

# 人工智慧財務金融應用

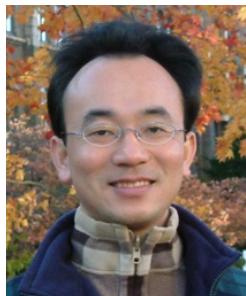
AI in Financial Application

## 社會網絡分析財務金融應用 (Social Network Analysis for Finance Application)

1081AIFA09

EMBA, IMTKU (M2457) (8413) (Fall 2019)

Fri 12,13,14 (19:20-22:10) (D301)



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<http://mail.tku.edu.tw/myday/>

2019-12-27



# 課程大綱 (Syllabus)

週次 (Week)	日期 (Date)	內容 (Subject/Topics)
1	2019/09/13	中秋節 (Mid-Autumn Festival) 放假一天 (Day off)
2	2019/09/20	人工智慧財務金融應用課程介紹 (Course Orientation for AI in Financial Application)
3	2019/09/27	人工智慧投資分析與機器人理財顧問 (Artificial Intelligence for Investment Analysis and Robo-Advisors)
4	2019/10/04	金融科技對話式商務與智慧型交談機器人 (Conversational Commerce and Intelligent Chatbots for Fintech)
5	2019/10/11	國慶日補假 (Bridge Holiday for National Day, Extra Day Off)
6	2019/10/18	財務金融事件研究法 (Event Studies in Finance)

# 課程大綱 (Syllabus)

週次 (Week) 日期 (Date) 內容 (Subject/Topics)

- |    |            |   |
|----|------------|---|
| 7  | 2019/10/25 | 人工智慧財務金融應用個案研究 I<br>(Case Study on AI in Financial Application I)                                       |
| 8  | 2019/11/01 | Python AI智慧金融分析基礎<br>(Foundations of AI in Finance Big Data Analytics with Python)                      |
| 9  | 2019/11/08 | Python Pandas 量化投資分析<br>(Quantitative Investing with Pandas in Python)                                  |
| 10 | 2019/11/15 | 期中報告 (Midterm Project Report)   |
| 11 | 2019/11/22 | Python Scikit-Learn 機器學習財務金融應用<br>(Machine Learning in Finance Application with Scikit-Learn In Python) |
| 12 | 2019/11/29 | TensorFlow 深度學習財務金融應用 I<br>(Deep Learning for Finance Application with TensorFlow I)                    |

# 課程大綱 (Syllabus)

週次 (Week) 日期 (Date) 內容 (Subject/Topics)

- |    |            |  |
|----|------------|--|
| 13 | 2019/12/06 | 人工智慧財務金融應用個案研究 II<br>(Case Study on AI in Financial Application II)                      |
| 14 | 2019/12/13 | TensorFlow 深度學習財務金融應用 II<br>(Deep Learning for Finance Application with TensorFlow II)   |
| 15 | 2019/12/20 | TensorFlow 深度學習財務金融應用 III<br>(Deep Learning for Finance Application with TensorFlow III) |
| 16 | 2019/12/27 | 社會網絡分析財務金融應用<br>(Social Network Analysis for Finance Application)                        |
| 17 | 2020/01/03 | 期末報告 I (Final Project Presentation I)  |
| 18 | 2020/01/10 | 期末報告 II (Final Project Presentation II)  |

# Social Network Analysis (SNA)

# Outline

- Social Computing and Social Network Analysis (SNA)
- Social Network Analysis with Gephi
- Applications of SNA

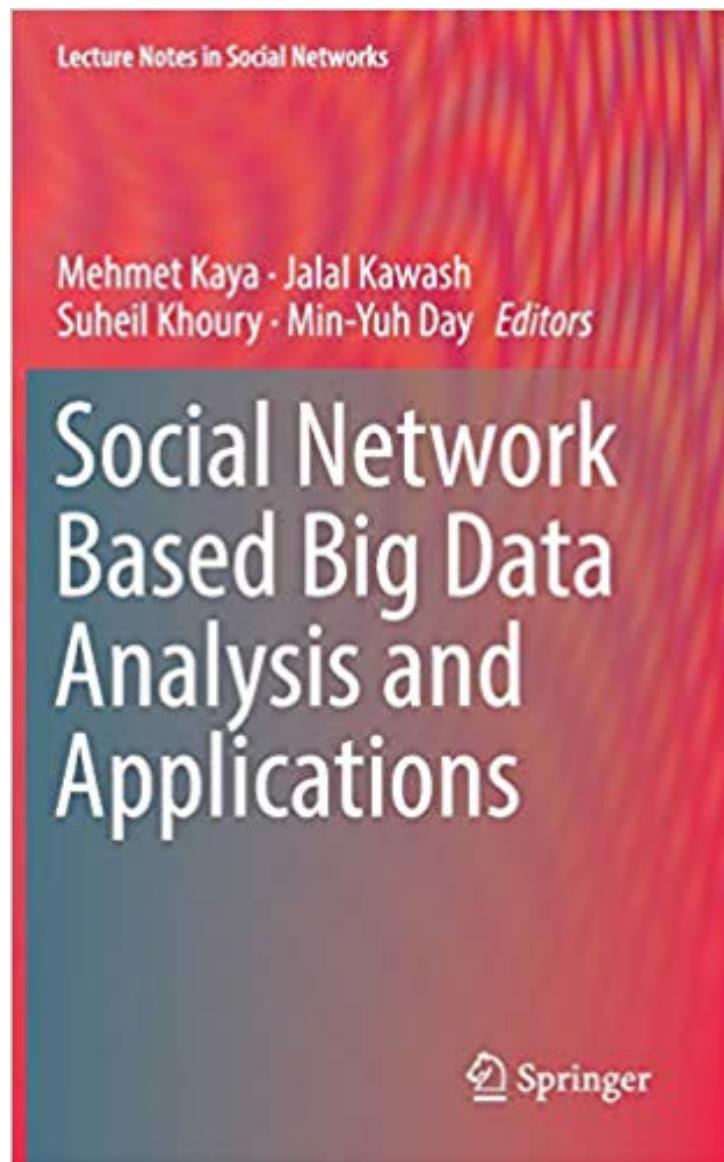
# Social Computing

# Social Network Analysis (SNA)

# Social Computing

- Social Network Analysis
- Link mining
- Community Detection
- Social Recommendation

Mehmet Kaya, Jalal Kawash, Suheil Khoury, Min-Yuh Day (2018),  
**Social Network Based Big Data Analysis and Applications**, Springer

