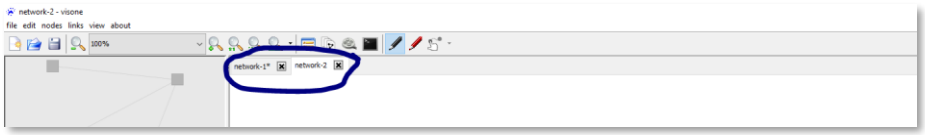
You can draw links between these nodes by clicking on an existing node and dragging a link to another node. Alternatively, you can click on an existing node and click on an empty area in the network to create a node with a link to the existing node.

<u>Draw at least 4 nodes, each connected by at least one link.</u> Don't draw too many nodes, because you will be manually entering data for them in the coming steps.

Step 4

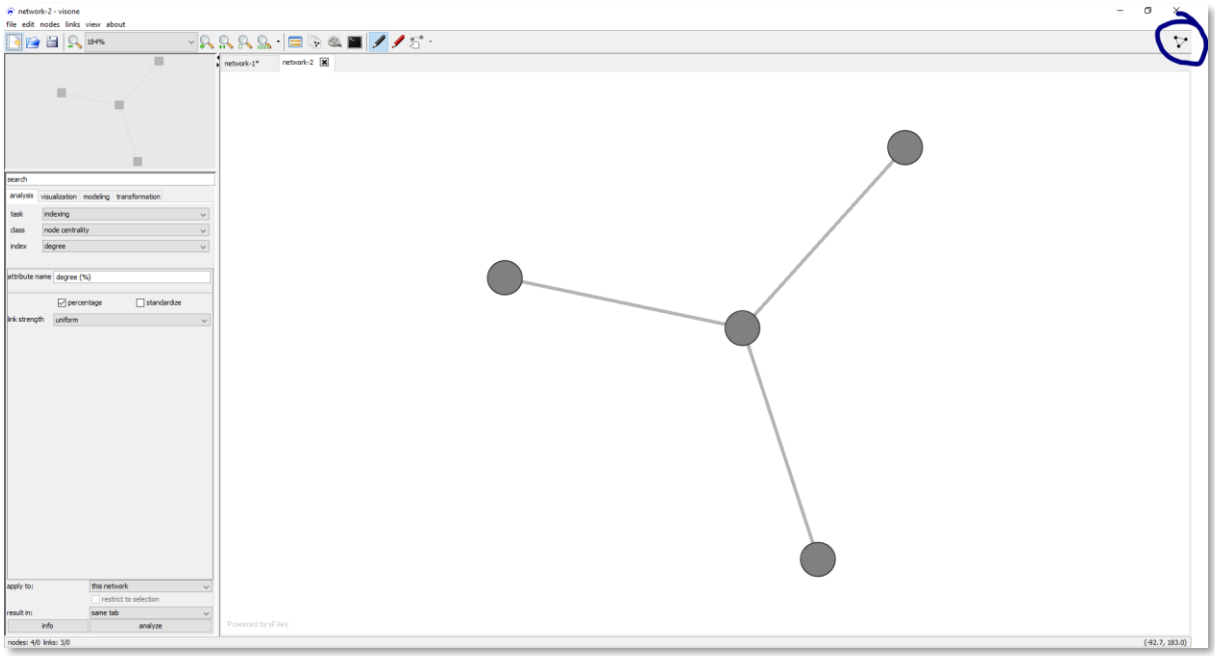
Let's change the layout of the network you just handmade, but first, let's create a copy of this network via *file -> create Copy* or using the shortcut Ctrl+Y.

> **Note**: every time you see text in *italics* during the steps of this tutorial it refers directly to text that should be visible on the screen at that moment.



Once copied you will see network-1* and network-2 in the tabs. The * indicates that the network has been changed but not been saved. We will get to that in the next step, first let's change the layout of network-2.

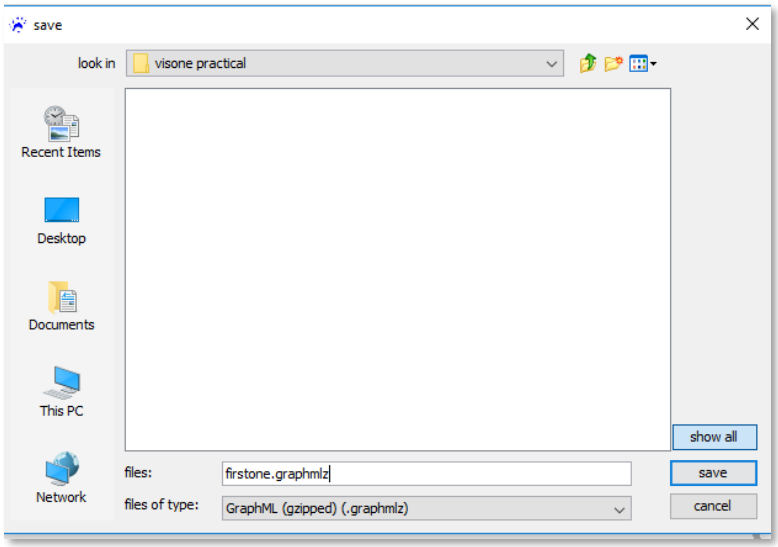
Press the Quick Layout button in the top right corner of visone's window.



Your network will now be layouted differently from when you first drew it, which you can verify by changing the tabs between network-1 and network-2.

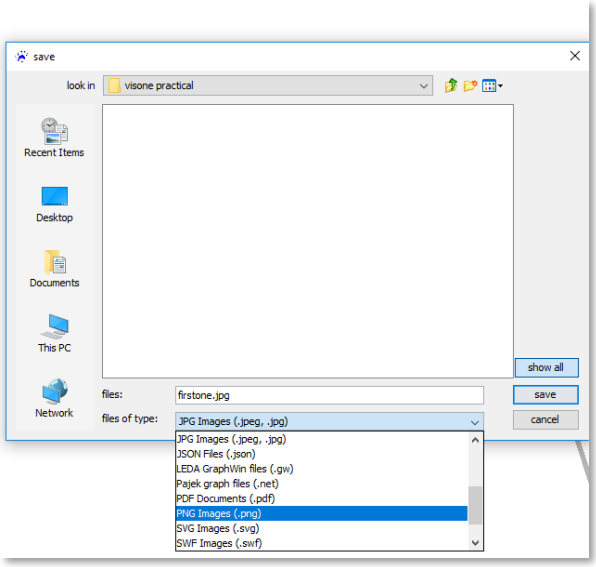
Step 5

Let's save the network you created and quick layouted using *file -> save as*. Navigate to the folder you created in Step 1 and save your network as a .graphmlz file (e.g. firstone.graphmlz). This file type is used or can be read by many types of network software. Any network saved as a .graphmlz file can always be opened by visone, will have the same look as the moment it was saved in visone.



Step 6

Aside from saving networks as .graphmlz files, you are also able to export your network in a bunch of other file formats using *file->export*.



You can see there are more options for file types now, including the option to save in an image format such as .jpg or .png or even as a PDF.

Save the network as a .png without changing any of the image export options

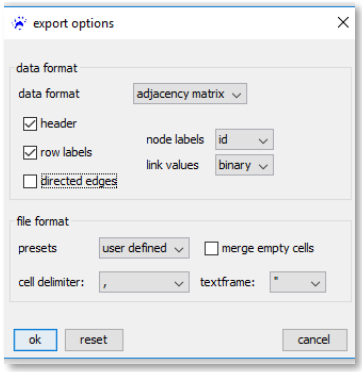
> **Note**: if you ever want to increase the export size of an image, you can do so by adjusting the *scalar* option, e.g. a scalar of 2.0 will scale up the image of the network by a factor of 2 or 200%.
>
> **Note on the note:** I found that visone will often crash by running out of memory when exporting images (especially of large networks) with a scalar of 5.0 or higher.

You will now have a PNG file of your network in the folder you exported to.

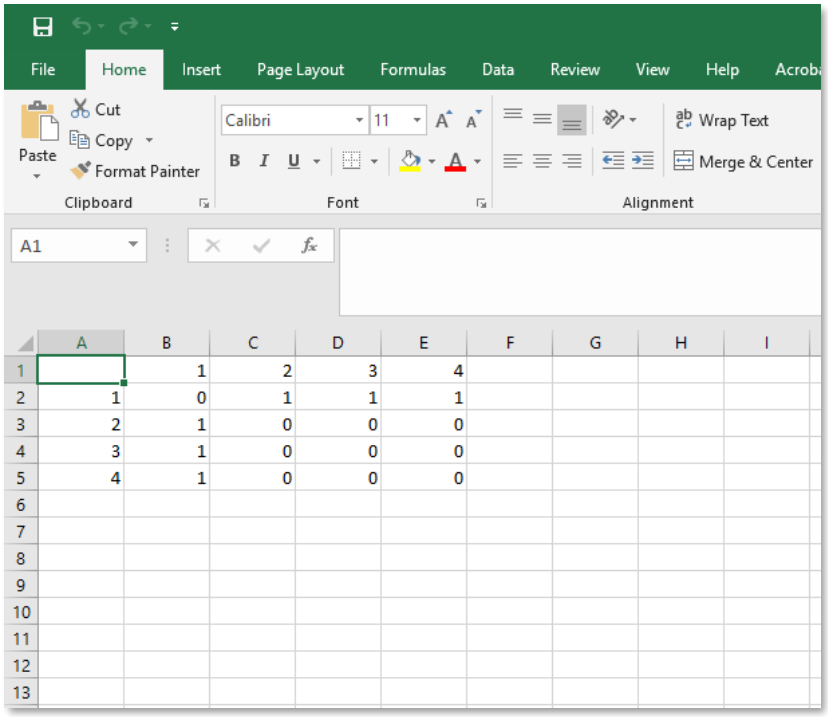
Step 7

While you were drawing a network, visone was creating the data structure beneath your network. This can be used to analyze the network (which we will get to later), but can also be exported using the same *file->export* method. This time, choose to export it as a CSV file (.txt, .csv).

In the next window, choose "adjacency matrix" as the *data format* and untick the *directed edges* box. The rest of the settings should be able to remain unchanged, but for reference:



You can inspect the exported CSV file by opening it in excel (or in any spreadsheet or text editor. A text editor will give you a similar idea of the structure of the data, except it will not be in separate cells but divided by commas). It should be a symmetrical matrix with 0s and 1s and (unless you created loops, i.e. links from a node to itself) 0s running diagonally through it.



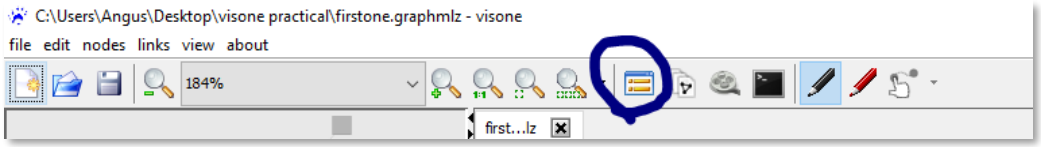
	A	B	C	D	E
1		1	2	3	4
2	1	0	1	1	1
3	2	1	0	0	0
4	3	1	0	0	0
5	4	1	0	0	0

The 1,2,3,4 (or more if you choose to make more nodes) are the names of the nodes. These are auto-generated by visone, but we can change these if we like.

