



A Tutorial – on dynamic networks

By Clement Levallois, Erasmus University Rotterdam

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Bio notes



- Education in economics, management, history of science (Ph.D.)
- Since 2008, turned to digital methods for research.
 - data visualization, network analysis, natural language processing, web applications and more.
 - **Member of the “Gephi Community Support” team**
 - **Gephi certified trainer**
- <https://marketplace.gephi.org/service/data-analysis/>
- **Contact, requests for training sessions, feedback welcome:**
 - on twitter @seinecle or www.clementlevallois.net

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Gephi

- Created in 2008 by a core team of 4 French computing engineers inspired by a professor.



The initial Gephi Team

- Mathieu Bastian / [www](#)
- Sebastien Heymann / [www](#)
- Julian Bilcke / [www](#)
- Mathieu Jacomy
- Franck Ghitalla / [www](#)



Gephi

- In 2013,
 - 11 core developers
 - 15 developers of plugins
 - 4 Google Summer of Code
 - One Java Duke Award
 - **210,000 downloads in the past year**
- Localization is available in **French, Spanish, Japanese, Brazilian Portuguese, Russian, Chinese and Czech.**
- About 1,000 academic papers citing Gephi
- Very active forum (www.forum.gephi.org)



Gephi

- A software written in Java for Mac, PC and Linux
- A headless version (the Gephi Toolkit) to generate graphs automatically via API
- An ecosystem of plugins and related tools



- A commitment to open source, quality, and freedom to use.

A note on the slides



Signals an important feature,
or an error to avoid.

A note on dynamics with Gephi



Dynamic networks is an advanced feature in visualization. We assume you are already familiar with Gephi.

(if you are not familiar with Gephi, check first: www.clementvallois.net/training.html)

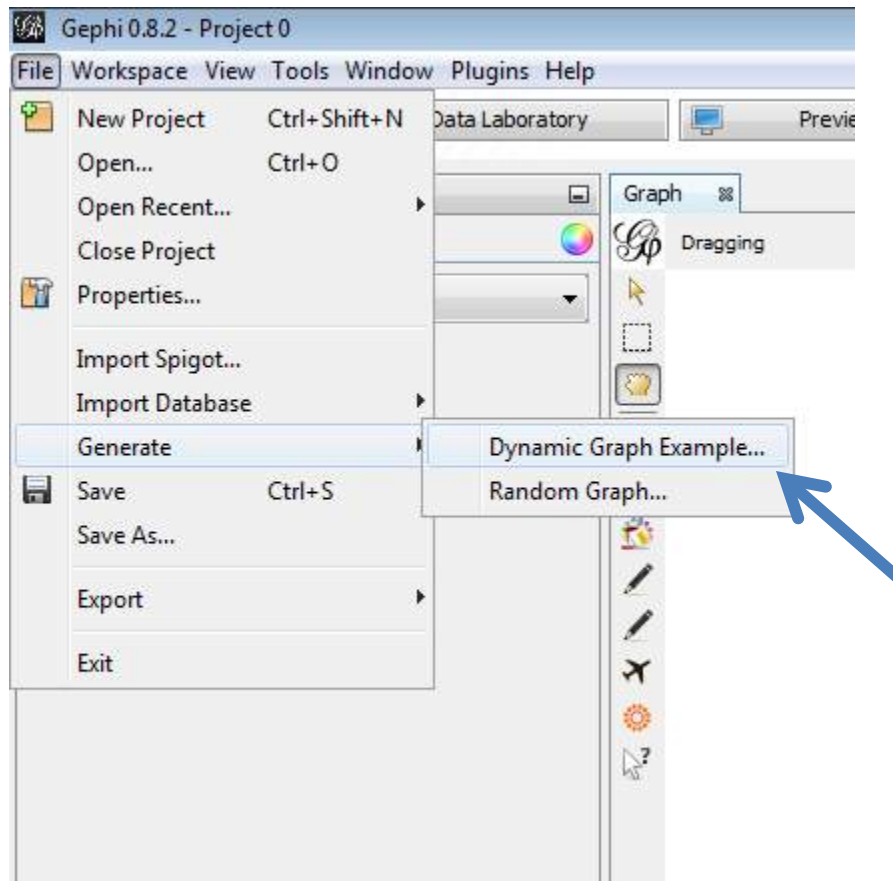
Gephi might become unstable: save your files frequently.

On the bright side: Gephi is the only software providing real time, animated dynamic network visualizations for non programmers. Congratulations, you are at the cutting edge of network viz!

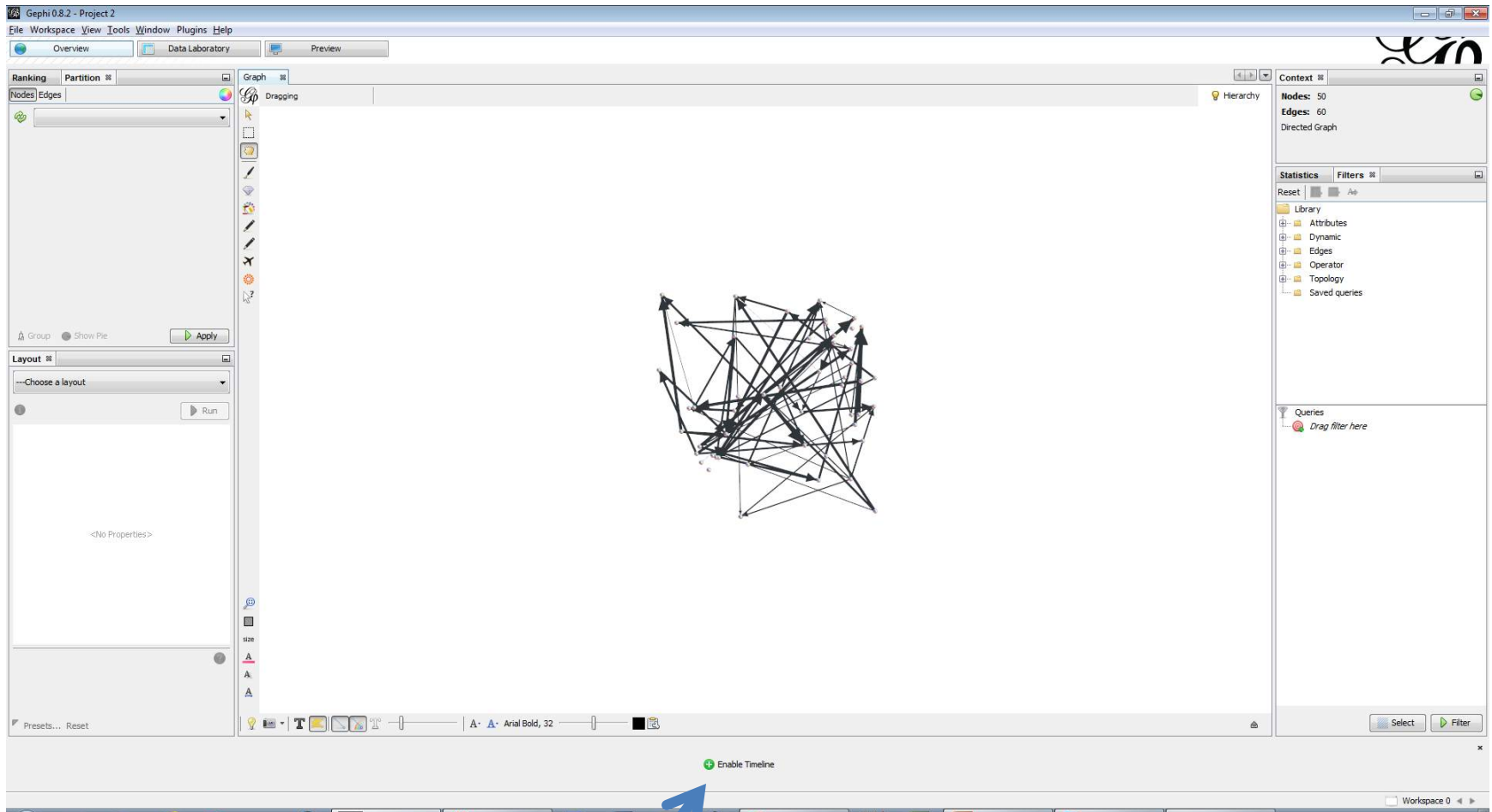
Dynamic topology vs dynamic attributes

- Dynamic topology:
 - Means that nodes and edges will change **positions, appear and/or disappear** through time.
 - Example: <https://gephi.org/2011/the-egyptian-revolution-on-twitter/>
 - Dynamic attributes:
 - Means that a nodes, edges and labels might change in **size and color** through time, to reflect changing values of their attributes
 - Example: <http://youtu.be/jU5Gbh8MNM4>
- => Dynamic topology is “easy”, dynamic attributes is harder (but so interesting!).