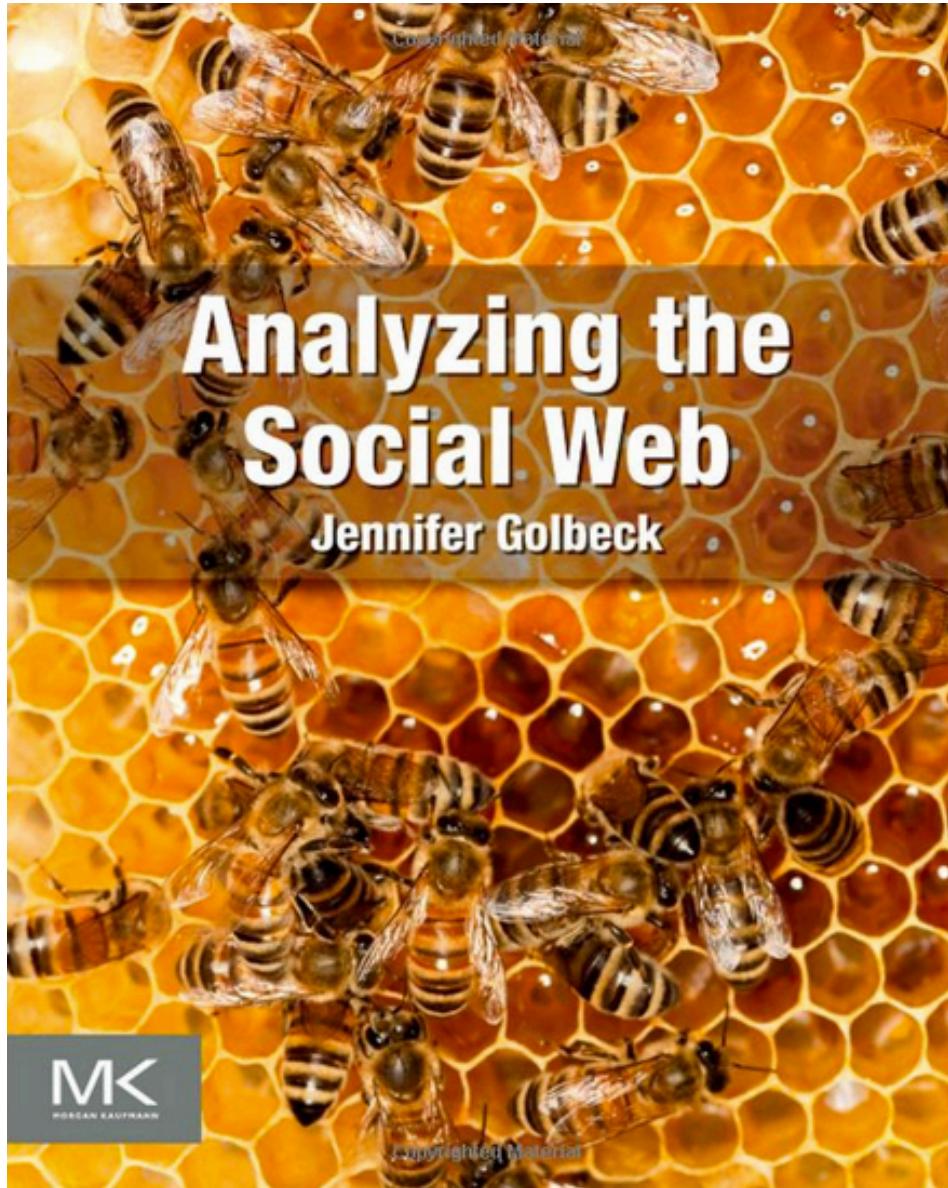


Source: <https://www.amazon.com/Network-Analysis-Applications-Lecture-Networks/dp/3319781952>

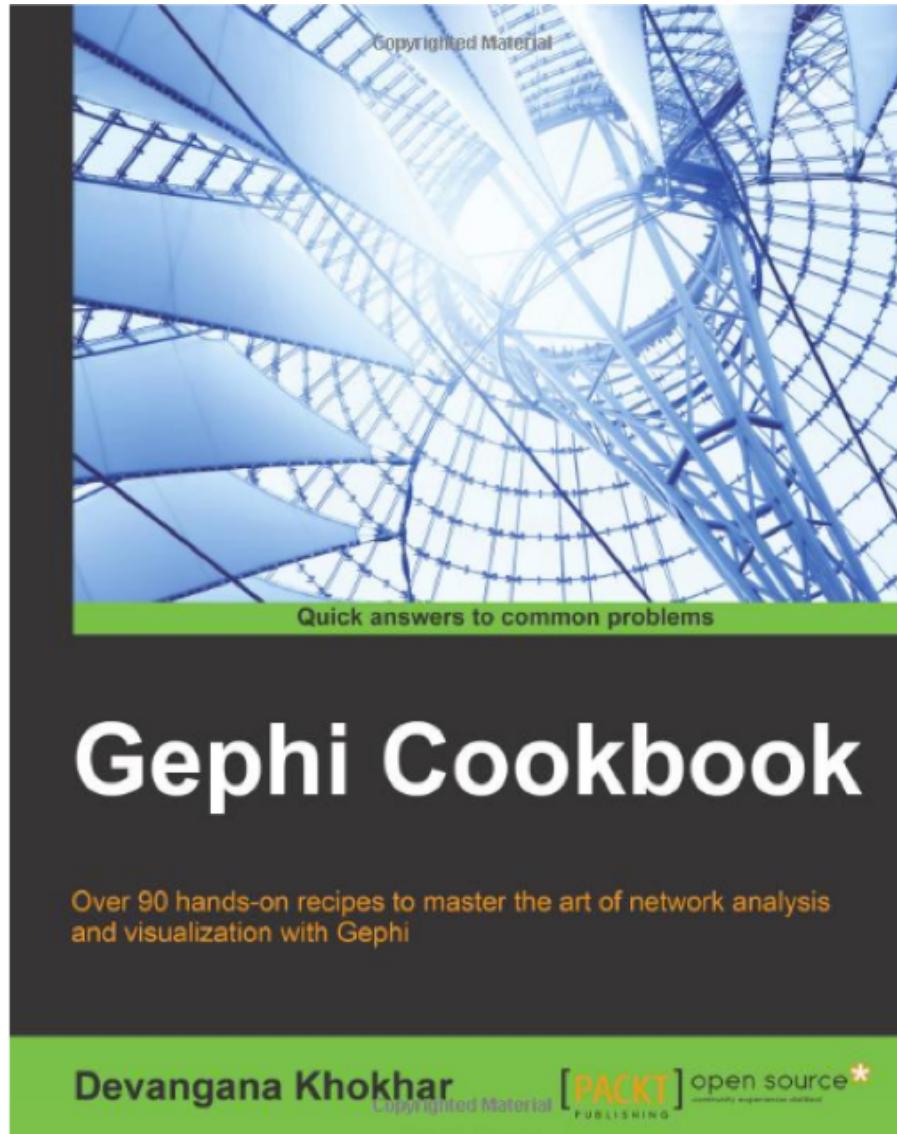
# **Business Insights with Social Analytics**