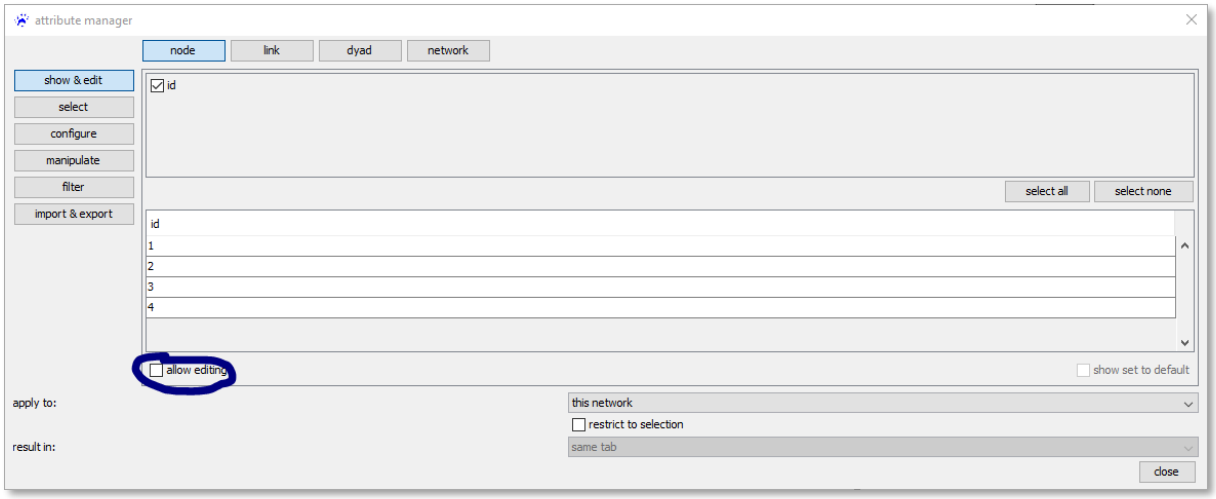
Try it yourself: Export the network as a .csv but instead of an adjacency matrix, export it at as a link list (name the file something else than firstone.csv). What does this data look like in Excel? How does it represent the relations in your network?

Step 8

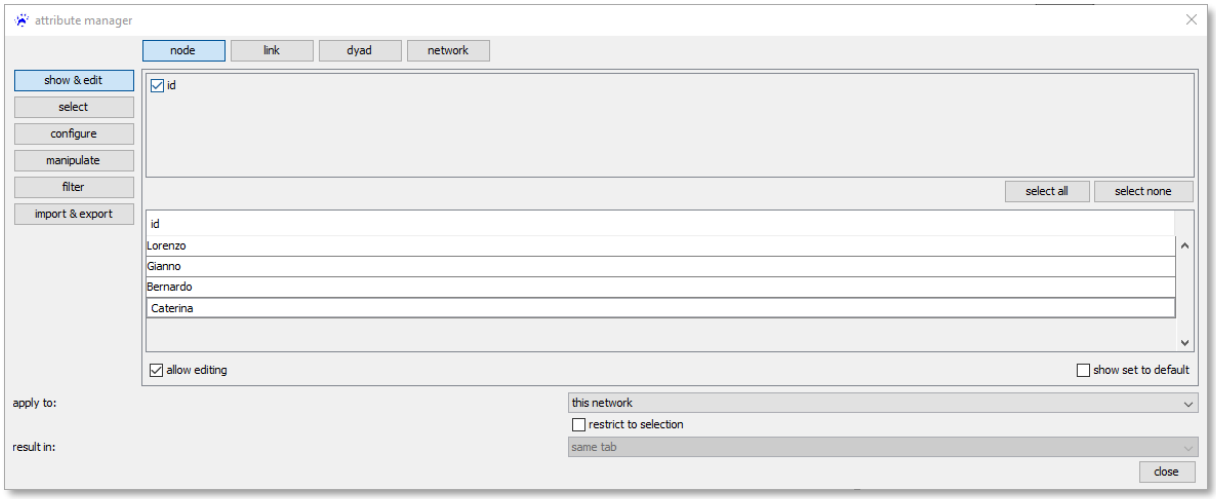
Return to visone and open the *attribute manager* (the little menu icon shaped like a window with golden text)



You will see the attributes of the nodes you created. Right now, it only has one: *id*



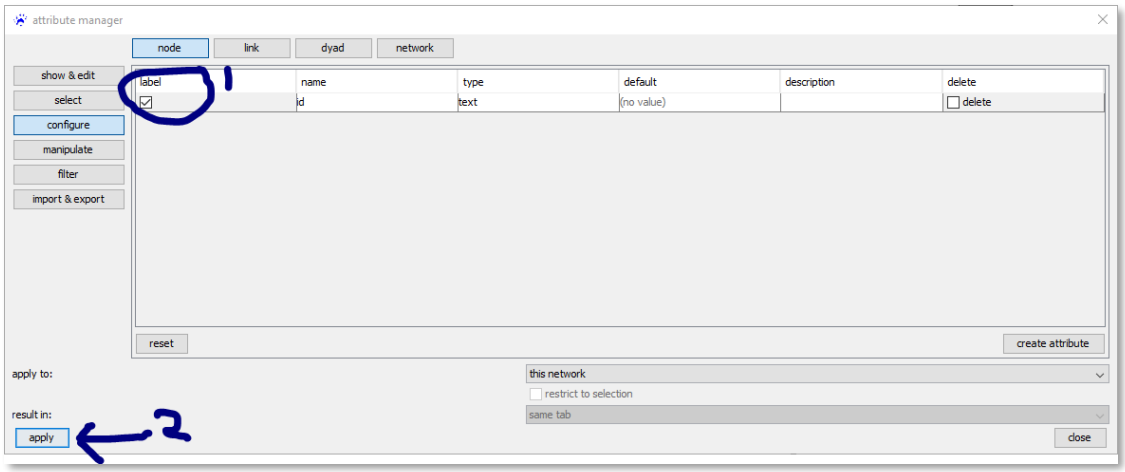
You can edit the value of any attribute by checking the *allow editing* box. Now you can change the id of the nodes to whatever you would like by double clicking on the value, e.g. to some Medici first names.



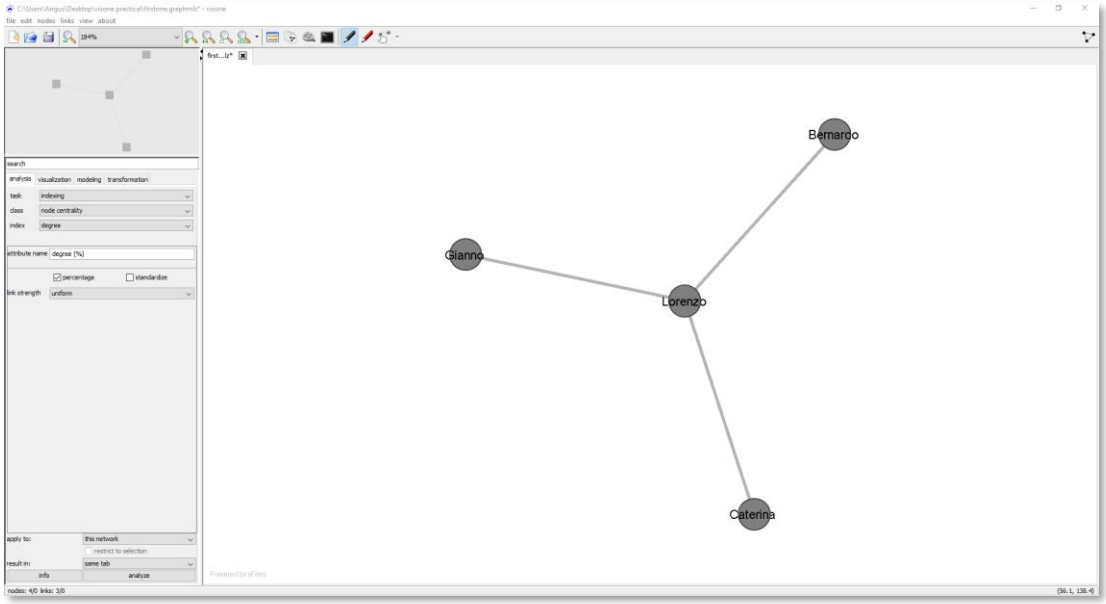
Step 9

In our visualization, nodes did not have labels so far, making it hard to identify them. Let's change that.

While still in the *attribute manager*, go to the *configure* tab and check the *label* tickbox and after press *apply*.



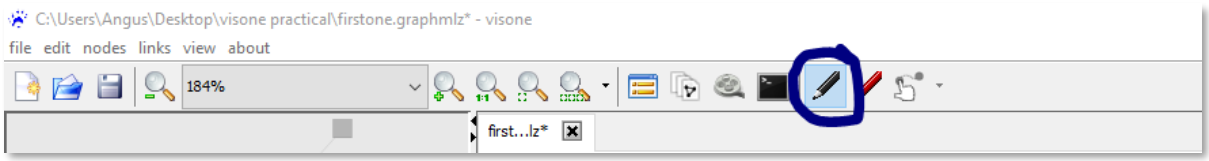
Now your nodes should have labels with the names you gave them.



Step 10

Your nodes are probably grey at the moment. Not very exciting is it? You can change the appearance of nodes in their *properties*.

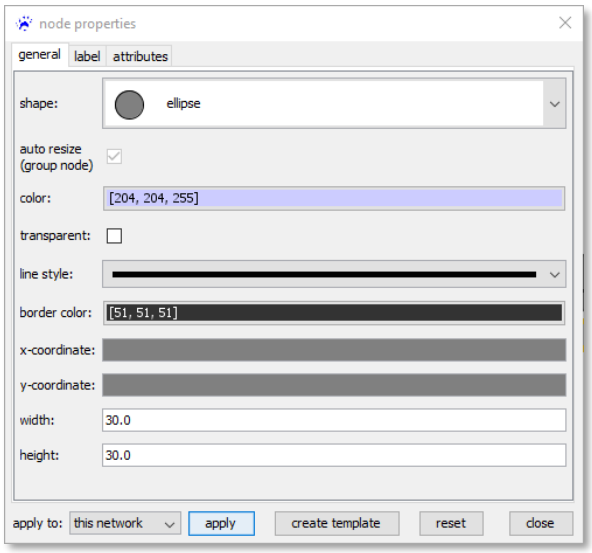
First select all the nodes. In order to do that, you can either use *nodes->select all* or by drawing a selection window around them. To do that you will first need to uncheck the Pencil menu item, otherwise you will end up drawing more nodes instead.



With all nodes selected either right click on one of them or use *nodes->properties.*

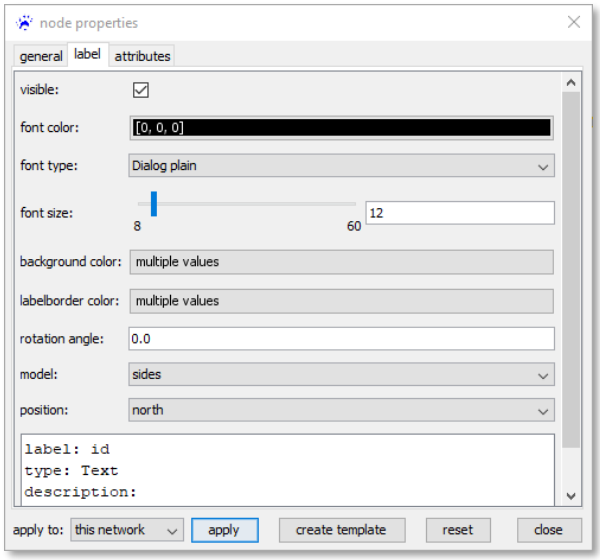
In the *properties* screen you can change all the visual aspects (*shape, color, width* and *height* [size], *transparency, line* [border] *style*, and *border color*) and even the location of the nodes in the *general* tab.

In the *general* tab use *color* to change to e.g. a pale blue (204, 204, 255). Also change the *line style* to something a bit thicker.