Generating a simple dynamic network



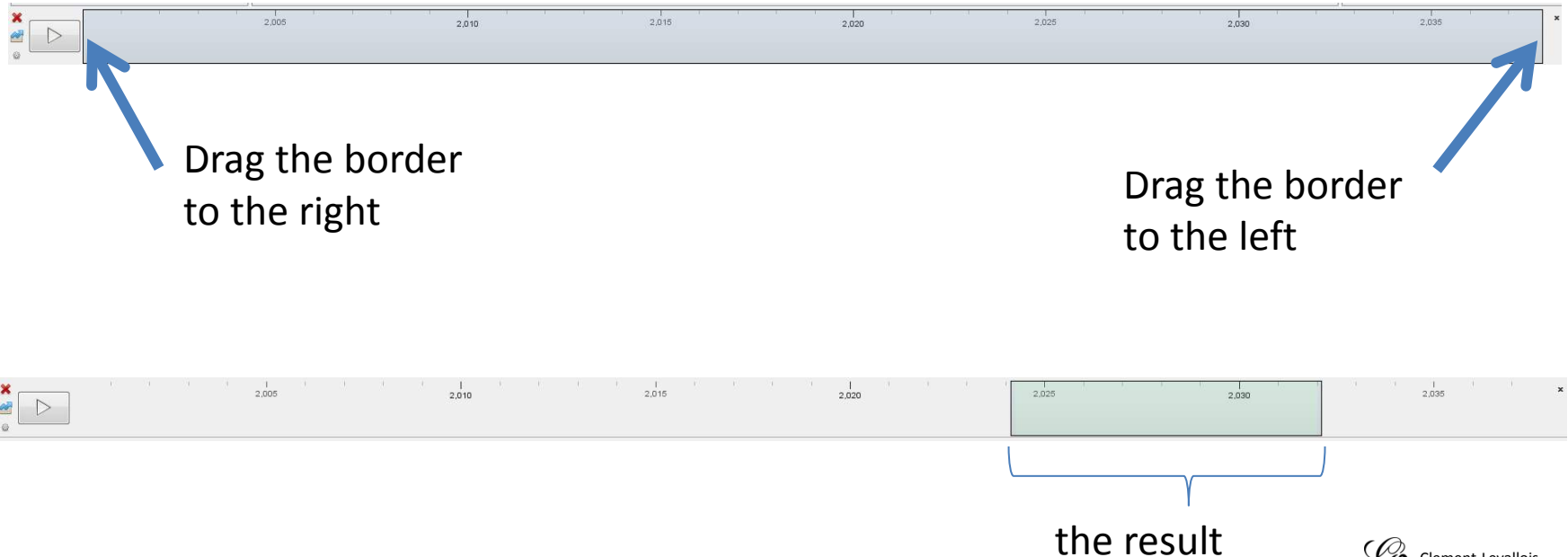
Timeline – 1st enable it!



Timeline – select a time window

When the timeline is enabled, by default the entire time period is selected.

Select a shorter time window by dragging the borders with your mouse.



Animating the timeline



1. Drag the time window with the mouse
(can cause slight changes in the size of the window, annoyingly)

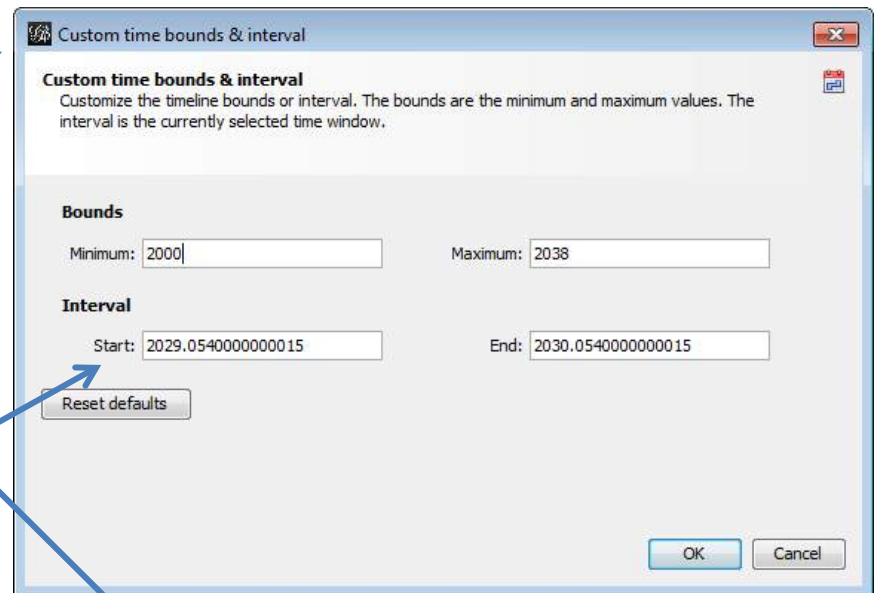
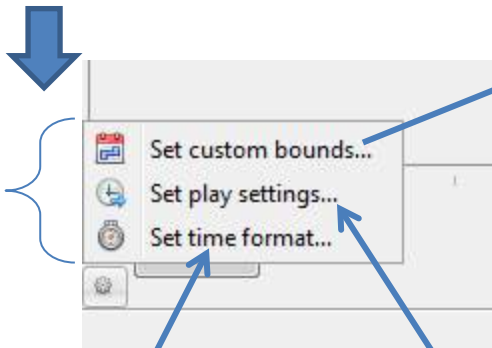


2. Or click the arrow

Timeline: parameters of the animation



1. Clicking on the bottom icon offers three more choices:

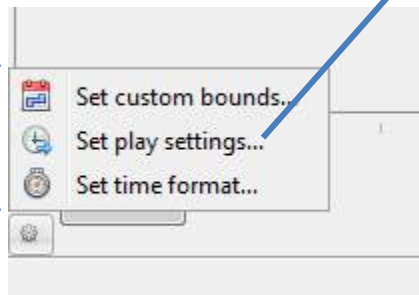


Is your time represented by dates or by arbitrary numbers?
(Gephi should detect that automatically, so **you should not need to use that**)

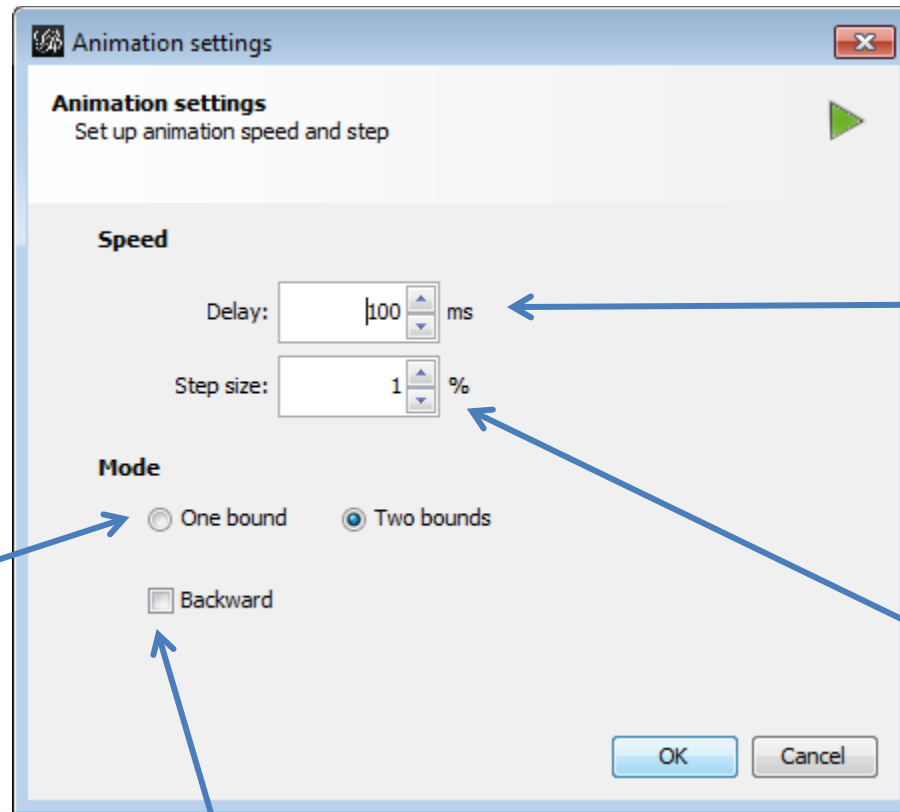
To control the speed of the animation
(see next slide)

Useful to define a time window of exactly one year, for example

More parameters for the animation



Two bounds:
sliding time window.
One bound:
expanding time window.



Larger values
slow down the
animation

Smaller values
make the
animation more
fluid.
1% is the
minimum value.



Select to animate the timeline from
right to left: towards the past

What you should know before playing the timeline

- You can run a layout during the animation!
⇒ it will change the spatial configuration of the network as time lapses
- Ranking operations can be active during the animation!
=> It will change the color / size of nodes / edges / label according to the changing values of their attributes.
- Filters can be “on” during the animation!
=> shows / hides parts of the network, according to parameters that change through time
But it can make the system unstable especially if a layout is running

See next slides for details

Running a layout during an animation

- To try it:
 - Generate a dynamic network (see previous slides).
 - Enable the timeline (), select a small time window that you position at the beginning of the timeline.
 - Run a Force Atlas 2 layout
 - Click on the “play” button of the time line ()

- What you should see:
 - Nodes and edges changing position automatically as time lapses.
- Does it work for every layout?
 - No, only for layouts that loop continuously without ever ending.
 - Force Atlas, Force Atlas 2 and Fruchterman Reingold are such layouts.



To know if a layout is still running, check its “run” button. It should remain red, not turn back to green.

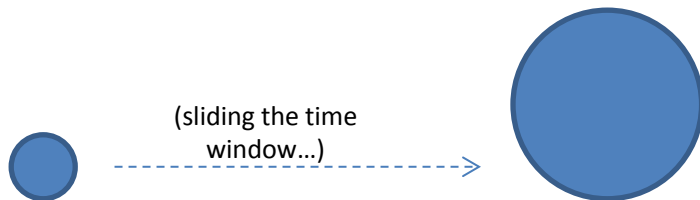
Running a ranking operation during an animation

What is ranking in dynamic networks?

Let's imagine you have a dynamic network where nodes have a "kilogram" attribute.