# Analyzing the Social Web: Social Network Analysis

Jennifer Golbeck (2013), **Analyzing the Social Web**, Morgan Kaufmann

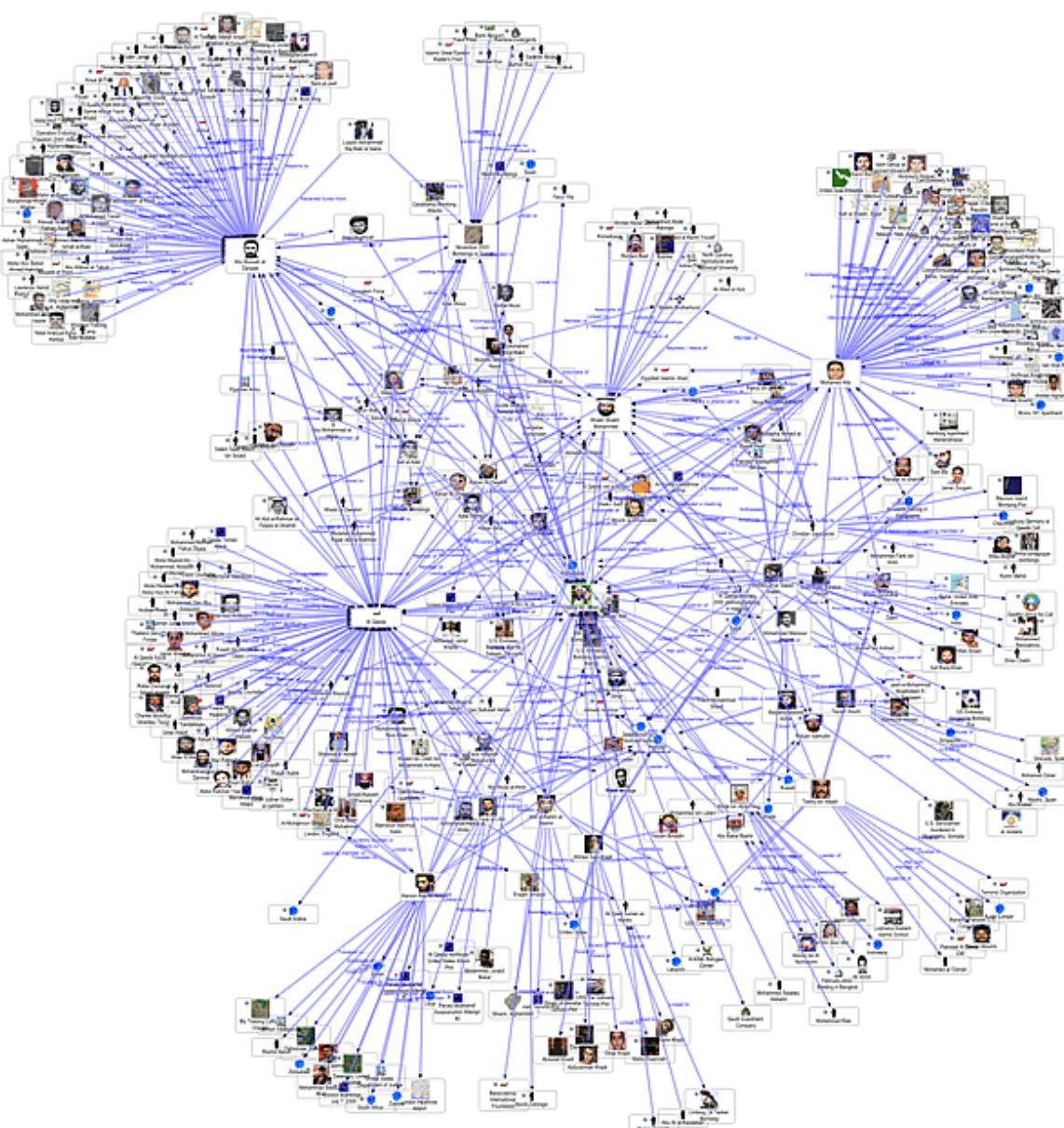


# Devangana Khokhar (2015), Gephi Cookbook, Packt Publishing



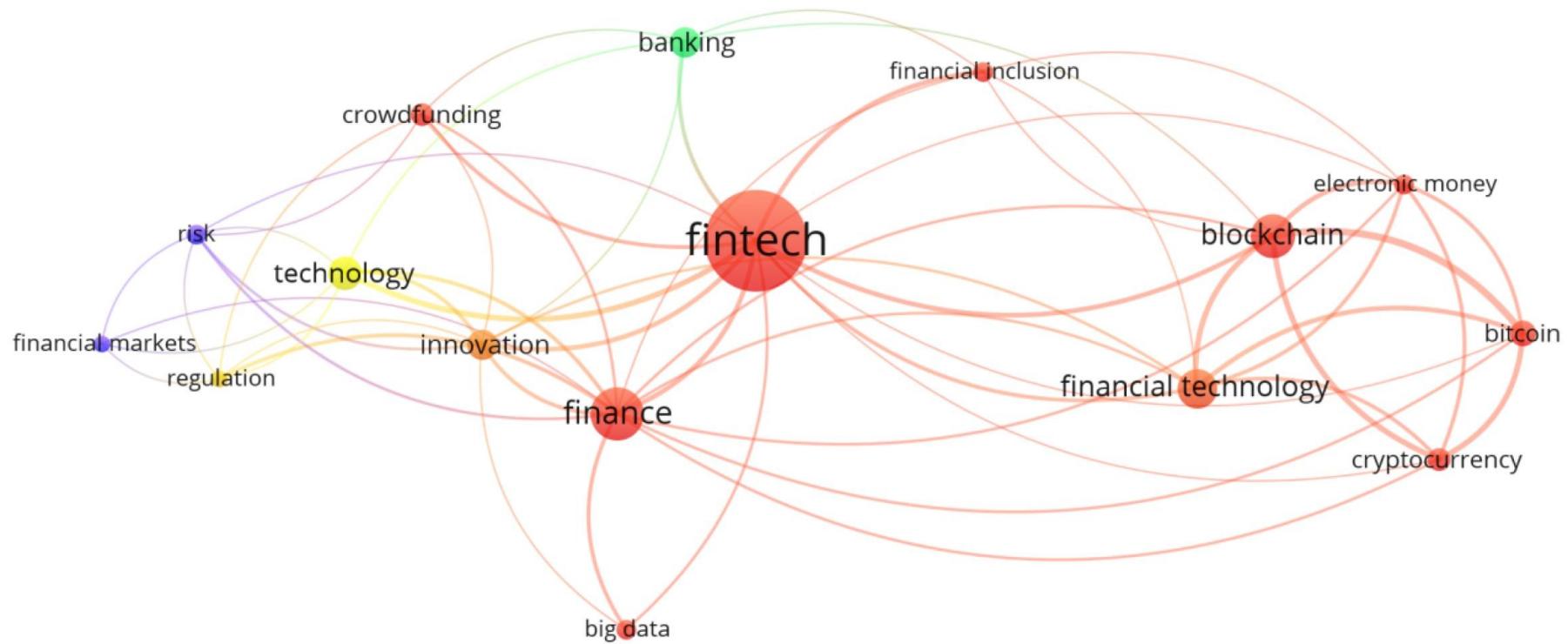
Source: <http://www.amazon.com/Gephi-Cookbook-Devangana-Khokhar/dp/1783987405>