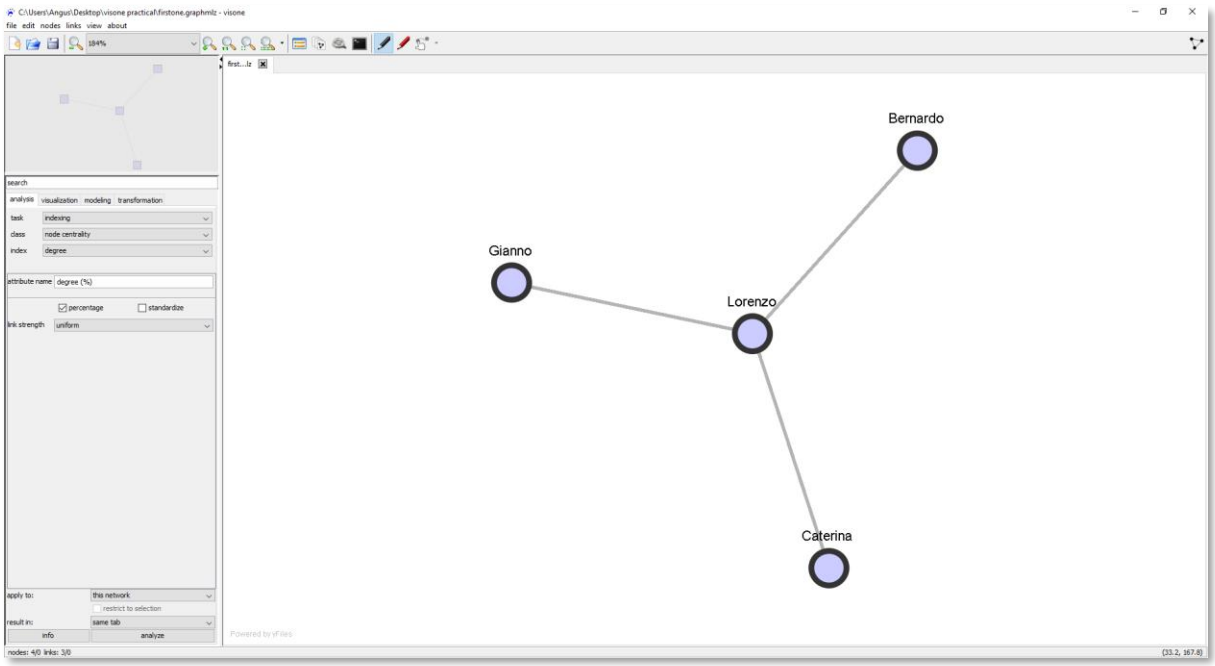


Press *apply* and your nodes will now have changed color and border thickness.

With this thicker border it is not very pretty to have the labels in the middle of the node. Let's change that in *properties* as well. With all nodes still selected, navigate to the *label* tab and set the *model* of the labels to "sides" and the *position* to "north." Don't forget to press *apply* and exit the *properties* window.

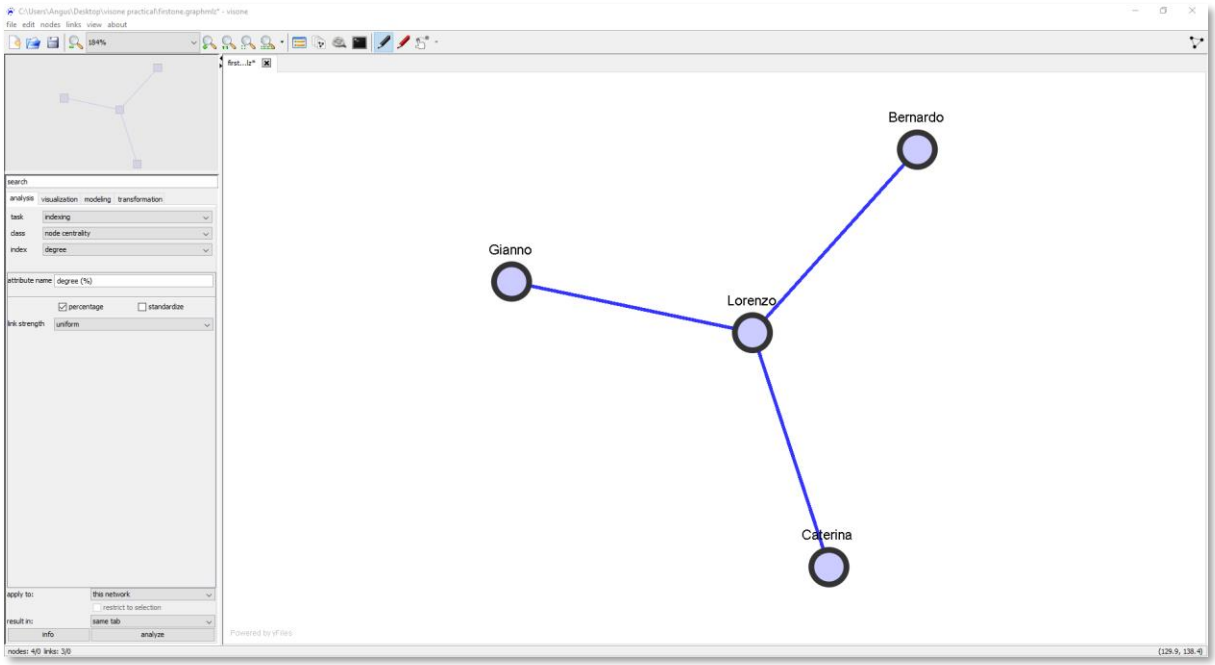


With the nodes deselected your network will look something like this.



Note that you can style individual or groups of nodes by selecting only those nodes you want to change. You can also style links in a similar way as you can style nodes: by selecting them and by going to *links-> properties* or by right clicking a link (not a node) and choosing *properties*.

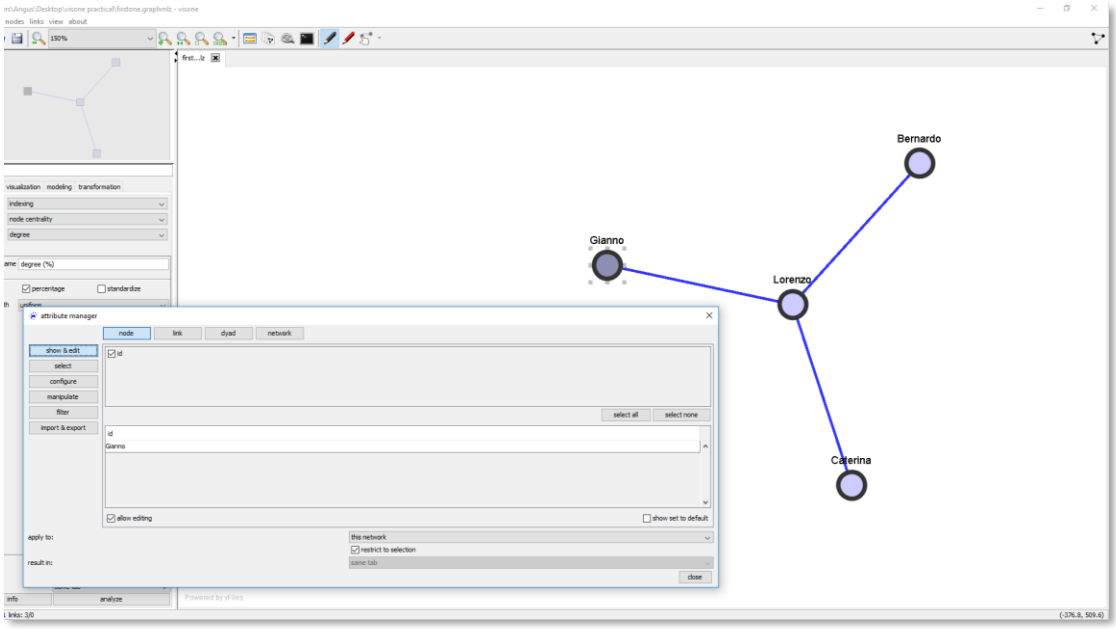
Try it yourself: Make all the links in your network a dark shade of blue.



Step 10

As an aside, you are also able to inspect a node's attributes in the *properties* window under the *attributes* tab. Select a node, right click it and choose *properties* and navigate to the *attributes* tab.

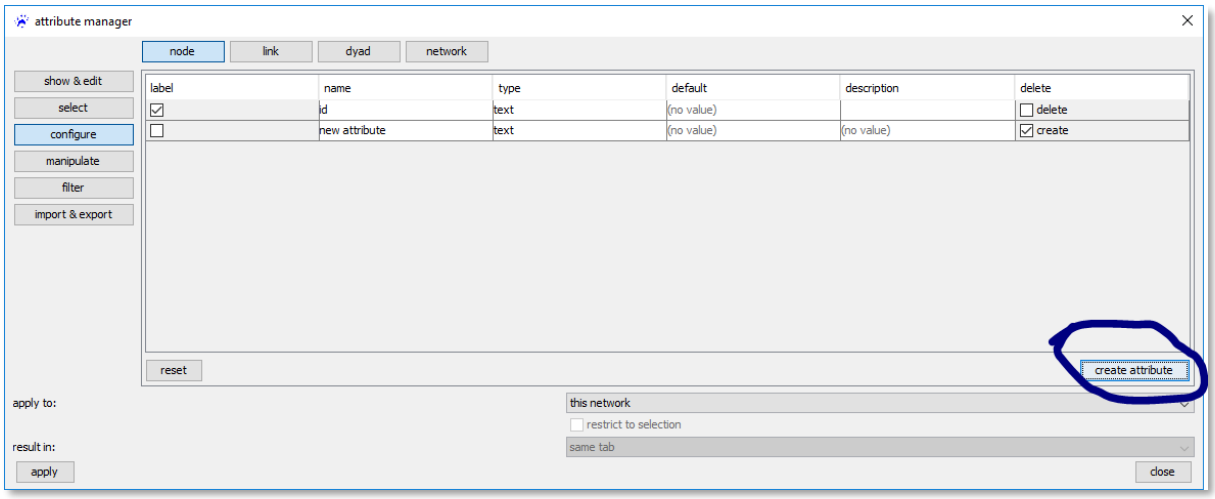
Remember the *attribute manager*? Open it and you will see that in the *show & edit* tab it will only show you the attribute of the node you currently have selected.



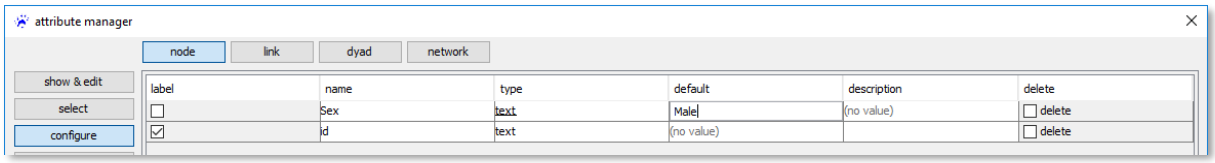
Step 11

We can also select nodes through their properties, but to make that useful, let's first add another attribute to our nodes: the biological sex of the *Medici* family member.

Navigate to the *configure* tab of the *attribute manager* and press *create attribute*

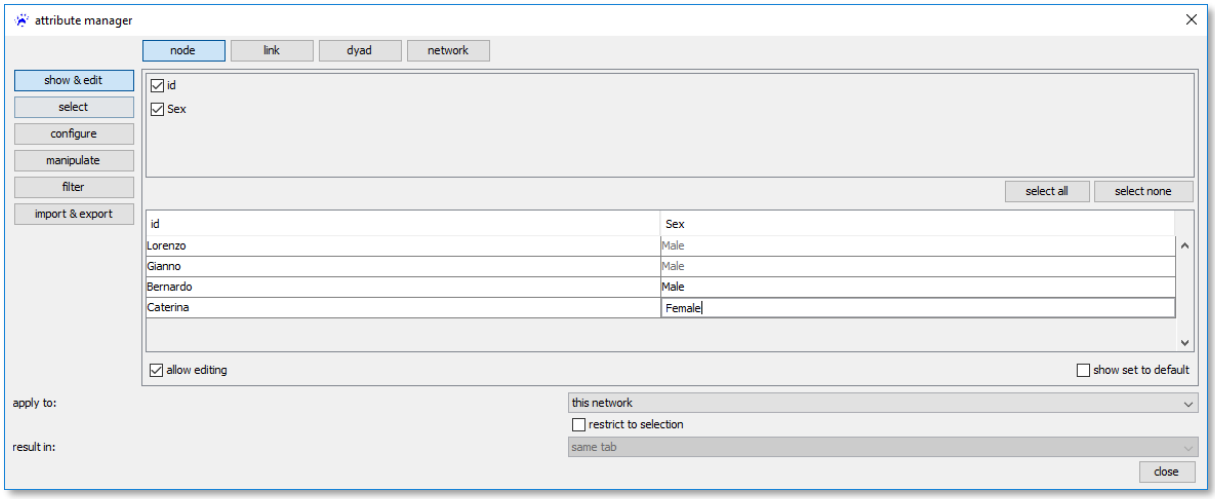


In the newly created attribute fill out the following: *name* “Sex”, *type* “text”, *default* “Male”.