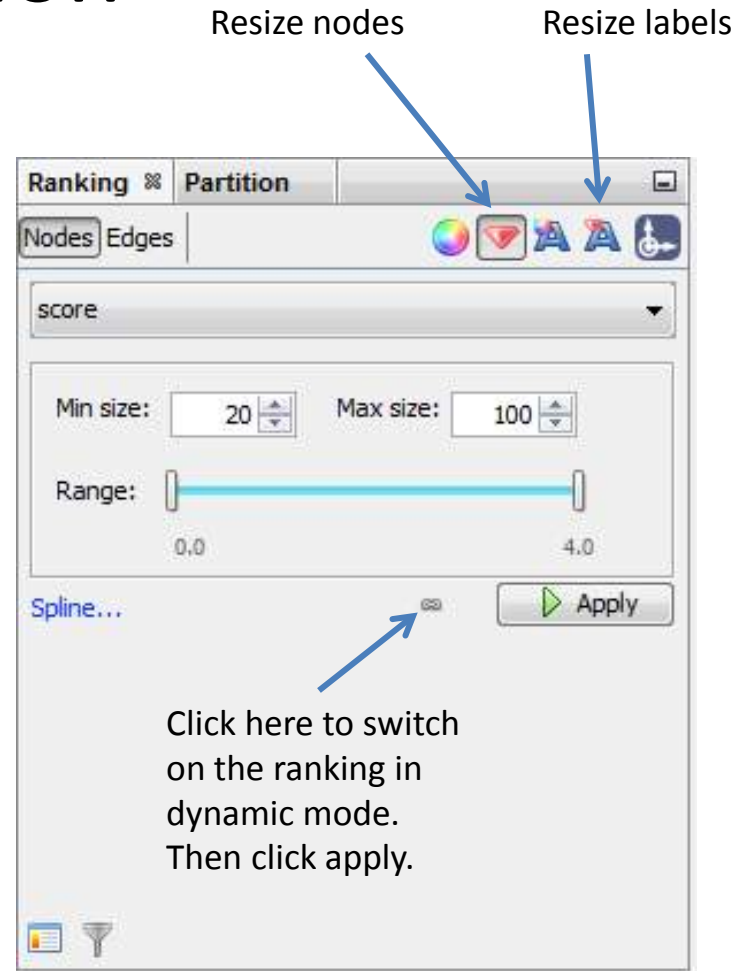
This attribute has different values at different dates.

By applying a "continuous ranking", the size of the node will change to reflect the value of this attribute in the current time window.



Node A will appear small in 2013/01/17 because the kilogram value of node A at this date is **25**.

Sliding to 2013/03/15, node A will grow (automatically) to a bigger size because the kilogram value of node A is **85** at this date.



Running a ranking operation during an animation

(see previous slide for the first part on ranking in a dynamic network)

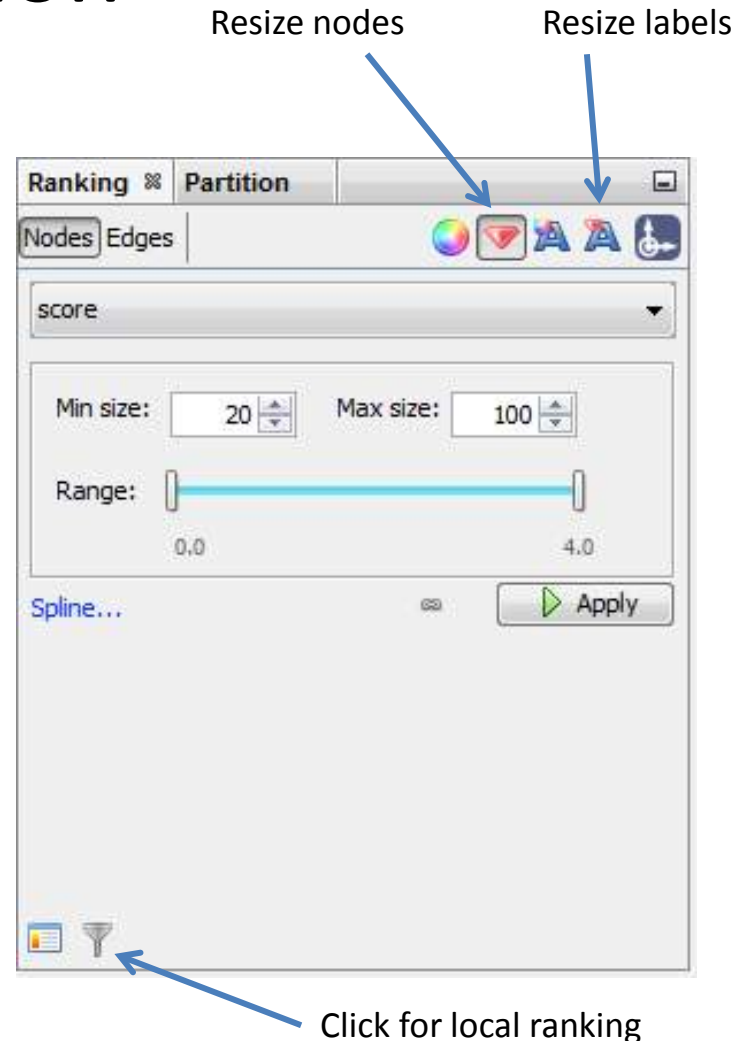
The values of the “kilogram” attribute in the current time window will determine the size of the nodes – in two possibilities:

- Global ranking (default choice):

If the “kilogram” attribute varies from 0 to 100 across the whole network, then the ranking will apply across this range.

- Local ranking (click on the icon):

If the “kilogram” attribute varies from 0 to 100 across the whole network, but only from 0 to 20 in the period covered by the time window, then the ranking will apply from 0 to 20. With the time window sliding, the local ranking is applied across a range which is continuously adjusted to reflect the current extreme values of the attribute.

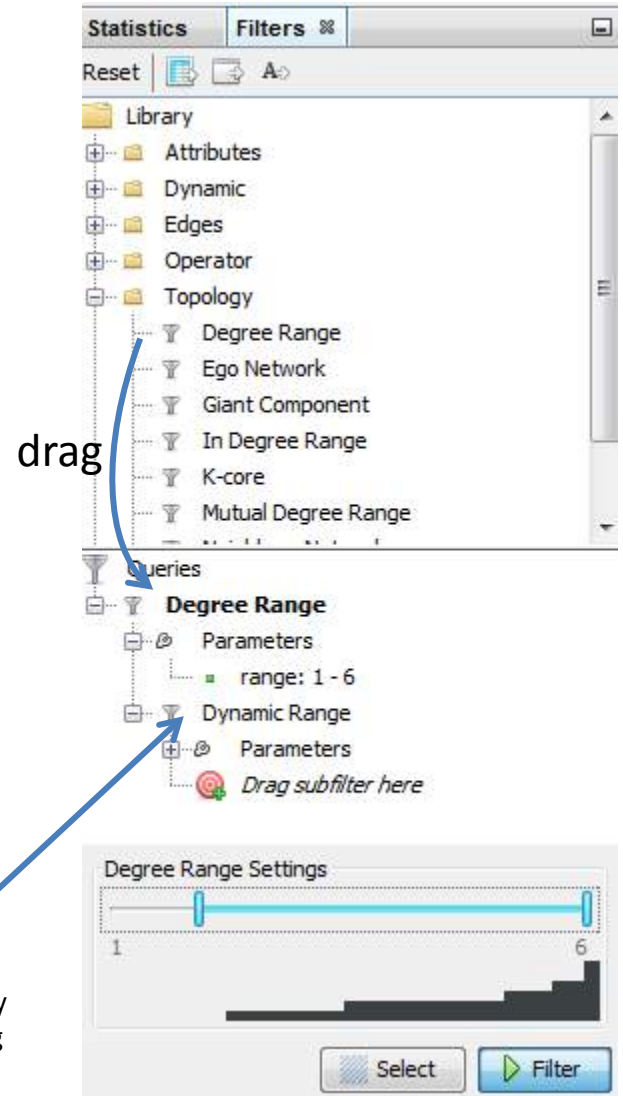


Filters in an animation

- Filters work in an animation just as they do normally, **just nest the dynamic filter inside the filter you select**
- Tip: Animations can cause that many nodes flicker around, because in the current time window they don't have edges.

=> Using a “degree range” filter to only show nodes with degree > 0 (which you find in the **topology** library) can help reduce the visual clutter.

This “dynamic range” filter is automatically created by Gephi when the timeline is enabled. You need to drag it inside the “degree range” filter as shown here for the degree range filter to work.



Importing a dynamic network through the data laboratory

- We have a Twitter network created with NodeXL
- Edges of this network have a timestamp
- Goal: import this network in Gephi and visualize the network evolve through time.



Let's be clear about this dataset:

- Is the topology evolving? Yes, to some extent.
 - edges appear (once) and disappear (once). But nodes remain static (always present).
- Are the attributes evolving? No.
 - Nodes and edges have attributes, but these attributes are not time dependent (they are static, with a unique value throughout).
- To insist: Gephi can handle more dynamics than that!
 - (nodes appearing and disappearing several times during the animation, same for edges, and attributes for nodes and edges evolving too!!)
- Anyway, we'll start from that.