# Social Network Analysis



# SNA in Fintech Research

VOSviewer – Network Visualization of the Occurrences of Keywords



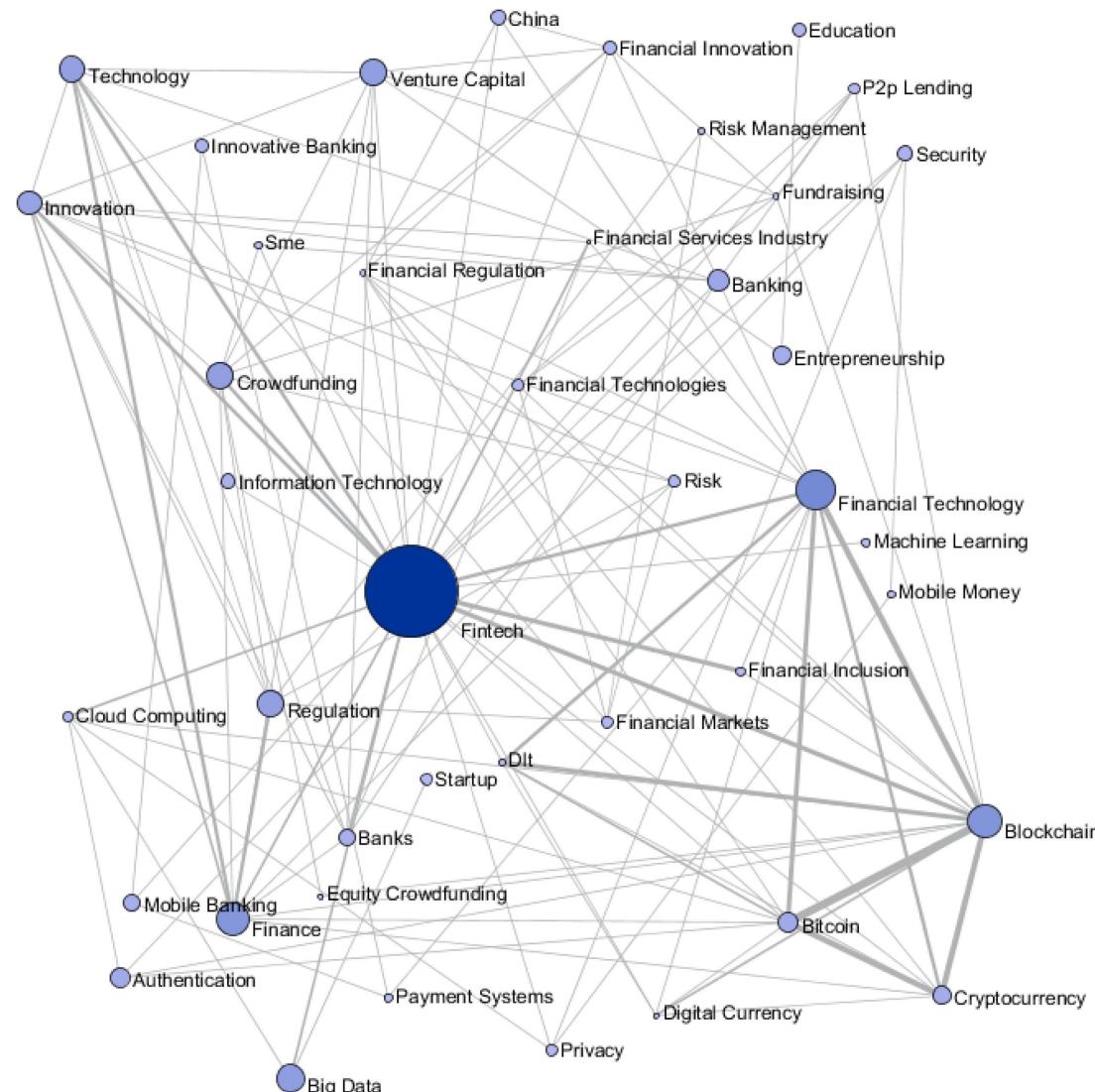
 VOSviewer



Source: Eduardo Z. Milian, Mauro de M. Spinola, and Marly M. de Carvalho (2019).  
"Fintechs: A literature review and research agenda." Electronic Commerce Research and Applications, 34, 100833.

# SNA in Fintech Research

## Sci2 Tool – Keyword Co-occurrence Network



Source: Eduardo Z. Milian, Mauro de M. Spinola, and Marly M. de Carvalho (2019).

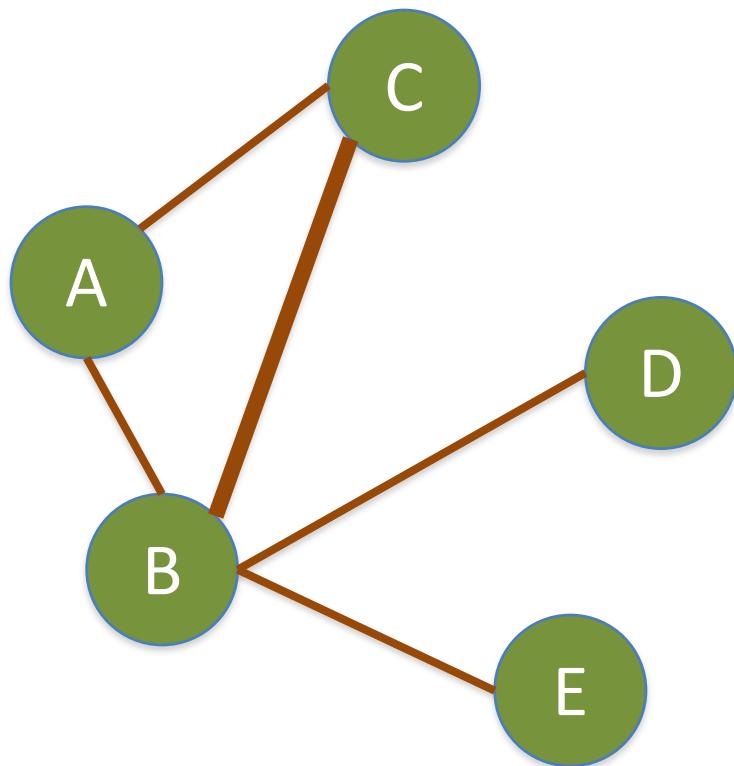
"Fintechs: A literature review and research agenda." Electronic Commerce Research and Applications, 34, 100833.