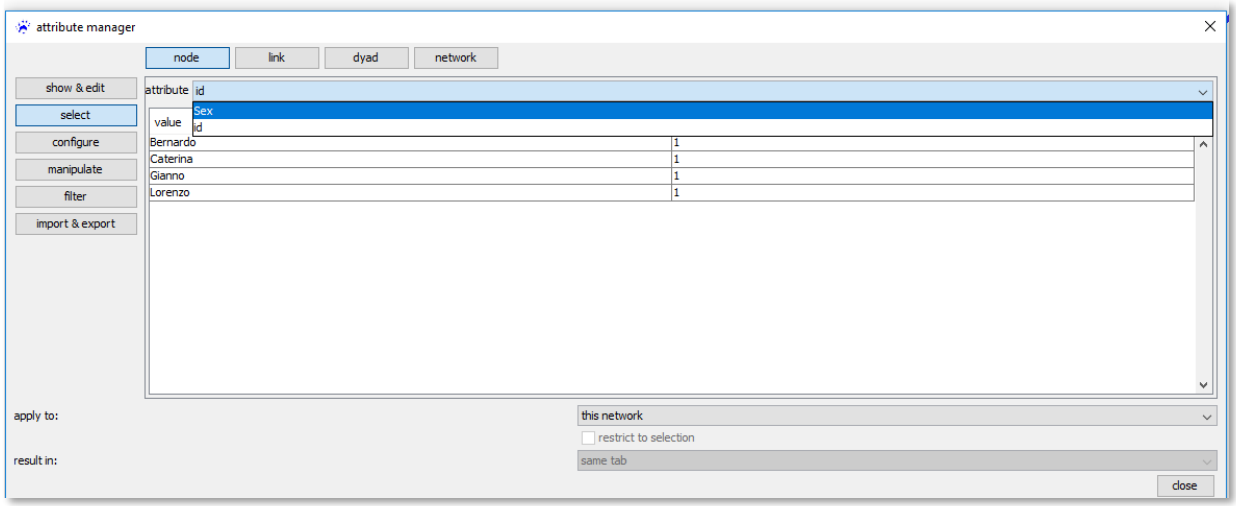
Don’t forget to press *apply* and then go to the *show & edit* tab. Make sure you deselect all nodes (by clicking anywhere in the empty space of the network or via *nodes-> deselect all*). You will see that all nodes now have the attribute “Sex”, which in all cases is “Male”.

Change the “Sex” of one or more node to “Female”, by double clicking the value and writing it in (make sure *allow editing* is checked).

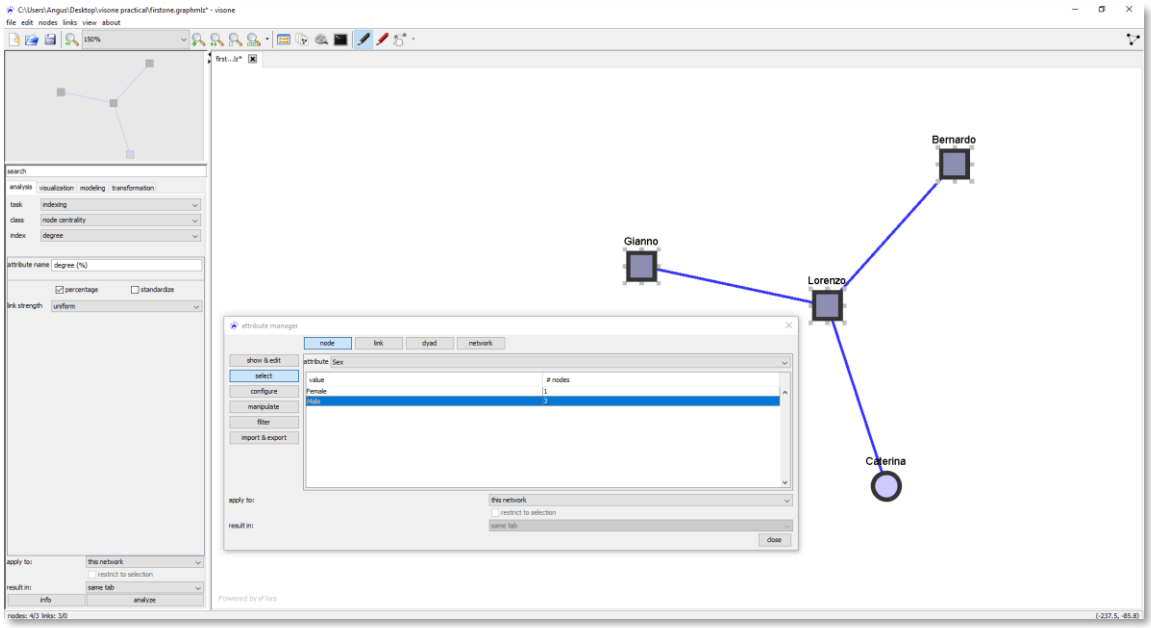


Step 12

While still in the *attribute manager*, navigate to the *select* tab and change the *attribute* value to “Sex” (if it is not already selected).

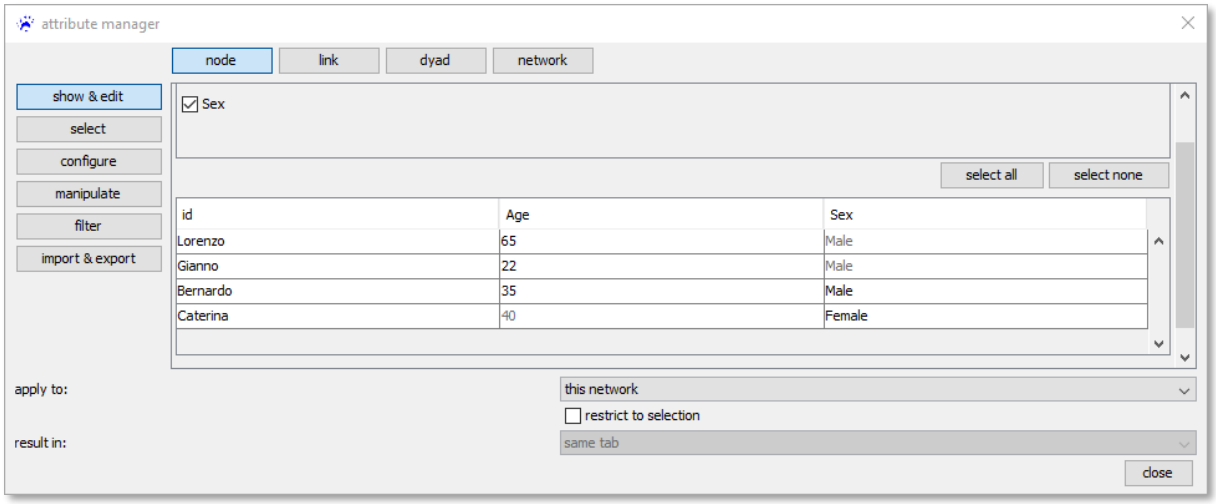


By clicking on one of either values ("Female" or "Male") you will see that you will select all the nodes with that attribute. Select all the Male nodes and in *properties* change their shape to a "rectangle".



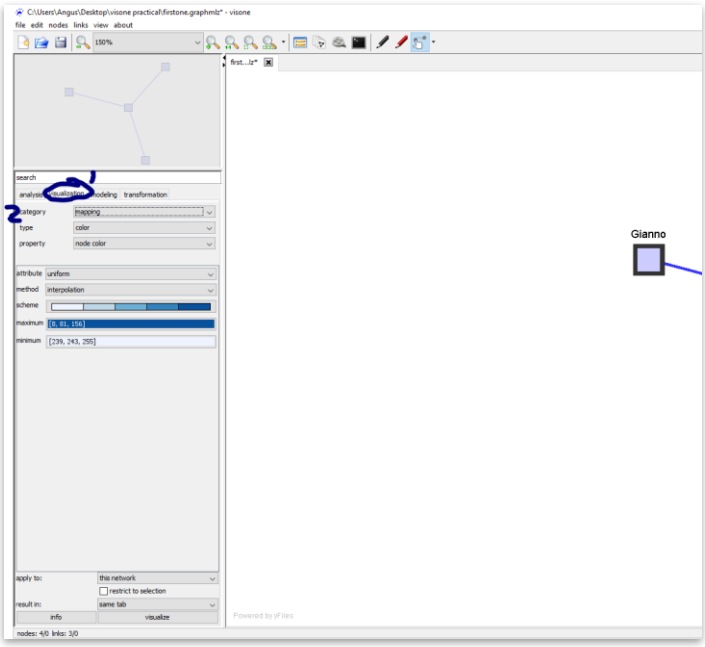
Try it yourself: Add an Age attribute to your nodes, make sure your attribute is an integer, and fill it out for all your nodes.

For example:



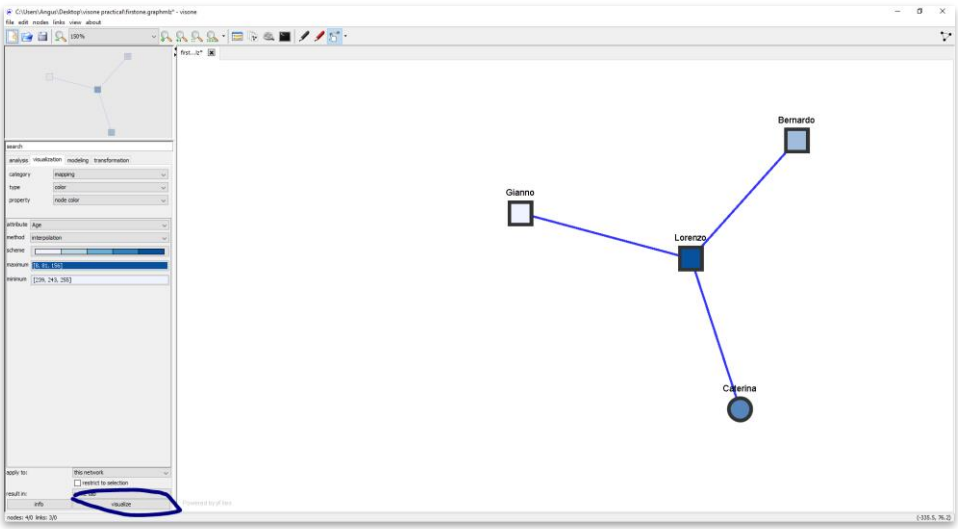
Step 13

Aside from the *properties* window there is another part of visone that allows you to change the style and layout of your network: the *visualization tab* in the sidebar. Navigate there and change *category to* "mapping"



Type should be "color" and *property* "node color."

In this tab change *attribute* to "Age", keep the *method* on "interpolation" and the *scheme* on blues. Press *visualize* at the bottom of the tab and your nodes will change hue based on the value of their age (the lightest blue is the 'youngest' or the minimum integer value, while the darkest blue will be the 'eldest' node, i.e. representing the maximum integer value).



This marks the end of the first part of this tutorial! You already know your way around some of the features of visone you will use most. Congrats!

Save your final network as both a .png file and as a .graphlmz file and let's continue to Part 2, where we will load in and analyze the Padgett dataset.

Part 2, Analyzing the network of Florentine families.

Step 1

Go to https://infovis.lucdh.nl/datasets and download the zip file named *Florentine Families (Padgett Data)*.

Unzip the file to the same folder you saved your network(s) from Part 1 of the tutorial.

After unzipping, inspect PadgettM.csv and PadgettB.csv (with excel or any text editor). What you will see are binary, undirected, matrices containing the same type of nodes: the headers of the rows and columns in both files contain the names of the same Florentine families that played a role in the turbulent politics of the early 15th century in this city-state.