Preprocessing of the edge list in Excel

N	O	P	Q	R
Other Columns				
Date start	Date end	Relationship	Relationship Date (UTC)	Edge Weight
27-03-13 16:36	27-03-13 22:36	Mentions	27-03-13 16:36	1
27-03-13 16:49	27-03-13 22:49	Mentions	27-03-13 16:49	1
27-03-13 16:56	27-03-13 22:56	Mentions	27-03-13 16:56	1
27-03-13 17:00	27-03-13 23:00	Mentions	27-03-13 17:00	2
27-03-13 17:25	27-03-13 23:25	Mentions	27-03-13 17:25	2
27-03-13 17:26	27-03-13 23:26	Mentions	27-03-13 17:26	2
27-03-13 17:38	27-03-13 23:38	Mentions	27-03-13 17:38	1
27-03-13 17:45	27-03-13 23:45	Mentions	27-03-13 17:45	1
27-03-13 18:12	28-03-13 0:12	Mentions	27-03-13 18:12	2
27-03-13 18:17	28-03-13 0:17	Mentions	27-03-13 18:17	2

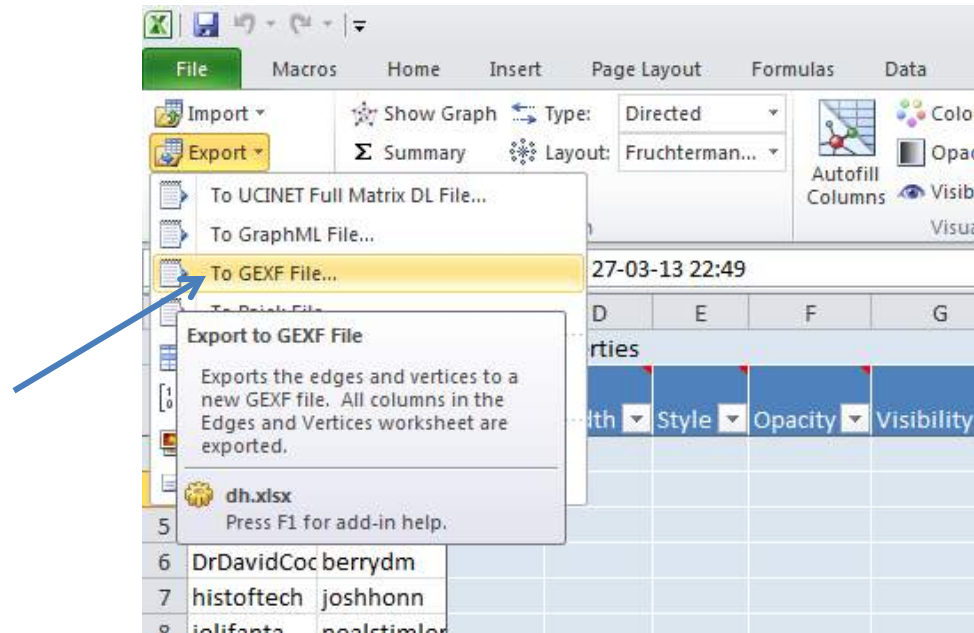
2. Same column as column Q, but reformatted as text. (steps: copy column Q in a text editor, then paste back to column N).

3. [optional column] Using an Excel function, this column adds 6 hours to the date of start in column Q.
Function for cell O3:
`=Q3+TIME(6,0,0)`.
Then it is transformed from date to text by the same process as used in **2**.

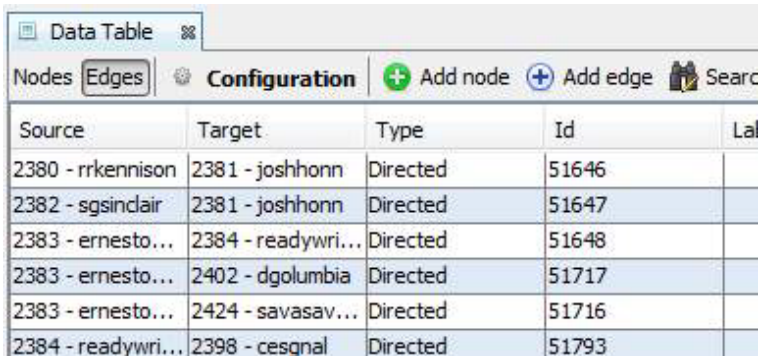
1. The original column with the date of the tweet. It is in Excel's "date" format, which is unsuitable for dynamics in Gephi.

Import Excel data to Gephi

- Through the “Import Spreadsheet” function of the data laboratory in Gephi
 - See the “Gephi: a tutorial” training material for a refresher:
www.clementvallois.net/training.html
- Or since our data is in NodeXL, use NodeXL’s export function to a GEXF file:

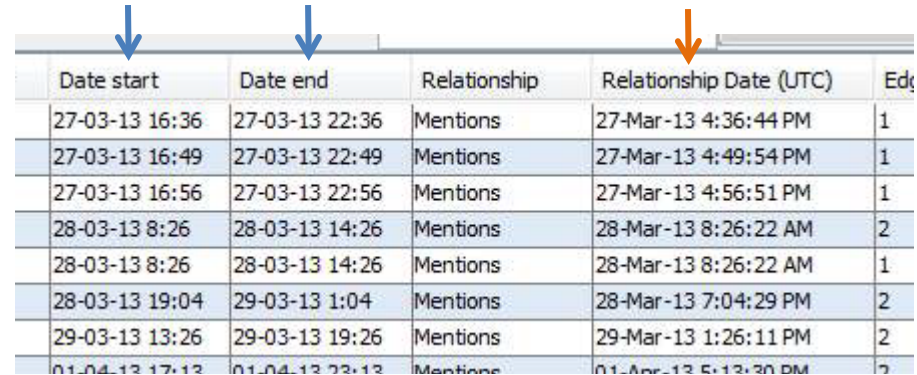


Making a network dynamic with Gephi's data laboratory



The screenshot shows the 'Data Table' window in Gephi. The 'Edges' tab is selected. The table has columns for Source, Target, Type, Id, and Label. The data is as follows:

Source	Target	Type	Id	Label
2380 - rrkennison	2381 - joshhonn	Directed	51646	
2382 - sgsinclair	2381 - joshhonn	Directed	51647	
2383 - ernesto...	2384 - readywri...	Directed	51648	
2383 - ernesto...	2402 - dgolumbia	Directed	51717	
2383 - ernesto...	2424 - savasav...	Directed	51716	
2384 - readywri...	2398 - cesgnal	Directed	51793	




The screenshot shows an Excel spreadsheet with columns for Date start, Date end, Relationship, Relationship Date (UTC), and Edge ID. Blue arrows point to the 'Date start' and 'Date end' columns, and an orange arrow points to the 'Relationship Date (UTC)' column. The data is as follows:

Date start	Date end	Relationship	Relationship Date (UTC)	Edge ID
27-03-13 16:36	27-03-13 22:36	Mentions	27-Mar-13 4:36:44 PM	1
27-03-13 16:49	27-03-13 22:49	Mentions	27-Mar-13 4:49:54 PM	1
27-03-13 16:56	27-03-13 22:56	Mentions	27-Mar-13 4:56:51 PM	1
28-03-13 8:26	28-03-13 14:26	Mentions	28-Mar-13 8:26:22 AM	2
28-03-13 8:26	28-03-13 14:26	Mentions	28-Mar-13 8:26:22 AM	1
28-03-13 19:04	29-03-13 1:04	Mentions	28-Mar-13 7:04:29 PM	2
29-03-13 13:26	29-03-13 19:26	Mentions	29-Mar-13 1:26:11 PM	2
01-04-13 17:13	01-04-13 23:13	Mentions	01-Apr-13 5:13:30 PM	2

This is the list of edges seen from Gephi's data laboratory after opening the network imported from NodeXL.

Note the two columns "Date start" and "Date end" that we created in Excel – see previous slides.

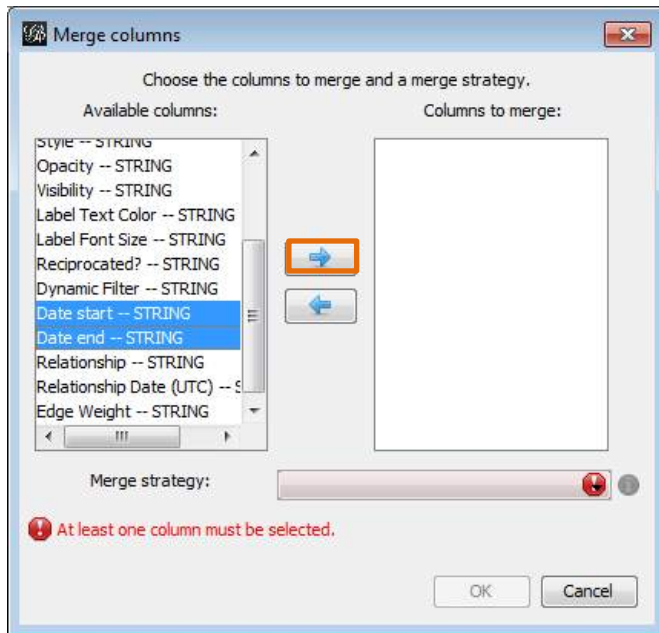
 Only one column is actually necessary for the creation of a dynamic network. With just one column, Gephi assumes that edges are created (at the given date) and then stays for ever. Here, our 2nd column "Date end" specifies that after 6 hours, the edge is deleted from the network.

Note how the column we had before preprocessing ("Relationship Date (UTC)") is not properly formatted for dynamic networks in Gephi, because months are indicated in full letters, not numerals. That is the reason why we preprocessed the data in Excel (to get months into 2 digits, get rid of the "AM / PM" indication etc.).

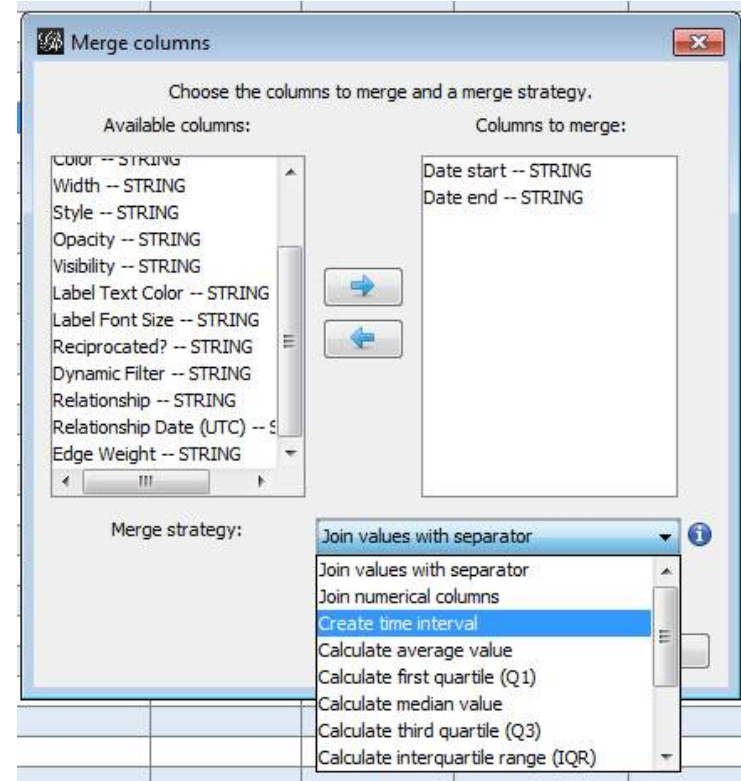
See next slide for the action!