# Social Network Analysis

- A **social network** is a social structure of people, related (**directly** or **indirectly**) to each other through a common relation or interest
- **Social network analysis (SNA)** is the study of social networks to understand their **structure** and **behavior**

# Graph Theory

# Graph



# Graph

$$g = (V, E)$$

# Vertex (Node)



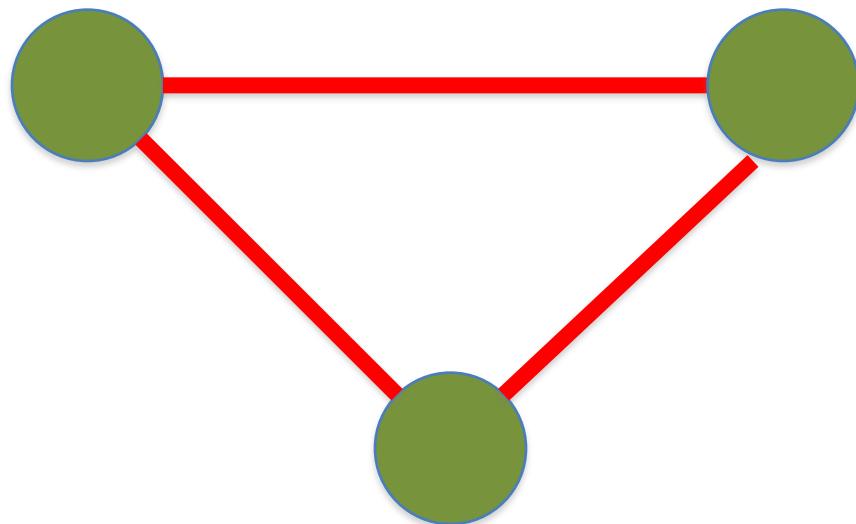
# Vertices (Nodes)