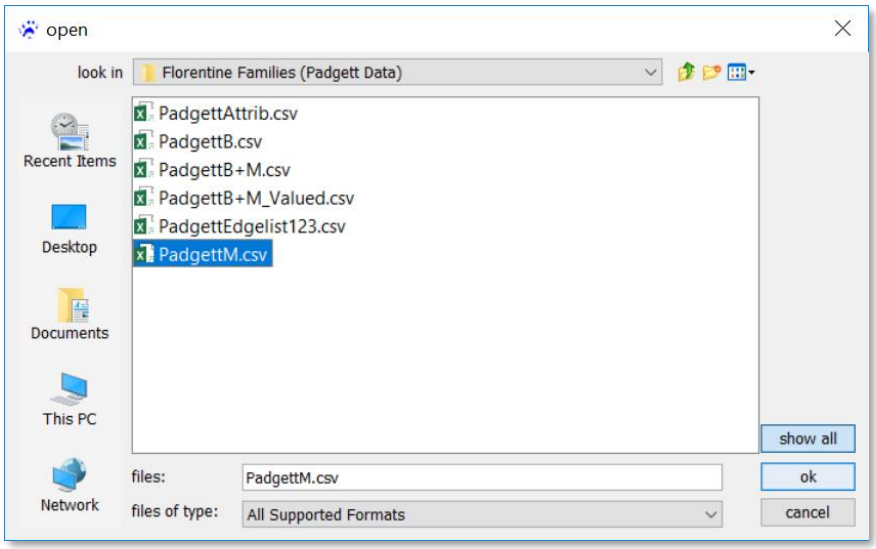
Even if we would not know the matrix is binary, you would be able to intuit this from the way the data looks. Remember a "0" at the intersection of a row and column marks the absence of a link, while a "1" means a link is present. The same applies to its undirectedness as the matrix is symmetrical: the top diagonal mirrors values of the bottom diagonal. Similarly, you'd be able to guess that this was a one-mode dataset as all nodes have the same name and thus seem to be of the same type. In addition, the matrix is square (i.e. has the same number of columns as rows). Two-mode matrices tend to be rectangular. If you want to know more about two-mode matrices, you will have to continue studying networks

Despite their similar structure, the two matrices are clearly not the same, which makes sense as they reflect different types of relations: PadgettM shows marriage ties between families, while PadgettB shows business ties.

Let's see what they look like in visone.

Step 2

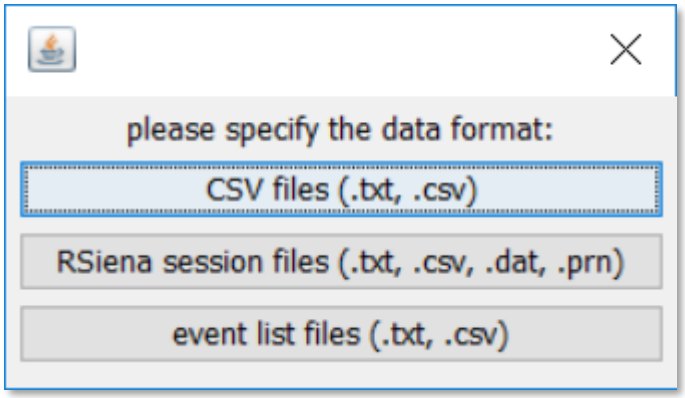
If visone is not open already, start it.



After opening PadgettM via *file -> open*. One of the good things about visone is that it is able to open up many file types (*files of type*) that are standard in network analysis. If you keep *files of type* on "All

Supported Formats" it will automatically list all the files visone is potentially able to read.

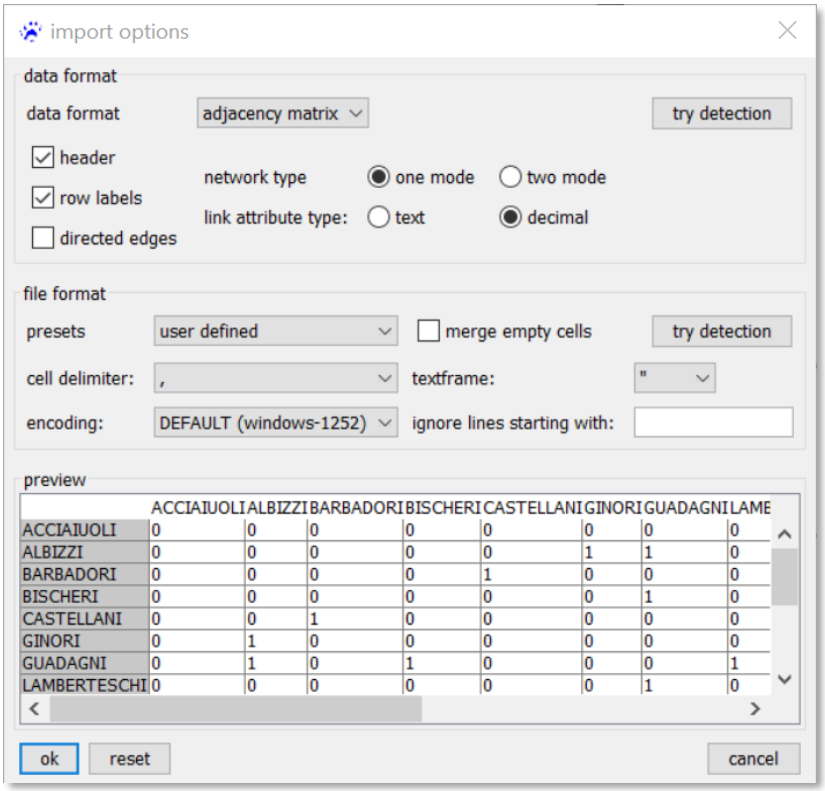
Click *ok* and visone will ask you to *please specify the data format:*



While the other types of files could potentially be very useful for historical network analysis, in this tutorial we will only work with data in regular "CSV files (.txt, .csv)", so select that option.

In the next screen you will need to make some important choices. If you do not make the correct ones, your network will not display or display a wrong structure.

Fortunately, we already inspected the data beforehand in Step 1, so we know we are dealing with an "adjacency matrix" *data format*, which has a *header* and *row labels*. The matrix was square, the nodes were of the same type and it was symmetrical, so we are also dealing with a "one mode" *network type* without directed links (*directed edges*).



	ACCIAIUOLI	ALBIZZI	BARBADORI	BISCHERI	CASTELLANI	GINORI	GUADAGNI	LAME
ACCIAIUOLI	0	0	0	0	0	0	0	0
ALBIZZI	0	0	0	0	0	1	1	0
BARBADORI	0	0	0	0	1	0	0	0
BISCHERI	0	0	0	0	0	0	1	0
CASTELLANI	0	0	1	0	0	0	0	0
GINORI	0	1	0	0	0	0	0	0
GUADAGNI	0	1	0	1	0	0	0	1
LAMBERTESCHI	0	0	0	0	0	0	1	0

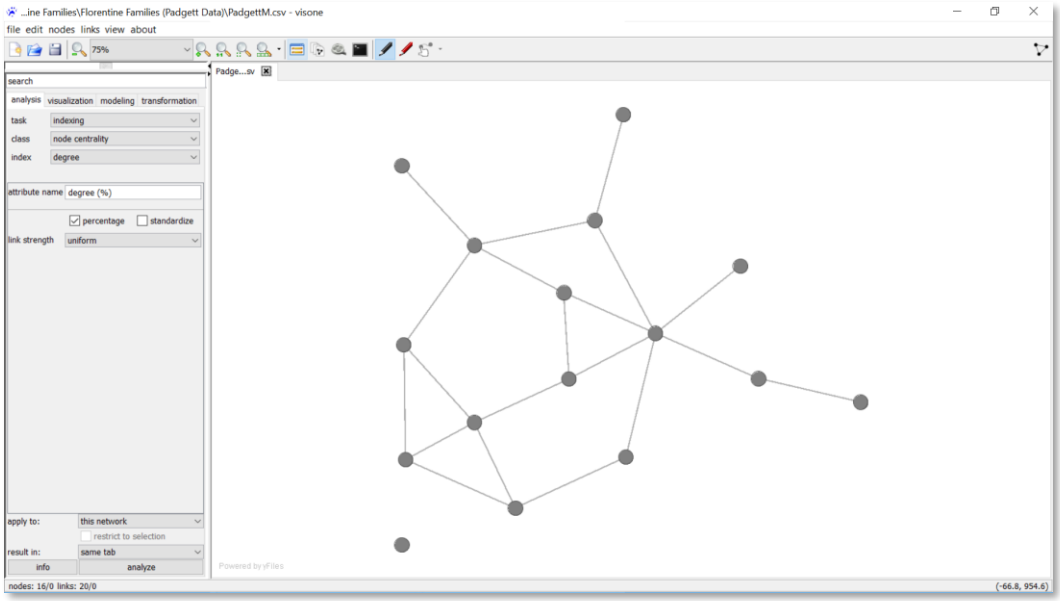
Make sure these values are selected in the *data format* section of the *import options* window.

Perhaps you will also need to set some of the values in the *file format* window, if so see the correct ones in the figure or use *try detection*.

If you set everything correctly, you should see a *preview* of the data that looks similar to the one you've inspected during Step 1.

Press *ok*.

Step 3

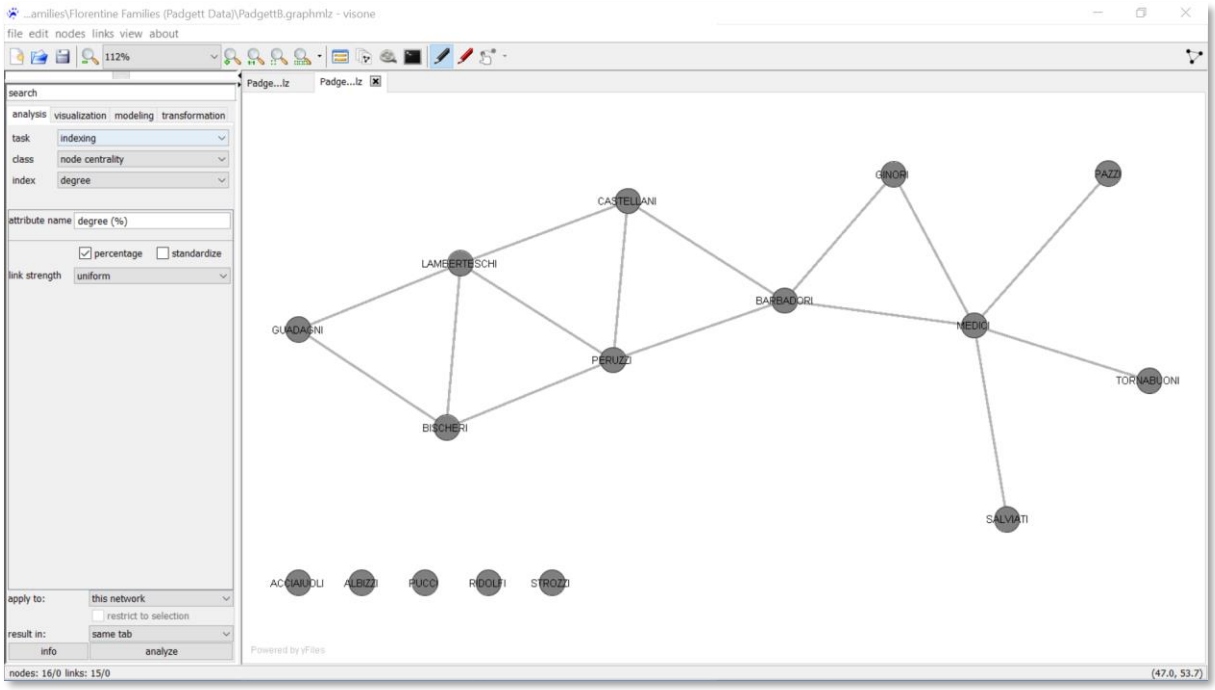


You will see a network that should look <u>exactly</u> like this.

Use the *configure* tab of the *attribute manager* to check the *label* box of the id attribute to give names to the nodes.

Don't forget to save the file as a .graphmlz (*file* -> *save* as) or you will need to re-import the data if you want to exit visone and later load this network.

Try it yourself: Repeat Step 2 and 3 on the PadgettB.csv file.

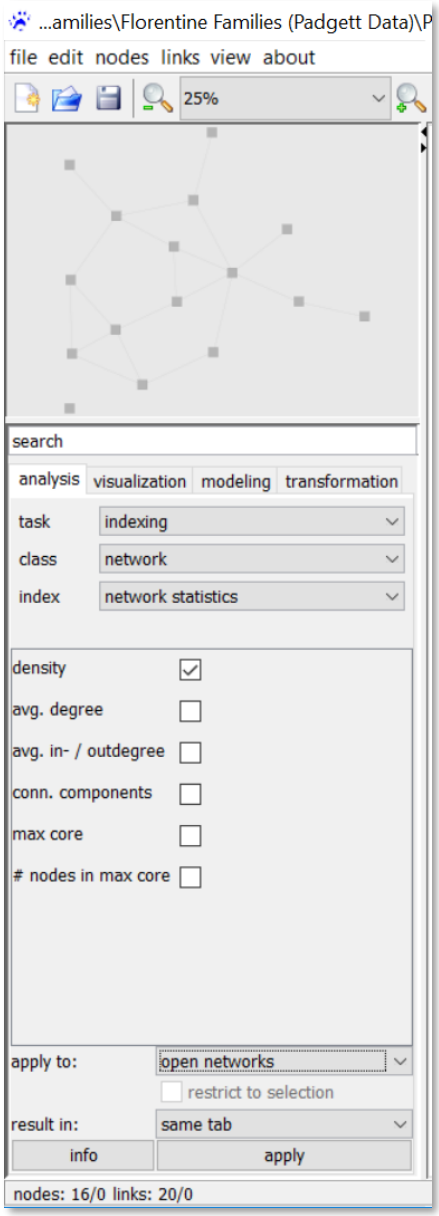


Step 4

You will see that our hunch that this data would yield very different networks was correct: the PadgettB(usiness) network is much less connected than the PadgettM(arriage) network.