The Merge Column function

2. With the arrow, move “Date Start” and “Date end” to the right empty window



3. Select “Create time interval”



1. Click on “Merge columns” in the bottom icon bar of the data laboratory. Make sure you are in the “edges list” view!



Final step: create time interval

Create time interval

Time Interval creation options

Choose columns to use as start and/or end times.
Also you can choose default start and end times to use when values are not correct or missing, else infinity will be used instead.

Start time column:

End time column:

Parse numbers

Default start time:

Default end time:

Parse dates

Date format:

Default start time:

Default end time:

Leave that empty if you don't have a 2nd column



Careful here: make sure the date format matches exactly the date format of your columns!

A mistake will make Gephi unstable.

Our dates are like:

27-03-13 15:27

So the format is:

dd-MM-yy HH:mm

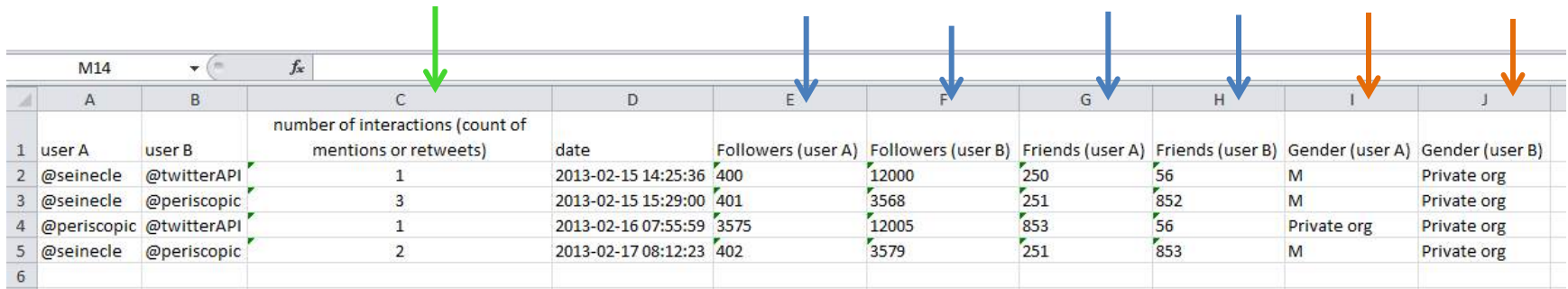
And that's it! You can now switch to the overview, activate the timeline & play the animation.

Import daily data with Eonydis

This is a mock example of a twitter network between 3 users of twitter.

Each line shows how many interactions 2 users have had this day, + some info about each user.

You can download it from www.clementvallois.net/gephi/tuto/exceldynamic.xlsx



	A	B	C	D	E	F	G	H	I	J
	user A	user B	number of interactions (count of mentions or retweets)	date	Followers (user A)	Followers (user B)	Friends (user A)	Friends (user B)	Gender (user A)	Gender (user B)
1	@seinecle	@twitterAPI	1	2013-02-15 14:25:36	400	12000	250	56	M	Private org
2	@seinecle	@periscopic	3	2013-02-15 15:29:00	401	3568	251	852	M	Private org
3	@periscopic	@twitterAPI	1	2013-02-16 07:55:59	3575	12005	853	56	Private org	Private org
4	@seinecle	@periscopic	2	2013-02-17 08:12:23	402	3579	251	853	M	Private org
5										
6										

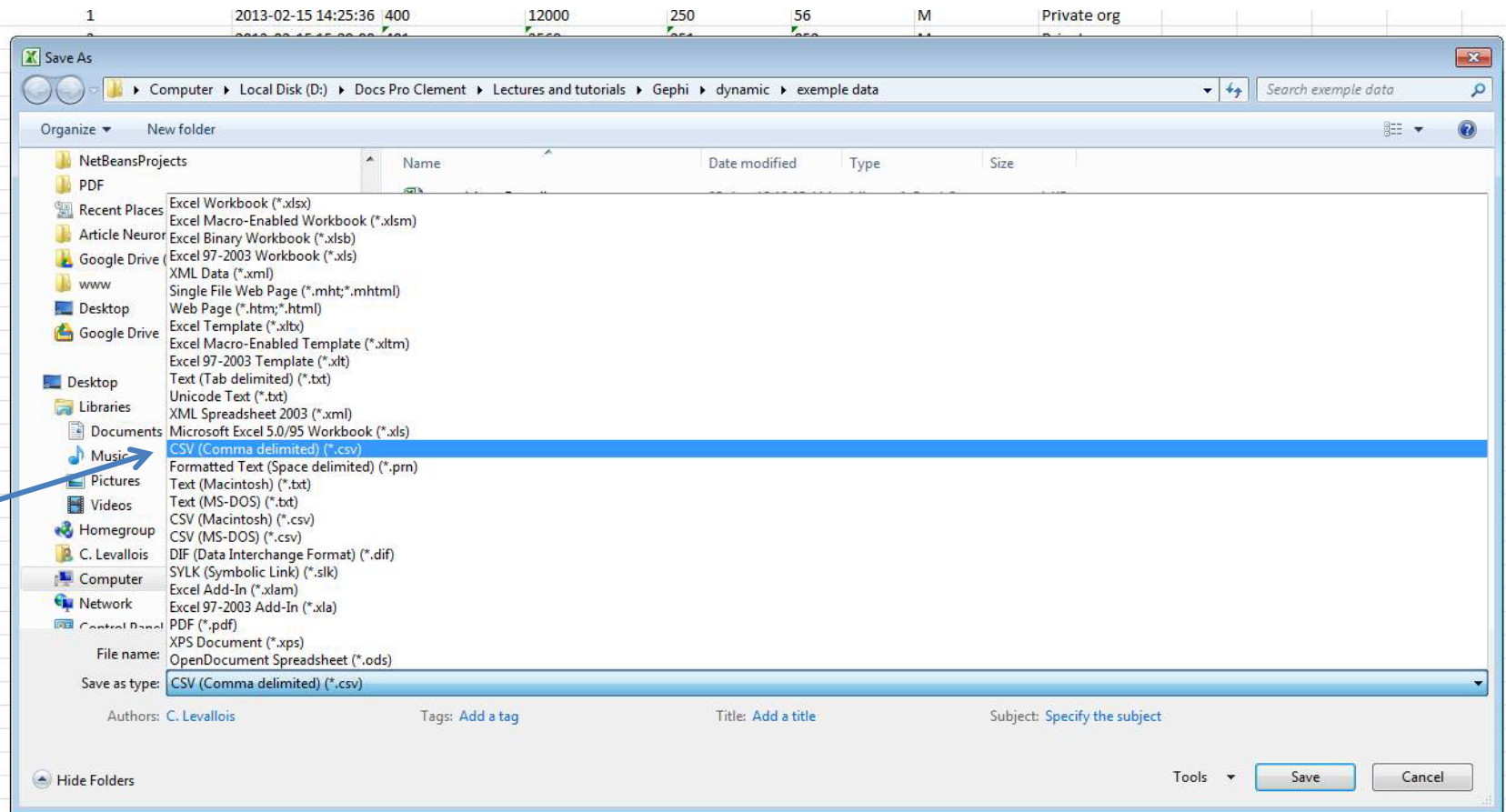
Blue arrows denote dynamic attributes for nodes.
For example, the number of followers of @seinecle is not a static value: it increases day after day

Orange arrows denote static attributes for nodes.
For example, the value of "Gender" for each twitter user will presumably remained unchanged across the dataset.

The green arrow denotes a dynamic attribute for edges.
For example, the connection between @seinecle and @periscopic changes over time: it has a "strength" of 3 one day, and of 2 another day.

Eonydis: from dynamic data in a spreadsheet to Gephi

1. Save your Excel file with “save as”, as a csv file.



Eonydis: from dynamic data in a spreadsheet to Gephi with Eonydis

2. Download and unzip Eonydis from www.clementvallois.net/portfolio.html
3. Launch “eonydis_1.1.exe” for PC, or “Eonydis.jar” for Macs.
4. Click on “Select file” and select the csv file you just saved (see previous slide).

- In the screens that follow select...

... “Source node”: the first node of the edge

=> “user A” in our example

... “Target node”: the second node of the edge

=> “user B” in our example

... “Attributes for source node”: select all attributes for user A

=> “Followers (user A)”, “Friends (user A)” and “Gender (user A)” in our example

... “Attributes for target node”: select all attributes for user B

=> “Followers (user B)”, “Friends (user B)” and “Gender (user B)” in our example

... “Attributes for edge weight”: select the attribute for the edge’s strength

=> “number of interactions (count of mentions or retweets)” in our example

- In the screens that follow select...

... “Other edge attributes”: the edge attribute that will act as the weight of the edge
=> we have no other edge attribute in our example, so we click on “next”

... “Select static attributes”: among the attributes we listed, which one are static?
=> only “Gender” is static in our example. We select it.

... “Select textual attributes”: among the attributes we listed, which one are made of text, not numbers?
=> only “Gender” is a text attribute in our example. We select it.