# Edge



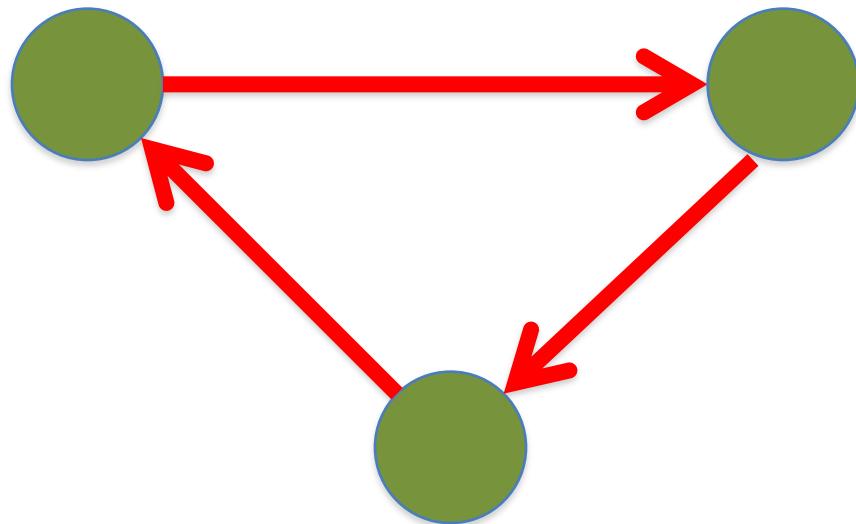
# Edges



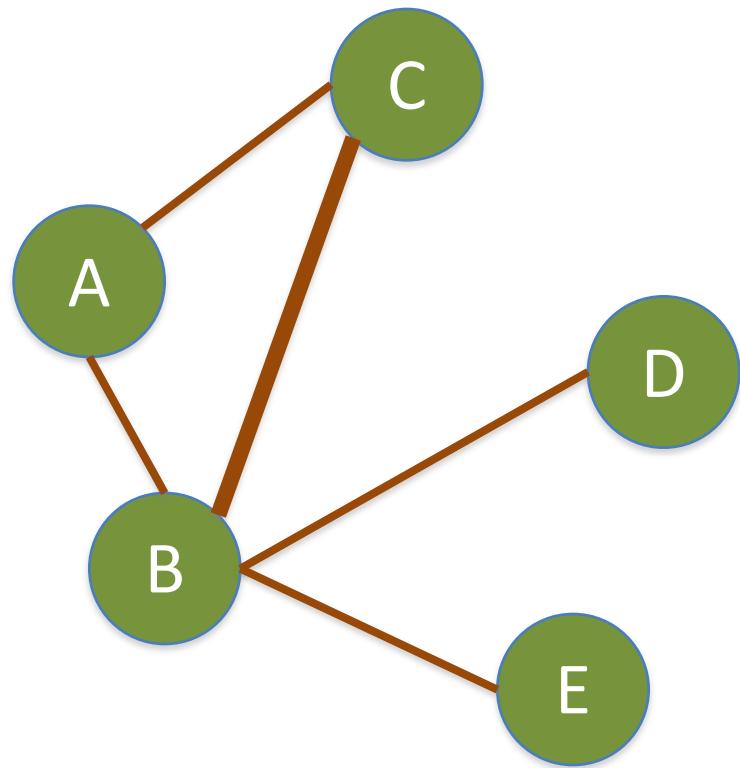
# Arc



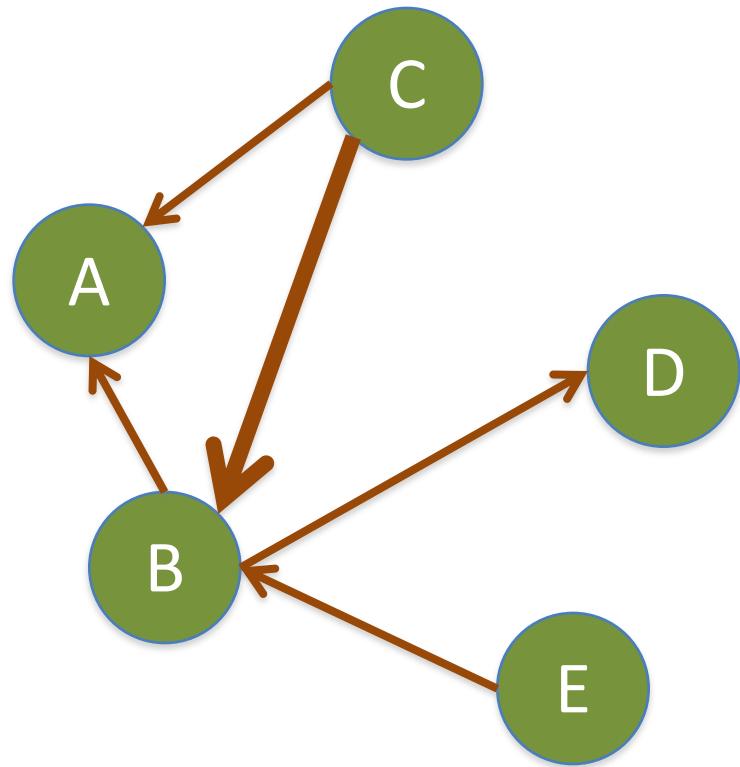
# Arcs



# Undirected Graph

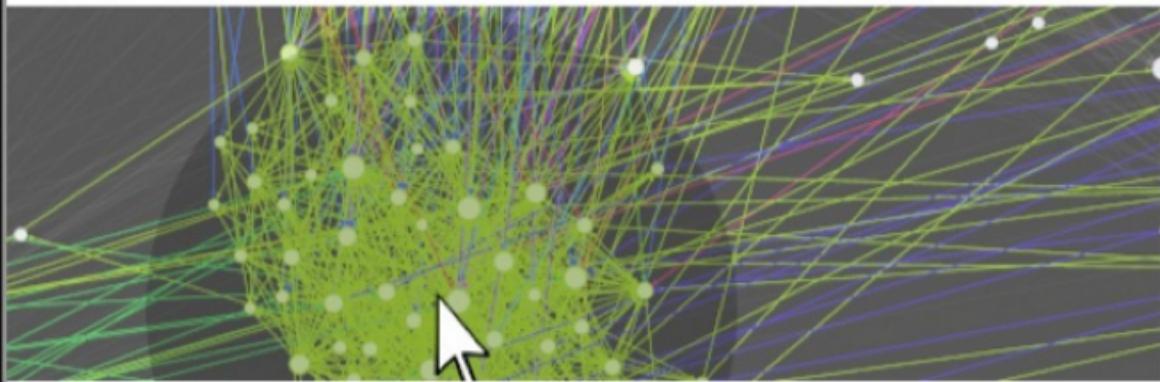
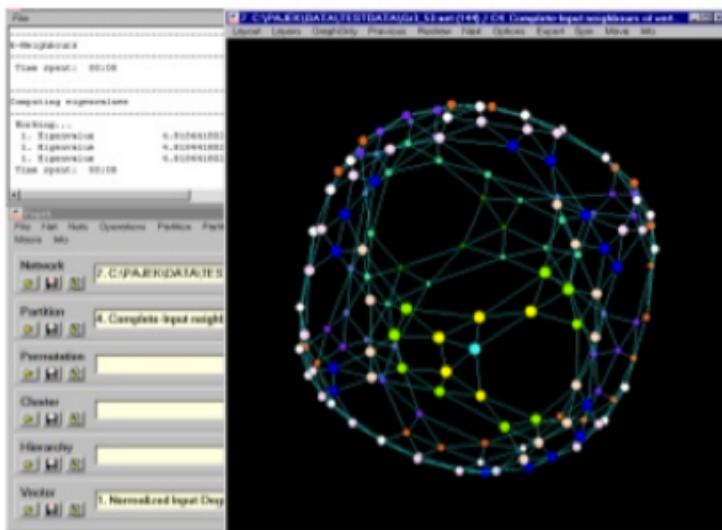


# Directed Graph



# Measurements of Social Network Analysis

# Exploratory Network Analysis

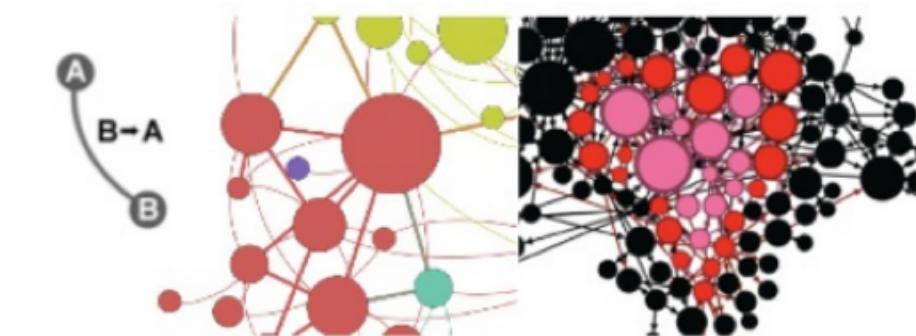
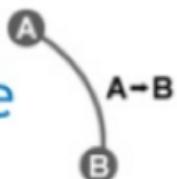