Let's analyze this network and find out how different they are from each other by measuring their density!

> **Side note**: You may ask yourself: Why even analyze these small networks through measurements? I can simply look at them and draw my conclusions?
>
> True, with smaller networks like these it is relatively easy to spot differences in their structures and maybe even identify central nodes or detect specific communities (groups) in the network. When networks become even slightly larger (more nodes) or denser (more links) analyzing them by eye becomes much harder. There is another argument for using network metrics in your analysis. Networks have a certain structure with which they can be compared to each other, (often) regardless of the size of the dataset.



To start measuring the differences between networks, in the sidebar of the main menu go to the *analysis* tab, and choose "network" in the dropdown list of the *class* option (if you do not see it, make sure the *task* is set to "indexing"). You will see a set of options to *index* "network statistics" in the bottom part of the sidebar: from *density* to *# nodes in max core*. Right now, we are only interested in the density of the network, so uncheck all others.

We are interested in knowing the density of both networks we currently have open, so at the very bottom change *apply to* to "all open networks." Note that you can keep it on "this network", but in that case you would have to analyze both networks separately.

Push *apply*

Nothing seemed to happen, but visone in fact just ran through the following calculation:

$$\frac{Actual\ Links}{Potential\ Links}$$

, where *Actual Links* are the number of links in the network, e.g. in PadgettM this number is 20. You can view this in the extreme bottom left corner of the main window (20/0, i.e. 20 links, of which 0 are currently selected).

And the number of *Potential Links* for an undirected network such as this one can be calculated as follows:

$$\frac{N * (N - 1)}{2}$$

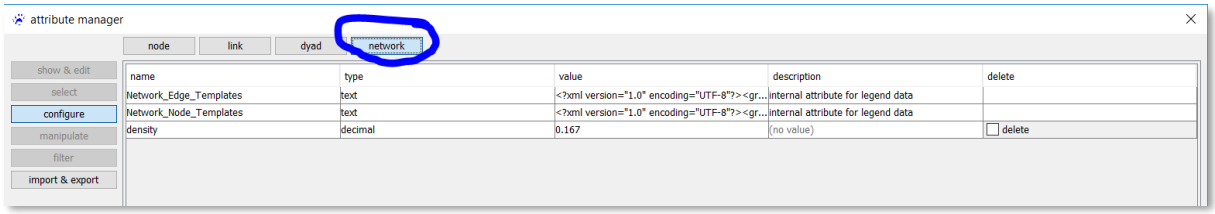
, where *N is* the number of nodes in the network. In the case of PadgettM this number is 16, which is also shown next to the number of links at the bottom of the main window.

With this information you could also manually calculate the density of the network.

$$Potential\ Links = \frac{16*(16-1)}{2} = 120 \text{ and } \frac{Actual\ Links}{Potential\ Links} = \frac{20}{120} = 0{,}166.$$

The result of such a density calculation will be always between 0 and 1, so another way to view it is in percentages: 0,1666 = 16,66%, i.e. the PadgettM network has 16,66% of the density that it could maximally have.

You can see the result of visone's calculation in the *attribute manager*, in this case not under the *node* but under the *network* tab (as this is not an attribute of a single node, but of the entire network).



As you can see in the *value* of the *density* attribute is 0,167 (visone rounded up).

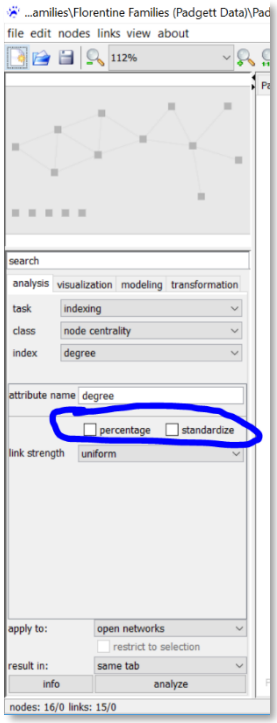
Try it yourself: Manually calculate the network density of PadgettB and verify whether it is correct by checking the value in the attribute manager of PadgettB's network.

As you will see the density of the PadgettB network is lower than the PadgettM network. This already tells us something quite interesting: there where (at least according to our data) more marriage connections between families in Florence than business connections.

The take-away message of Step 4 is that every measurement of any aspect of a network has an algorithm that could, in theory, be calculated manually. Of course, this is too much work for more complex measures, which is why we let software like visone compute this for us. Still, **whenever you use a measure** in network analytic software like visone, **you need to understand what it calculates**. If not, you will not be able to interpret or explain the results of the analysis.

Step 5

Now we have taken a measure of the whole network, let us measure the position or centrality of nodes in the network. Let's consider degree centrality first.



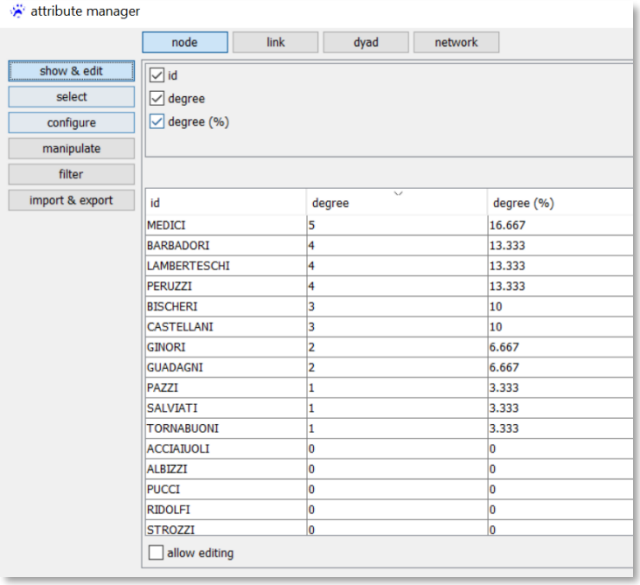
In the sidebar's *analysis* tab change *class* to "node centrality." Next, make sure "degree" is selected as the *index* and in the tickbox in the section below you have selected *percentage*.

Apply to "open networks" and press *analyze*.

Keep all the settings the same, except for <u>unticking</u> the *percentage* box.

In the PadgettB network using the *attribute manager* in the *show & edit* section of the *node* tab, inspect the nodes' degree(%) and degree.

The degree is the total amount of links a node has. In this case the total amount of marriage ties connecting one family to others. The degree(%) is the percentage of that node's degree relative to the sum of all node degrees in the network.



id	degree	degree (%)
MEDICI	5	16.667
BARBADORI	4	13.333
LAMBERTESCHI	4	13.333
PERUZZI	4	13.333
BISCHERI	3	10
CASTELLANI	3	10
GINORI	2	6.667
GUADAGNI	2	6.667
PAZZI	1	3.333
SALVIATI	1	3.333
TORNABUONI	1	3.333
ACCIAIUOLI	0	0
ALBIZZI	0	0
PUCCI	0	0
RIDOLFI	0	0
STROZZI	0	0

Sort the degree attribute in ascending order, you will see that the MEDICI node has the highest degree (5), which amounts to 16,666% of the total degree in the PadgettB network.

Step 6

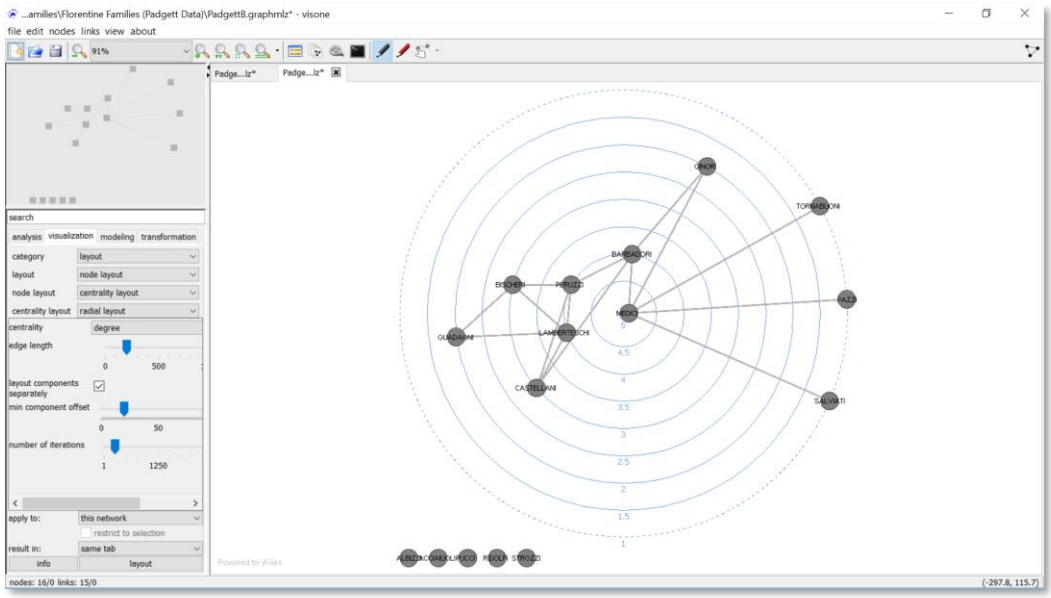
Next we will visualize the degree centrality of the nodes in the PadgettB network. In the main window go to the sidebar's *visualization* tab.

With *category* on "layout" and *layout* on "node layout", pick the "centrality layout" from the dropdown list at *node layout*.

In the subsection below these option pick "degree" in the dropdown list under *centrality*.

Next, press *layout*.

The network area has changed, adding concentric circles with values to the background and placing nodes with higher degree centralities closer to the center of the circles.



Try it yourself: Make the same visualization for the PAdgettM network. What is the result for the MEDICI node? What is the position of the LAMBERTESCHI node in both networks?

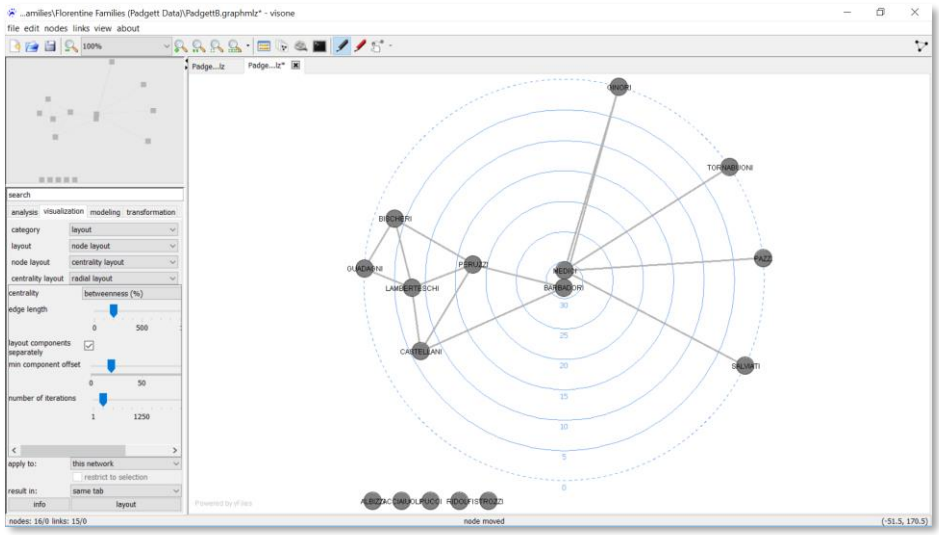
Note that if you had measured the degree centality on all open networks at the beginning of this step, you should not have to measure it again for PadgettM.