... “Select attributes to be averaged”: should multiple values in the same day be summed or averaged?
=> In our case we would prefer to sum them, but in the case of an interest rate for example an average could have made sense.

... “Select attributes to be averaged”: should multiple values found on the same day be summed or averaged?
=> In our case we would prefer to sum them, but in the case of an interest rate for example an average could have made sense.

... “Indicate the format of your time field”

use y for years, d for days, m for months, h for hours, i for minutes, s for seconds, and # for any other character.

=> In our Excel example, the dates are in the form: 2013-02-15 14:25:36 => so in Eonydis this translates into:
yyyy#mm#dd#hh#ii#ss

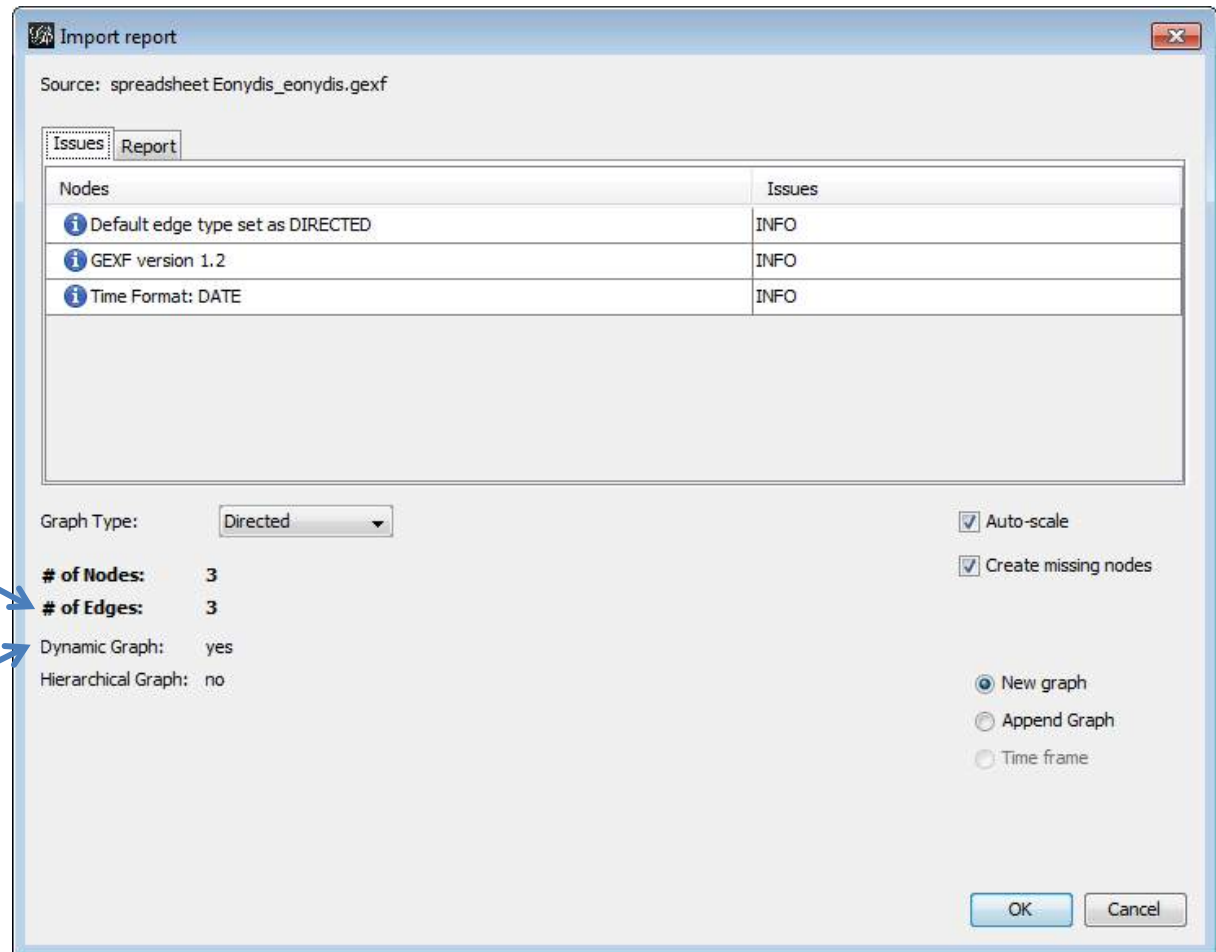
Eonydis – creation of the gexf file

- The previous steps lead to the creation of a gexf file located in the same folder as your Excel file. You can import it in Gephi.
- Eonydis works in a few seconds, if it get stuck:
 - See the “bug” section at the bottom of this page:
<https://github.com/seinecle/Eonydis/wiki/wiki>

Importing the dynamic network generated by Eonydis into Gephi

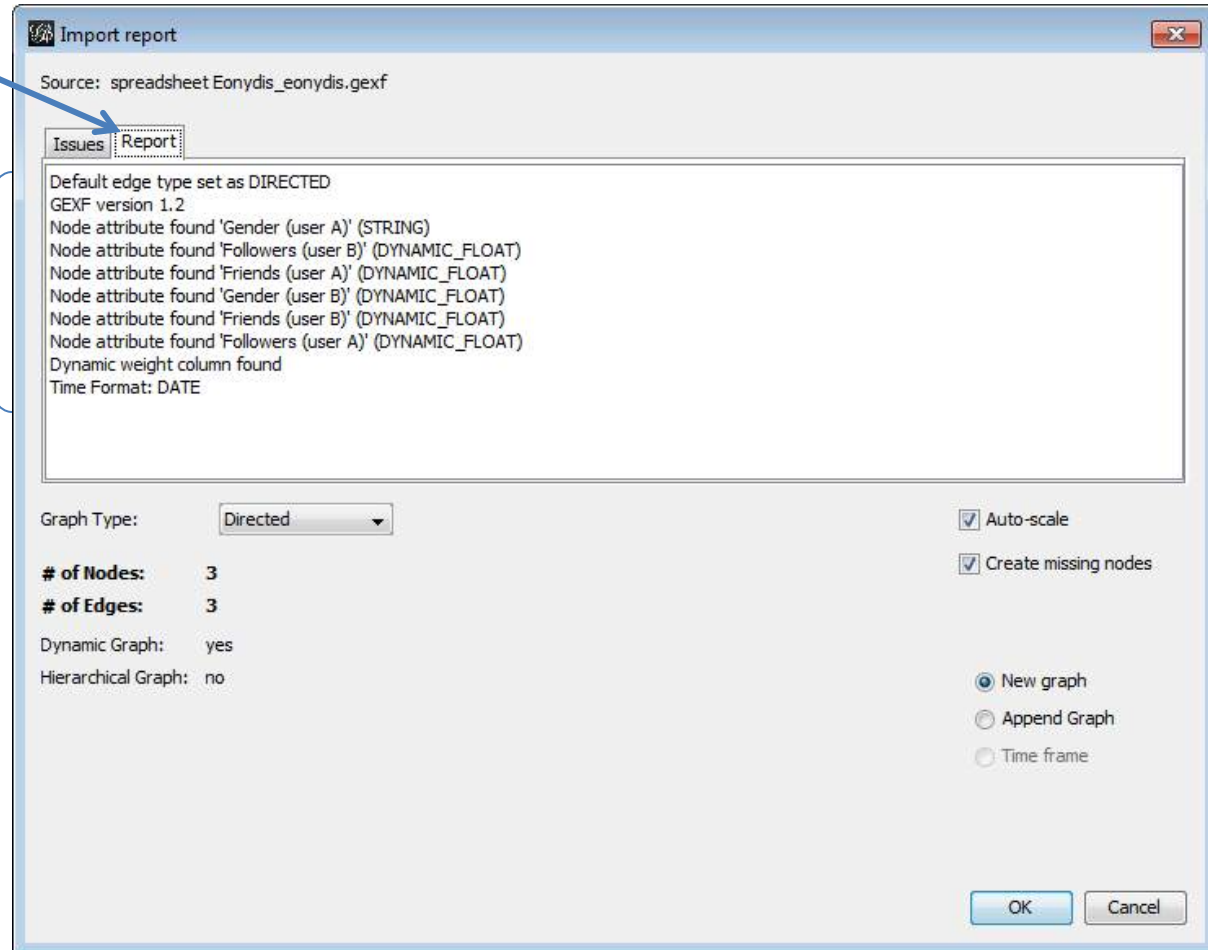
We had 4 rows in Excel, why just 3 edges found?
=> Because 2 rows represented the same edge (@seinecle -> @periscopic), just at 2 different days.
Eonydis has merged these edges into one and created dynamic attributes for it.

The file is recognized as dynamic



List of dynamic attributes found in the import

We switched to the “report” section of the Import window.

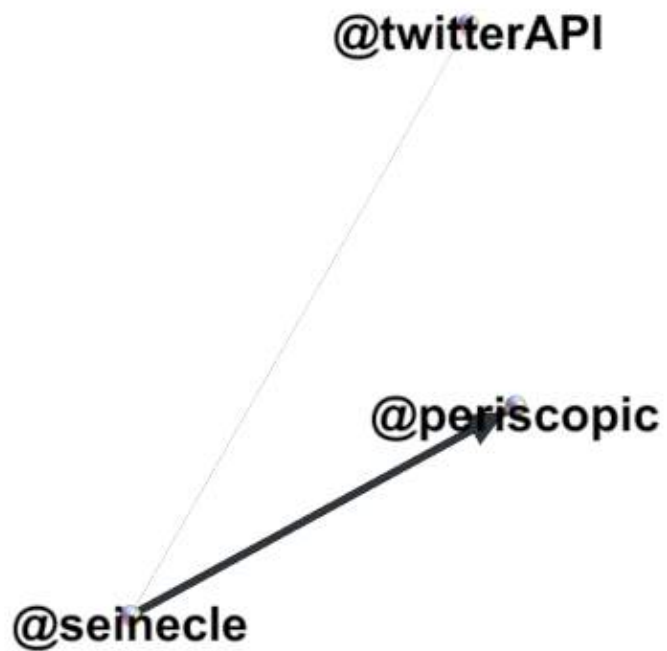


We see that Eonydis created a series of dynamic attributes for the nodes.