## 1 see the network

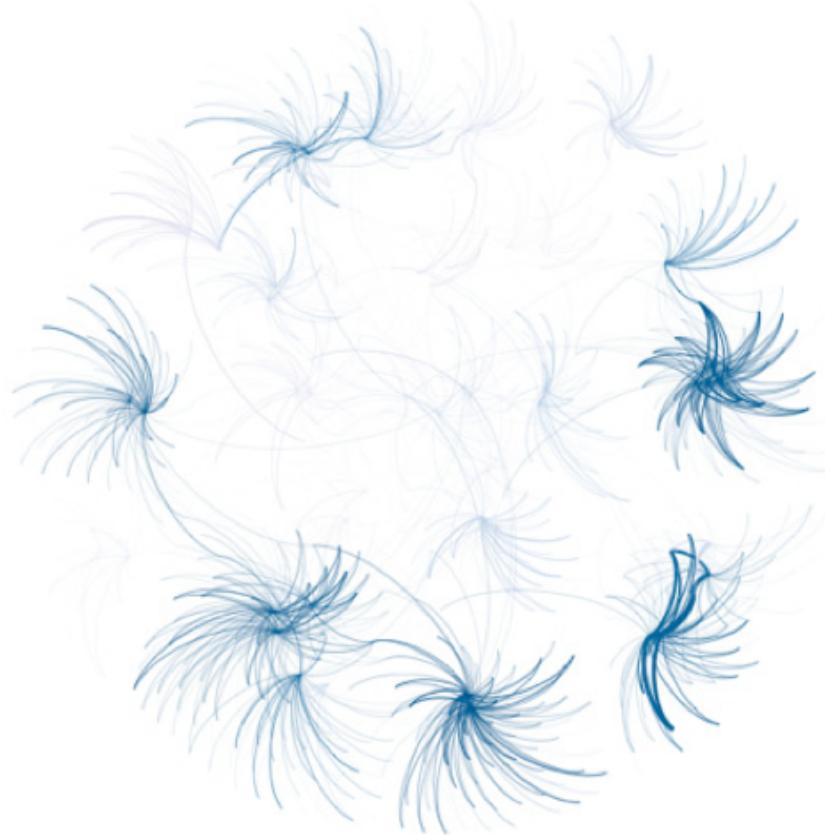
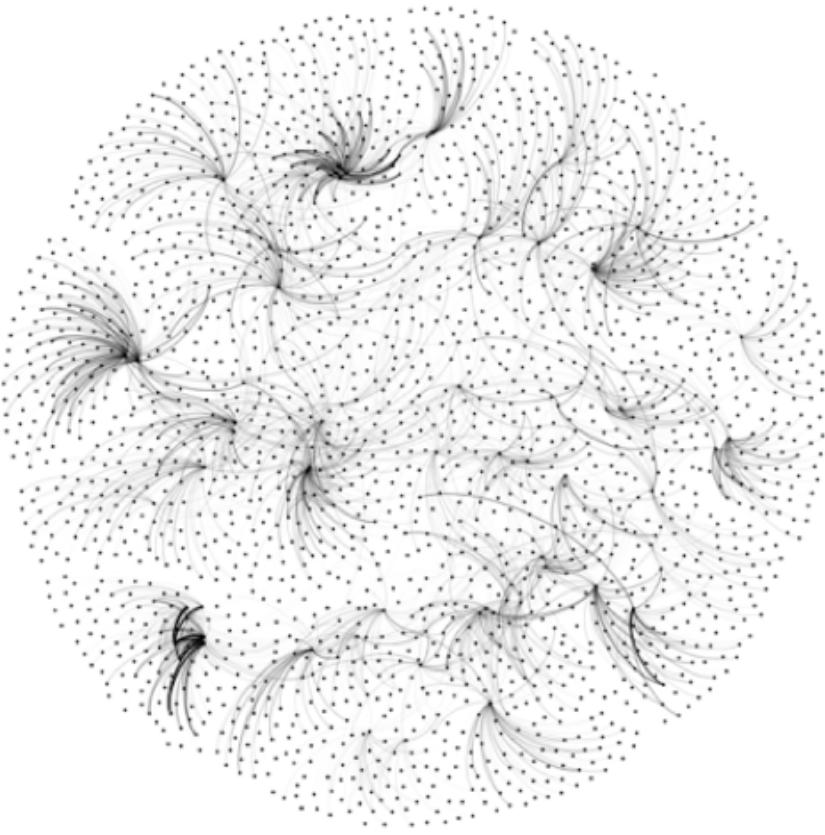
1st graph viz tool: Pajek (1996)  
Vladimir Batagelj, Andrej Mrvar

## 3 build a visual language

size by rank, color by partition,  
label, curved edges, thickness...



# Looking for a “Simple Small Truth”? What Data Visualization Should Do?



1. Make complex things **simple**
2. Extract **small** information from large data
3. Present **truth**, do not deceive

# Measurements

# Looking for Orderness in Data

Make varying 3 cursors simultaneously to extract **meaningful patterns**



*at different levels*



*on multiple dimensions*

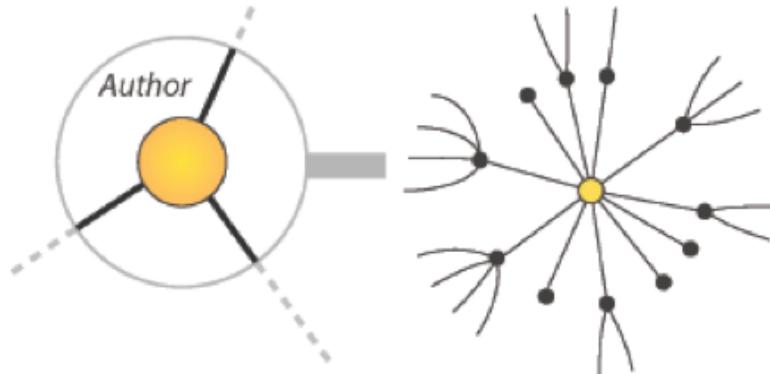
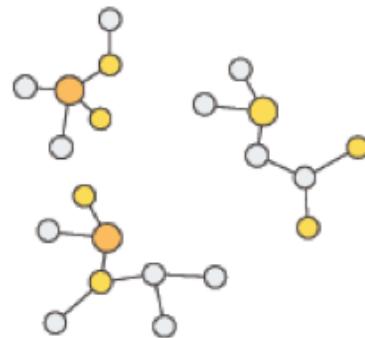


*at time scale*

# “Zoom” cursor on Quantitative Data

MICRO level

MACRO level



## Global

- connectivity
- density
- centralization

## Local

- communities
- bridges between communities
- local centers vs periphery

## Individual

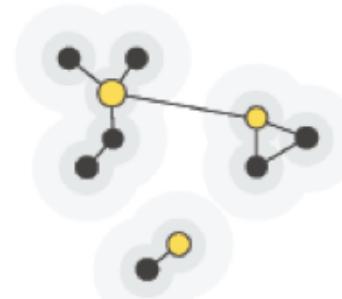
- centrality
- distances
- neighborhood
- location
- local authority vs hub