Step 7

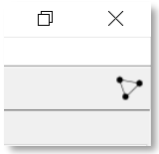
Different measures of centrality can yield different insights into the network position of nodes and therefore in this case the political power of Florentine families.

To visualize this, calculate the betweenness (%) centrality of the nodes in both networks (in the *analysis* tab, change *index* to " betweennes" and press *analyze*).

Now visualize the betweenness centrality of nodes in PadgettB in a centrality layout (in the *visualization* tab, change *centrality* to "betweenness (%)".



As you can see, both the BARBADORI and MEDICI node have the same position in terms of their betweenness centrality.



Press the *quick layout* button in the top right corner and inspect the structure of the network without centrality layouting.

Suppose you would want to "travel" via the links from, for example, the GUADAGNI node to the TORNABUONI node in the shortest way (i.e. travelling across the smallest possible number of links)? Whatever shortest route you take (or in this case whatever route you take, as it is the only route), you will always move through the BARBADORI node and the MEDICI node. These nodes literally lie between other nodes. They function as a type of gatekeepers for the network.

This is what betweenness centrality measures: the number of times a node acts as a bridge along the shortest path between two other nodes. Or as a formula:

$$Betweenness(n) = \sum_{s \neq n \neq t \in N} \frac{\sigma_{st}(n)}{\sigma_{st}}$$

The *Betweenness* of node *n* is the fraction of all shortest paths between each pair of nodes *s* and *t* (σst) that go through node *n*, summed (Σ) over all pairs of nodes in the network.

Clearly, this would be difficult to calculate by hand, even for a smaller network such as PadgettB, which is why network analyses rely greatly on a computer-based approach.

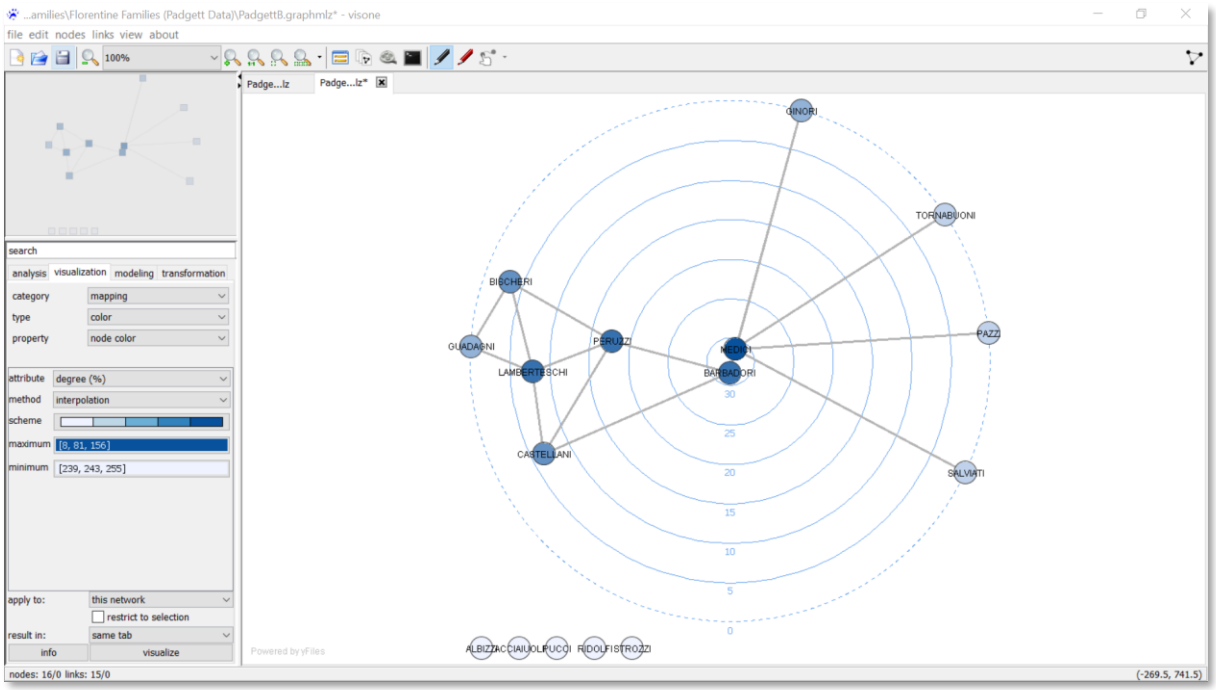
Step 7

As they are two different ways of conceptualizing of power in social networks (quantity of relations vs. strategic position), It would be interesting to be able to visualize the differences between degree and betweenness centrality of nodes.

This can be done by combining visual patterns, in this case position on the concentric circle (betweenness) and node color intensity (degree).

To do this first *layout* the network in a centrality layout based on betweenness (%). Note that you can drag nodes around with the Pencil tool not selected. So remove the overlap between the MEDICI and BARBADORI nodes (don't move them beyond the boundary of the middle circle, since that is the threshold of the value that both nodes have).

Secondly, while still in the *visualization* tab, change *category* to "mapping" and as an *attribute* choose "degree" (you can change the color *scheme* if you like, in this example we stick with blues). Don't forget to press *visualize*.



It is hard to see, but if you look closely, the MEDICI node is a shade darker blue than the BARBADORI, which has the same hue as the PERUZZI and LAMBERTESCHI nodes. This shows that, while the Barbadori family may have been as strategically located as the Medici when it came to the larger network of business ties, the latter still had the highest number of business ties with other families.

Try it yourself: Make the same visualization for the PadgettB network.

<u>Save both the PadgettM and PadgettB networks as .graphmlz files</u> in the folder you have been working in.

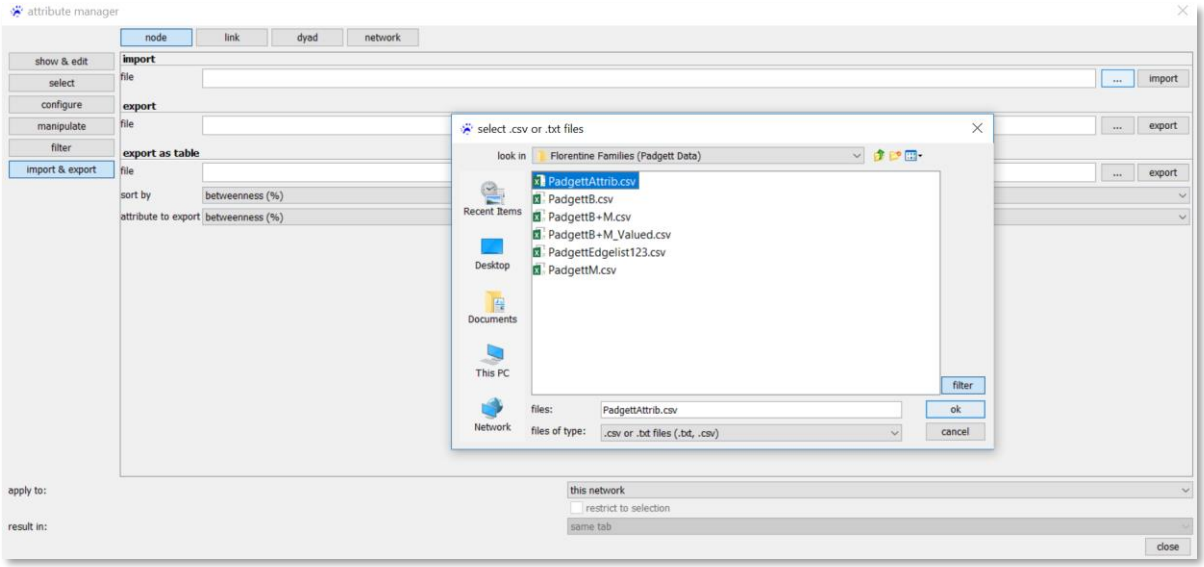
After this it is time for congratulations yet again! With the visualizations of your first network analyses, you've come to the end of Part 2 of this tutorial and you are now getting the hang of network exploration.

Part 3, comparing types of power by contrasting attribute and network data.

All of the data we've worked with so far have been based on dependency between nodes (i.e. has focused on the relations between them). Still, it can also be interesting to add attribute data to nodes. For example, to contrast the inherent attributes of nodes to their relational characteristics. In this particular case, we could for example contrast the wealth of these feuding families or the amount of political offices held to their position in their interfamily networks.

Step 1

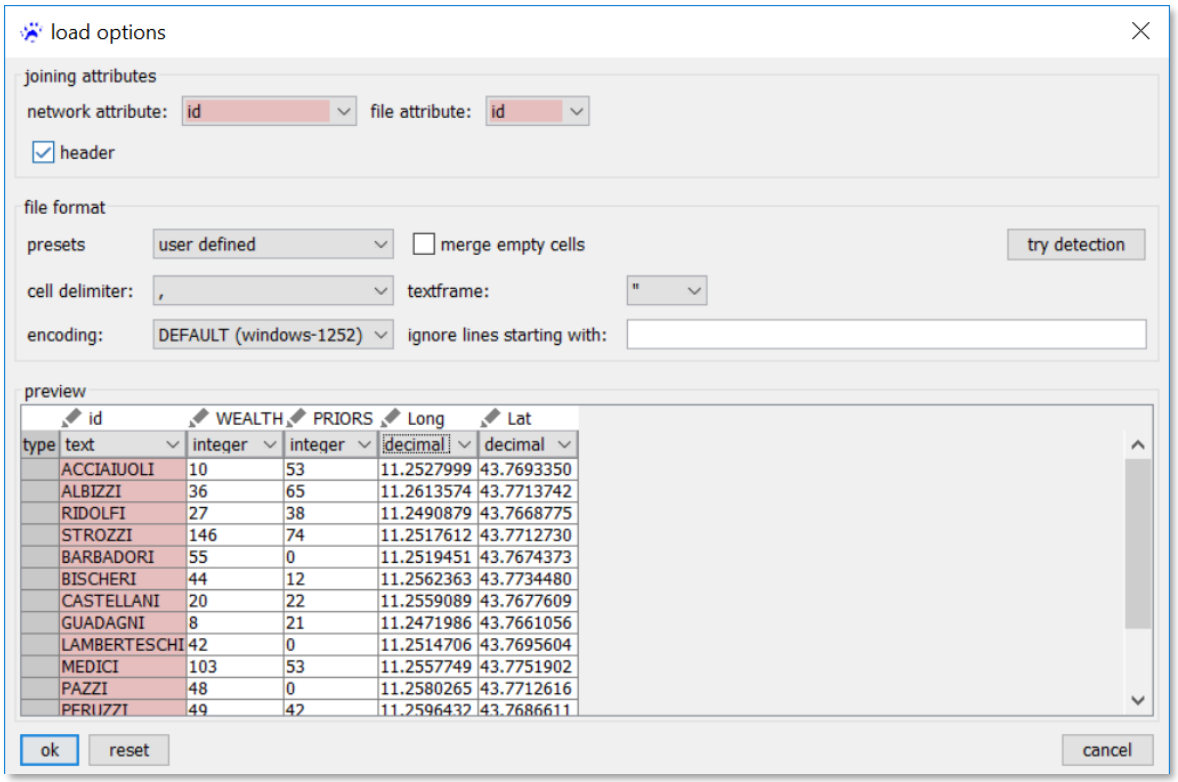
This attribute data can be found in PadgettAttrib.csv. To import this attribute data to PadgettB, make sure you are in the PadgettB network, then navigate to the *import & export* tab of the *attribute manager*. Press the … button next to *import,* navigate to the folder where you have stored PadgettAttrib.csv, select it, and press *ok.*



A window called *load options* will appear. Here the trick is to connect an attribute of the nodes that are already in the network (*network attribute*) to an attribute found in the file we're importing (*file attribute*). In both these cases, they can be identified with the "id" header.