Edges have a dynamic weight (which is the count of interactions in our original Excel file).

“Gender” has been properly recognized as a STRING attribute (meaning: text, and static) for nodes.

Result



Appendix



The Overview Panel

Where all the functions are available to explore the network visually.

Partition

(tab hidden here)

For categorical attributes.

Example:
to color all nodes representing males in yellow, and all nodes representing females in green

Ranking

For numerical attributes.

Example: the older the individual, the bigger the node. Works with gradients of colors too (ex: the older the indiv., the pinker it is).

Layout

Changes how the network is spread on the screen.

Select one of the layouts in the drop-down menu and apply it to see how the position of nodes is changed.

Statistics

(tab hidden here)

Computes metrics on the network.

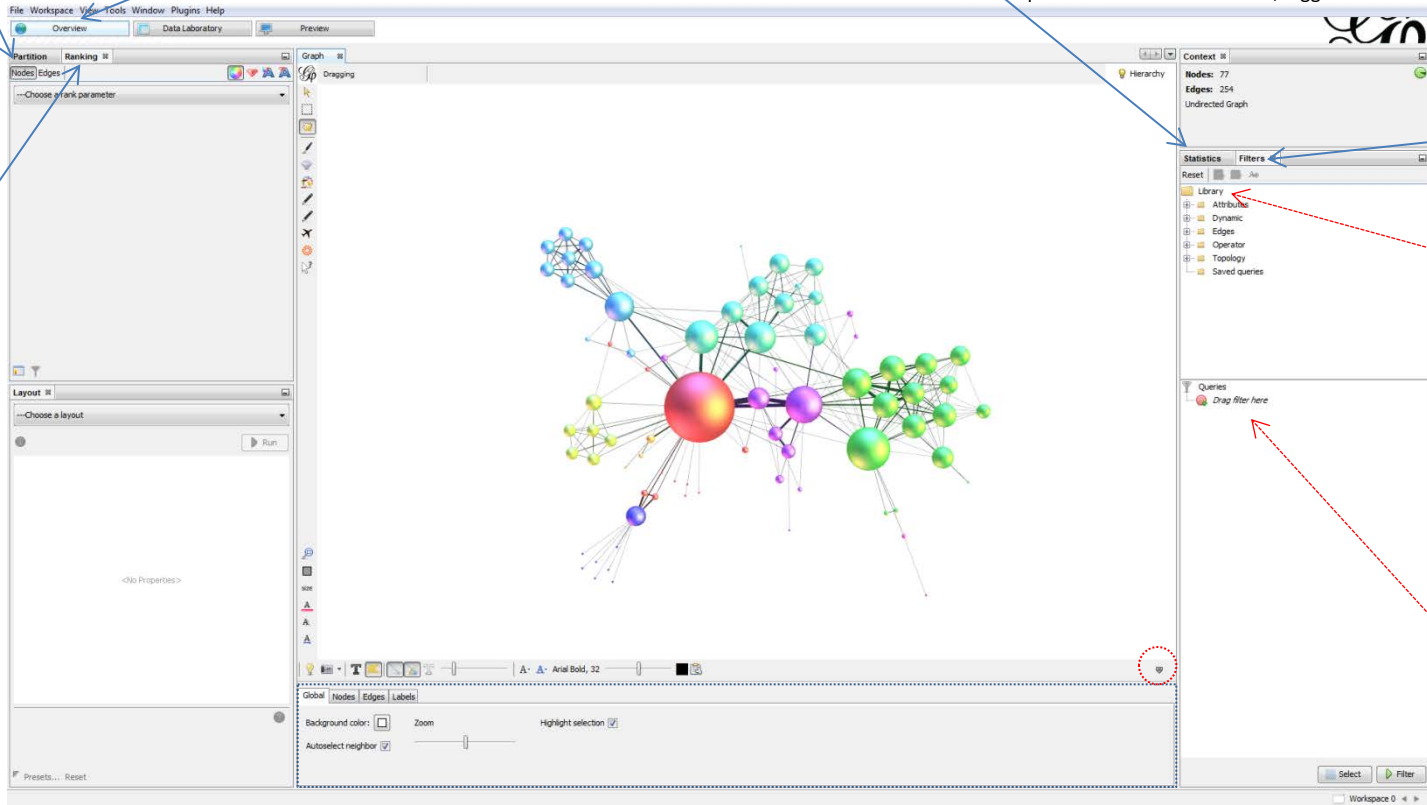
These metrics are recorded, and can then be used to be displayed on the graph. Ex: compute the centrality of nodes. Then use the ranking panel to make central nodes, bigger.

Filters

To hide or display only part of the network.

The "library" and its folders contain the filters. For example, filter out nodes which have less than 3 edges. Or filter out edges which have a weight above some value.

Drag and drop the filter you choose in the "queries" window. Several filters can be combined (ex: filter out male indiv. that have less than 3 connections to others).



General settings for the appearance of nodes, edges and labels

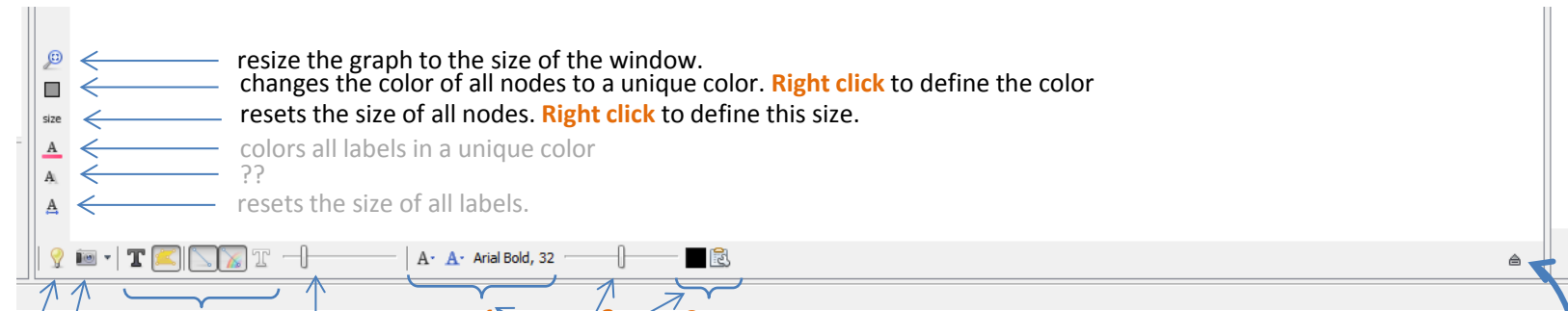
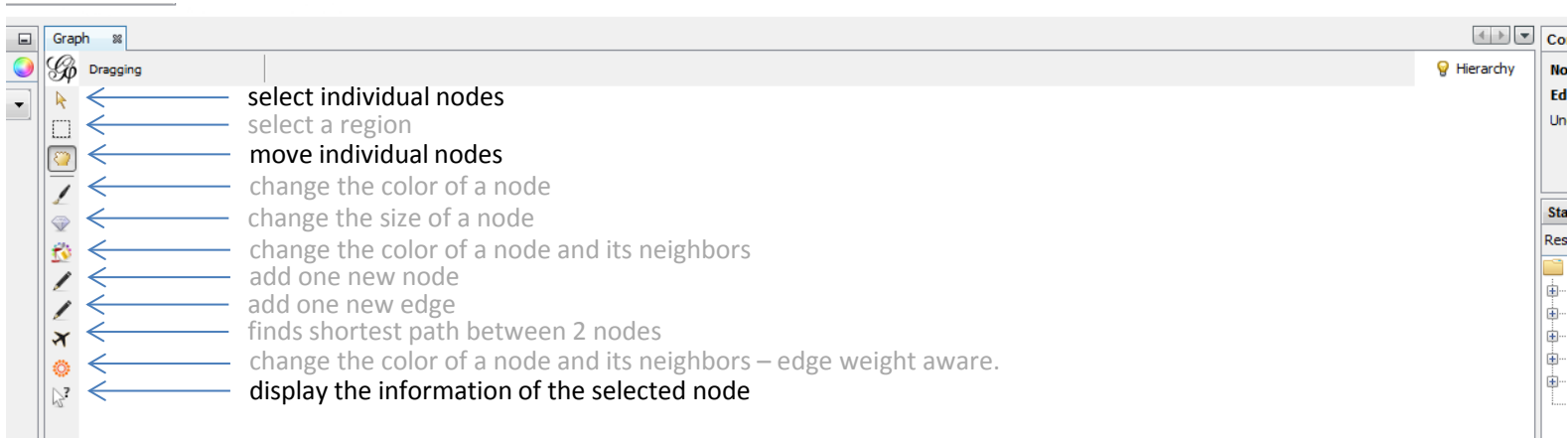
This box of settings can be shown / hidden with the little arrow circled in red on the top right. Here, you can set if nodes are visible in 2D or 3D, what is the default color of edges, etc. The "labels" tab is particularly useful: should they be displayed or not, and at which size.

Gephi Cheat Sheet (2)



Focus on the icons of the Overview panel

Functions which are less frequently used have been grayed out



switch background color! (useful for prints)

export a screenshot. **Click** the arrow for resolution settings

from left to right, switch on or off the display of:

- nodes labels
- hulls (not implemented yet)
- edges
- edge of the color of the source node
- edge labels

change edge thickness

More label settings:

- 1**, the 3 buttons on the left:
 - label size – should it track the node size?
 - label color – should it track the node color?
 - label font
- 2**, the slider: label size
- 3**, the 2 buttons on the right:
 - label color
 - text to be displayed in the label

How to memorize all these icons??