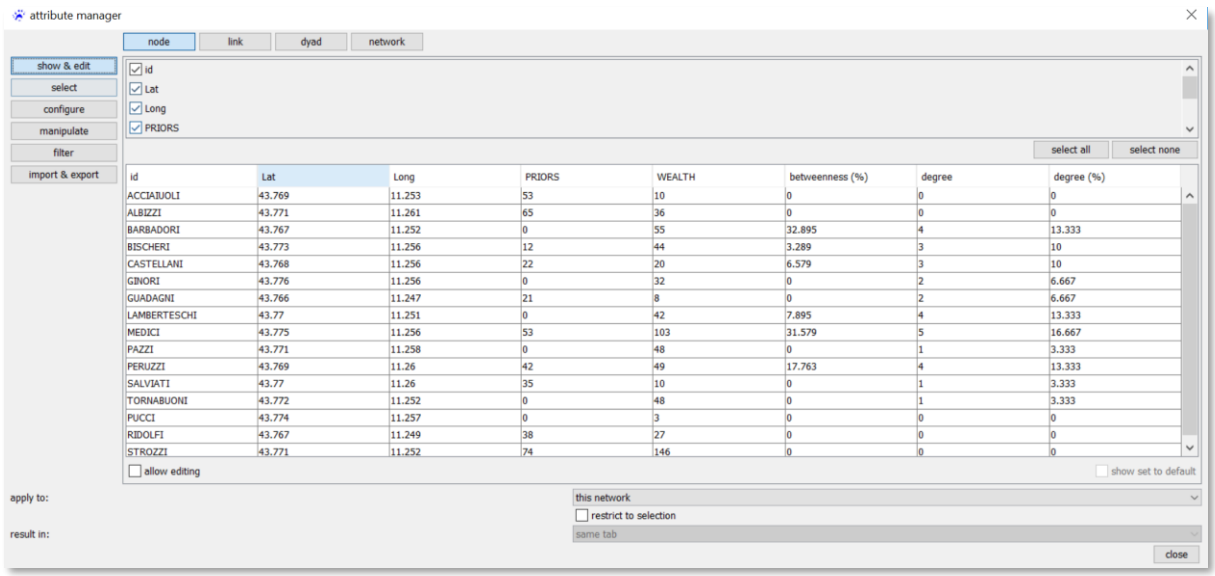
You should not have to change anything in the *file format* section, but if you do, click *try detection* and see if visone can automatically detect the settings for you.

Have a look at the *preview* of the data. Check if the attributes we are importing have the correct data type. WEALTH and PRIORS should be integers as they reflect a family's wealth in lire and the amount of times, a member of a family had been one of the Priori, a member of the Signoria, the counsel that governed Florence. Long(itude) and Lat(itude) should be decimals.



If everything checks out, press *ok*.

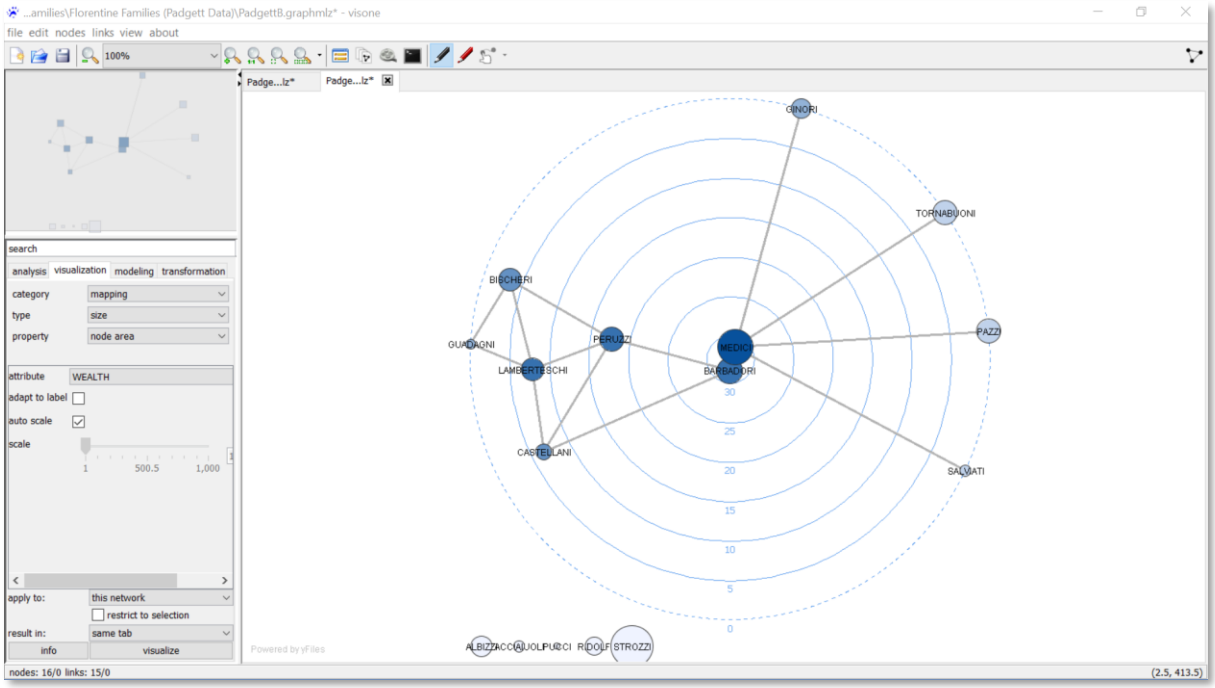
If you navigate to the *show & edit* tab of the *attribute manager*, you should see, aside from all the centralities we've calculated in part 2, the Lat, Long, PRIORS and WEALTH attributes with all their values with the correct nodes. This type of automated importing will greatly speed up the adding of attribute data to your nodes, compared to manually adding them in visone's *attribute manager*.



Step 2

Now let's provide some insight into this attribute data as part of the current centrality layout visualization we have created in Part 2.

Go to the *visualization* tab of the main window and in *category* mapping and *type* size, change the *node area* to match the "WEALTH" *attribute*.



Interestingly, while the MEDICI node, may be most central where it comes to business relations (from both a degree and betweenness centrality-perspective), in terms of wealth it was eclipsed by the STROZZI.

Try it yourself: See if the same pattern holds up when it comes to political offices and marriage relations between the families.

To do this, import the node attributes into PadgettM and visualize the number of PRIORS.

Step 3

Now let's reflect on the context of our networks. As we now know the Medici family managed to become and stay a dominant force in Florence and even European politics for the centuries to come. As the attribute data indicates, in the early 15th century the Medici were neither the most powerful from a wealth of political office perspective. What our network analysis shows is that, while they may not have been the richest or most politically embedded, the Medici family members were excellent at leveraging a different kind of power: that found in networks between (groups of) people. We've illustrated (one of) the points made in Padgett and Ansell's *The Rise of the Medici* paper.

This is also the point of network analysis, to explore the structure of connections between entities, such as Florentine families and thereby coming to some surprising insights into historic, social, cultural, and other forms of relational phenomena.

Save your networks as .graphmlz files.

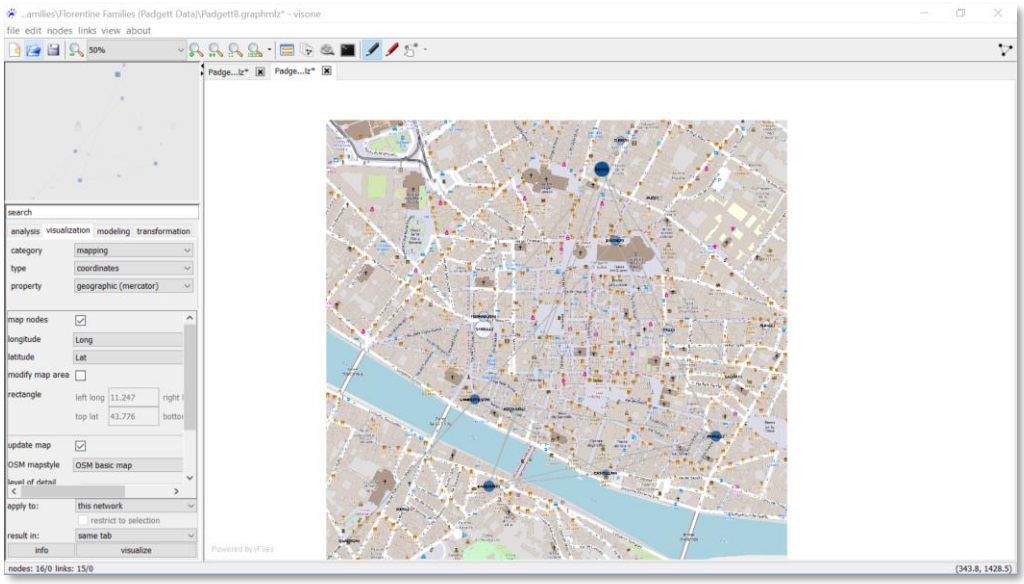
Step 4 (Bonus)

As a little extra feature, visone also allows you to use some map-based visualizations to augment your network visualizations. For this you will need to be connected to the internet as visone will connect the servers of Open Street Map to acquire the map data.

To show this in action in the *visualization* tab and with *category* set to "mapping", set *type* to "coordinates" and *property* to "geographic(mercator)"

Make sure to set *longitude* to "Lon" and *latitude* to "Lat." Leave all other settings the same and press *visualize*.

You will now see a modern map of Florence and a geographically layouted network of the Florentine families (feel free to give a different color to the links to make them stand out from the map background more). From this we can safely conclude that (as is to be expected) geographic distance between palazzi does not seem to factor into either business or marriage relations.



Assignment: Visualizing the combined and weighted network of PadgettM and PadgettB.

In the folder you downloaded for this tutorial you will **find the CSV file PadgettB+M_Valued**. It contains a matrix that is the merger of the M(arriage) and B(usiness) networks. This is an undirected, weighted network. This means that the values of the links, in the intersections of the rows and columns of the matrix have been given a specific value.

In this network links can be either absent (0) or have a strength of 1 or 2. A link with strength 1 indicates a family that is only connected by a marriage or business tie. A link with strength 2 indicates a family that is connected by both a marriage and business tie.

1. Use this file and the PadgettAttrib.csv file to make a **a single network visualization** that:
   - Uses one of visone's many visualization options to **visualize the strength of the links**
     - There is a link attribute which should be named "csv value" that holds these values.
     - In the *visualization* tab and the "mapping" *category*, you will be able to change to link properties in the *property* dropdown list.
   - Is a comparison that shows the differences in the measures of **betweenness** and **eigenvector** centrality of nodes in the network. You will **make use of the weight** of the links for the *link strength* in the measure of the eigenvector centrality.
   - **visualizes the PRIOR attribute** of all nodes in some way.
   - **has node labels** showing the family name.
   - Is **exported as a .png file** to the same folder as the one you have used for the tutorial.
2. In a **separate word document** (saved in the same folder as the one you have used for the tutorial):
   - **List all the dyads that are connected by both business and marriage ties** (i.e. all nodes connected by a link with a strength of 2).
   - **Provide the density** of the PadgettB+M network.
   - Provide an **explanation in your words of what *eigenvector* centrality is** and **how you would interpret it** in the case of the Florentine family network of business and marriage ties.
     - The Wikipedia article or this explanation by Massimo Franceschet on eigenvector centrality should provide some context.
   - **Provide a legend** to your network listing all visual properties used and what they indicate.
3. You will probably have noticed the isolated PUCCI node. **Change the adjacency matrix** in PadgettB+M_Valued.csv to give the PUCCI nodes the following relations (NB this is not based on any historical data):
   - A link of strength 1 with MEDICI
   - A link of strength 1 with BARBADORI
   - A link of strength 2 with ACCIAUUOLI

   Save this matrix as PadgettPUCCI.csv. U**se this new matrix to create a visualization with the same measures and visual properties as you've chosen for question 1** of this assignment. The only thing that should be different are the new PUCCI links. **Don't forget to export this network as a .png.**

4. Save both networks as .graphmlz files in the folder you also used for the tutorial. Zip the entire folder **and hand it in via blackboard** before the deadline. Your **zip file should contain:**
    - The original .csv files used for the tutorial and the assignment.
    - The PadgettPUCCI.csv file with the matrix you changed to include some Pucci family relations.
    - The .graphmlz of the network you created in Part 1 of the tutorial.
    - The .png file of the network you created in Part 1 of the tutorial.
    - The .graphmlz files of the networks you created in Part 2.
    - The .graphmlz files of the networks you created in Part 3.
    - The .graphmlz files of the networks you created as part of this assignment.
    - The .png files of the networks you created as part of this assignment.
    - The word document you created as part of this assignment.
    - Remove all other back-up or other files from the folder.

As always, don't wait with starting this assignment until the weekend. If there are any technical issues, e-mail me at a.a.a.mol@hum.leidenuniv.nl

Good luck and have fun exploring this network!