All these controls are also available with a more explicit description in the panel here.

Once you know these controls well, the icons are a quick way to access them.



Where the numerical and textual data for nodes and edges can be examined and modified.

Import function

Opens a dialog window to import nodes and edges from a csv file into Gephi

To switch between views of nodes & edges

3 default columns for nodes

Node: simply a copy of the label column (or the id if there are no labels).

Id: the unique identifier of the node

Label: the name of the edge which will be displayed next to it if we choose to.

id	Label	Modularity Class
0	Myriel	0
1	Napoleon	0
2	MlleBaptistine	1
3	MmeMagloire	1
4	CountessDeLo	0
5	Geborand	0
6	Champlercier	0
7	Cravatte	0
8	Count	0
9	OldMan	0
10	Labarre	1
11	Valjean	1
12	Marguerite	1
13	MmeDeR	1
14	Tobias	1
15	Gervais	1
16	Tholomyes	2
17	Lustier	2
18	Panneult	2
19	Macheville	2
20	Favourite	2
21	Dahla	2
22	Zephine	2
23	Fantine	2
24	MmeThenardier	7
25	Thenardier	7
26	Cosette	6
27	Javert	7
28	Fauchelevent	4
29	Bernadette	3
30	Perpetue	2
31	Simplice	2
32	Scarfare	1
33	Woman1	3
34	Judge	3
35	Championnet	3
36	Brevet	3

Extra columns
Each node can have extra information, besides its id and label.

This extra info is written in additional columns.

Example:
here, each node is characterized by a number, recorded in a column we choose to call "Modularity class".

Columns can contain numbers, text or booleans (true / false).

Helper functions to quickly edit columns





Where the numerical and textual for nodes and edges can be examined and modified.

Import function

Opens a dialog window to import nodes and edges from a csv file into Gephi

To switch between views of nodes & edges

6 default columns for edges

Source and Target: the two connected nodes forming the edge.

Type: Is the direction of the edge meaningful?

Id: the unique identifier of the edge.

Label: the name of the edge which will be displayed next to it if we choose to.

Weight: how "strong" is the tie between the two nodes forming the edge? This is a numerical value.

Extra columns
Each edge can have extra information, besides its id and label, type and weight.

For example here, I added a column to characterize the connection between the 2 characters of the Miserables: friends or enemies in the novel?

Source	Target	Type	Id	Label	Weight	Friend or enemy
0 - Mesdames	0 - Myriel	Undirected	1		8	
2 - MlleBaptistine	0 - Myriel	Undirected	2		10	
3 - MineMagloire	0 - Mesdames	Undirected	3		6	
4 - MonsieurDelormes	0 - Myriel	Undirected	4		1	
5 - Colobard	0 - Myriel	Undirected	5		1	
6 - Chouppin	0 - Myriel	Undirected	6		1	
7 - Cravatte	0 - Myriel	Undirected	7		1	
8 - Courte	0 - Myriel	Undirected	8		1	
9 - Oldban	0 - Myriel	Undirected	9		1	
11 - Valjean	0 - Myriel	Undirected	13		5	
11 - Valjean	2 - MlleBaptistine	Undirected	12		3	
11 - Valjean	3 - MineMagloire	Undirected	11		2	
11 - Valjean	10 - Labarre	Undirected	10		1	
12 - Marguerite	11 - Valjean	Undirected	14		1	
13 - MmeDelormes	11 - Valjean	Undirected	15		1	
14 - Jeabesou	11 - Valjean	Undirected	16		1	
15 - Gervais	11 - Valjean	Undirected	17		1	Enemy
17 - Listolier	16 - Tholomys	Undirected	18		4	
18 - Faneuil	16 - Tholomys	Undirected	19		4	
18 - Faneuil	17 - Listolier	Undirected	20		4	
19 - Blacheville	16 - Tholomys	Undirected	21		4	
19 - Blacheville	17 - Listolier	Undirected	22		4	
19 - Blacheville	18 - Faneuil	Undirected	23		4	
20 - Favourite	16 - Tholomys	Undirected	24		3	
20 - Favourite	17 - Listolier	Undirected	25		3	
20 - Favourite	18 - Faneuil	Undirected	26		2	
20 - Favourite	19 - Blacheville	Undirected	27		4	
21 - Dahlia	16 - Tholomys	Undirected	28		3	
21 - Dahlia	17 - Listolier	Undirected	29		3	
21 - Dahlia	18 - Faneuil	Undirected	30		3	
21 - Dahlia	19 - Blacheville	Undirected	31		3	
21 - Dahlia	20 - Favourite	Undirected	32		5	
22 - Zephine	16 - Tholomys	Undirected	33		3	
22 - Zephine	17 - Listolier	Undirected	34		3	
22 - Zephine	18 - Faneuil	Undirected	35		3	
22 - Zephine	19 - Blacheville	Undirected	36		3	
22 - Zephine	20 - Favourite	Undirected	37		4	
22 - Zephine	21 - Dahlia	Undirected	38		4	
23 - Fantine	11 - Valjean	Undirected	47		9	
23 - Fantine	12 - Marguerite	Undirected	46		2	
23 - Fantine	16 - Tholomys	Undirected	39		3	
23 - Fantine	17 - Listolier	Undirected	40		3	
23 - Fantine	18 - Faneuil	Undirected	41		3	
23 - Fantine	19 - Blacheville	Undirected	42		3	
23 - Fantine	20 - Favourite	Undirected	43		4	

Helper functions to quickly edit columns



The Preview panel

Where you make final adjustments before exporting your visualization to an image file (PDF, SVG or PNG)

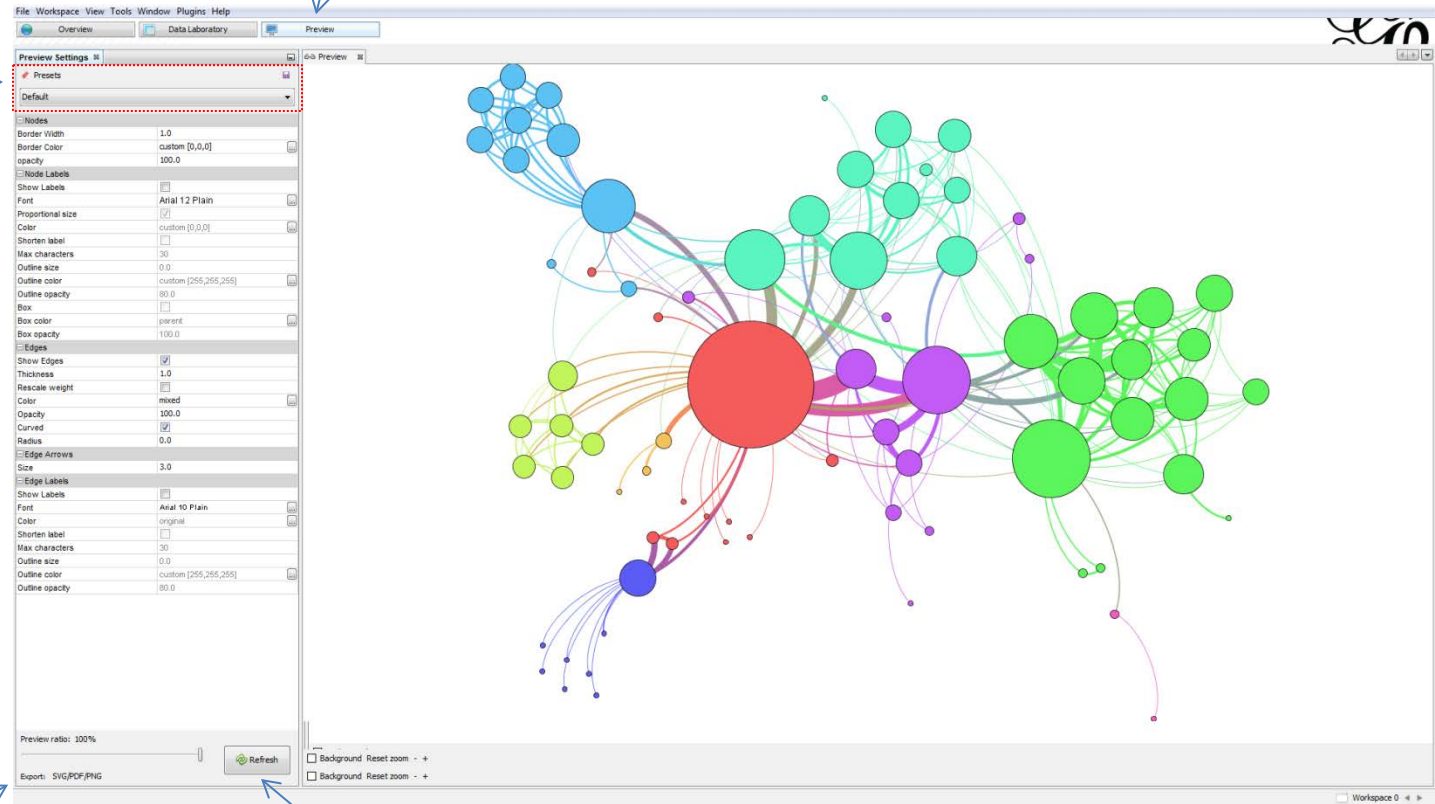
Load or save parameters

1. Setting the parameters

3. Export to a picture file format

2. Hit refresh!

After changing a parameter, you must hit "refresh" to see the effects.



Online tutorials on dynamics with Gephi

from the Gephi website:

https://wiki.gephi.org/index.php/Import_Dynamic_Data

[a video tutorial]

<http://www.youtube.com/watch?v=hKYku8b60Dc>

[in French]

<http://www.htitipi.com/blog/log-dataviz.html>