# “Crossing” cursor on Quantitative Data



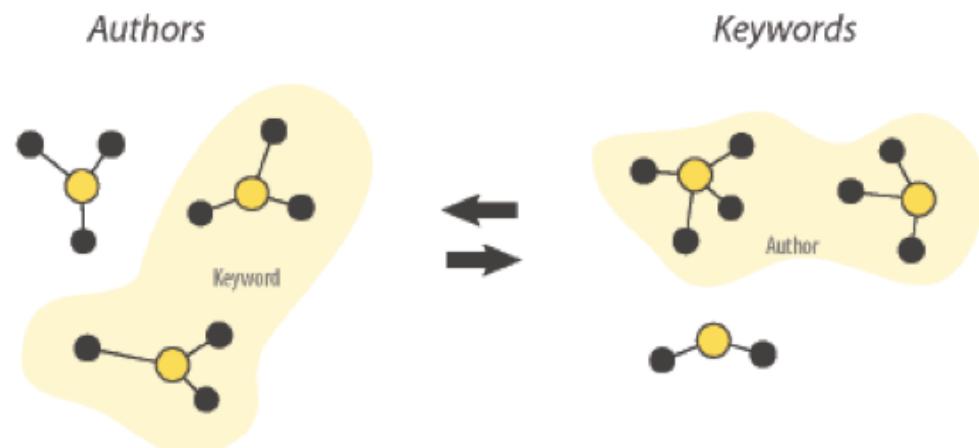
## Social

- who with whom
- communities
- brokerage
- influence and power
- homophily



## Semantic

- topics
- thematic clusters



## Geographic

- spatial phenomena

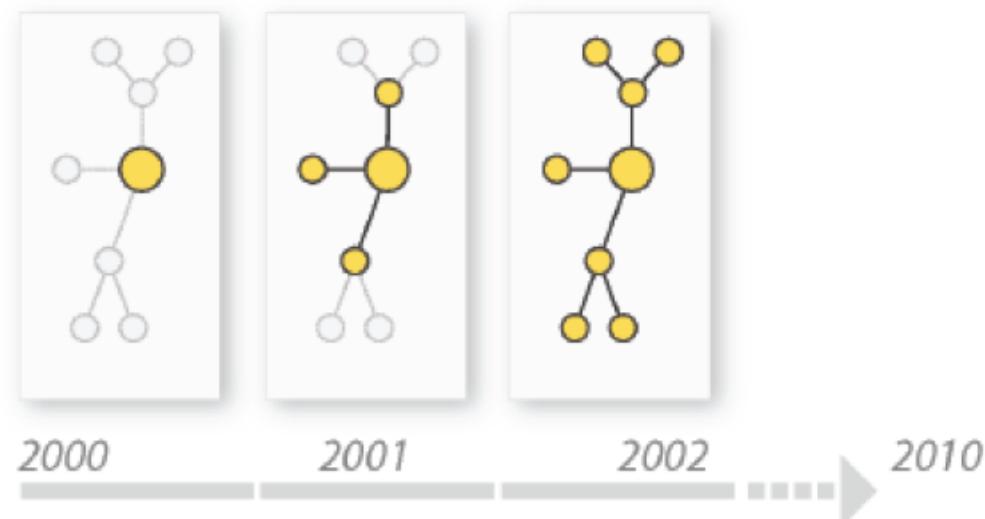
# “Timeline” cursor on Temporal Data



Evolution of social ties

Evolution of communities

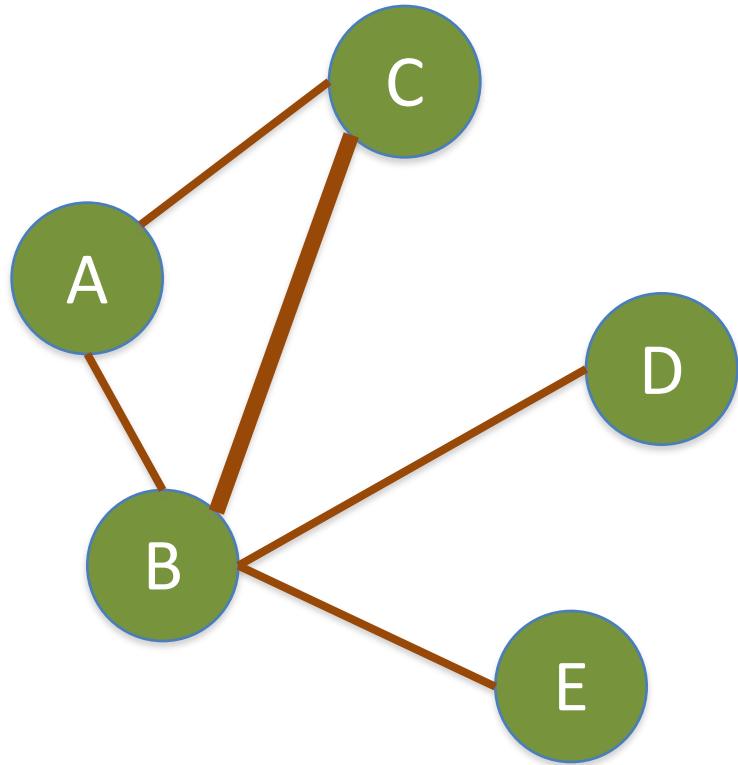
Evolution of topics



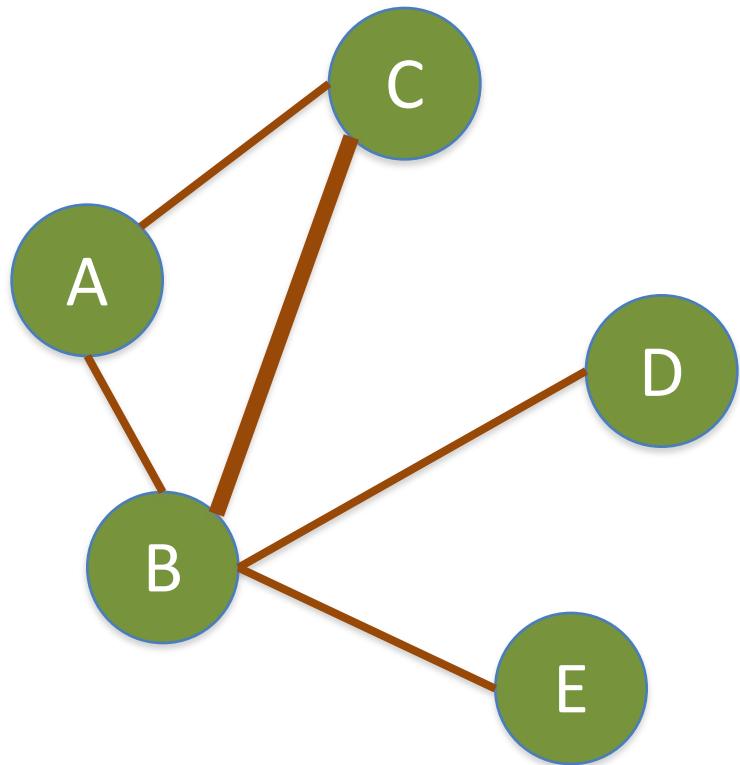
# SNA Guideline

# nodes	
1 - 100	lists + edges in bonus, focus on qualitative data
100 - 1,000	<p><b>How attributes explain the structure?</b></p> <ul style="list-style-type: none"><li>• easy to read, “obvious” patterns</li><li>• focus on entities (in context)</li><li>• metrics are tools to describe the graph (centrality, bridging...)</li><li>• links help to build and interpret categories of entities</li></ul> <p><b>challenge: mix attribute crossing and connectivity</b></p>
1,000 - 50,000	<p><b>How the structure explains attributes?</b></p> <ul style="list-style-type: none"><li>• hard to read, problem of “hidden signals”: track patterns with various layouts and filtering</li><li>• focus on structures</li><li>• metrics are tools to build the graph (cosine similarity...)</li><li>• categories help to understand the structure</li></ul> <p><b>challenge: pattern recognition</b></p>
> 50,000	require high computational power

# Degree

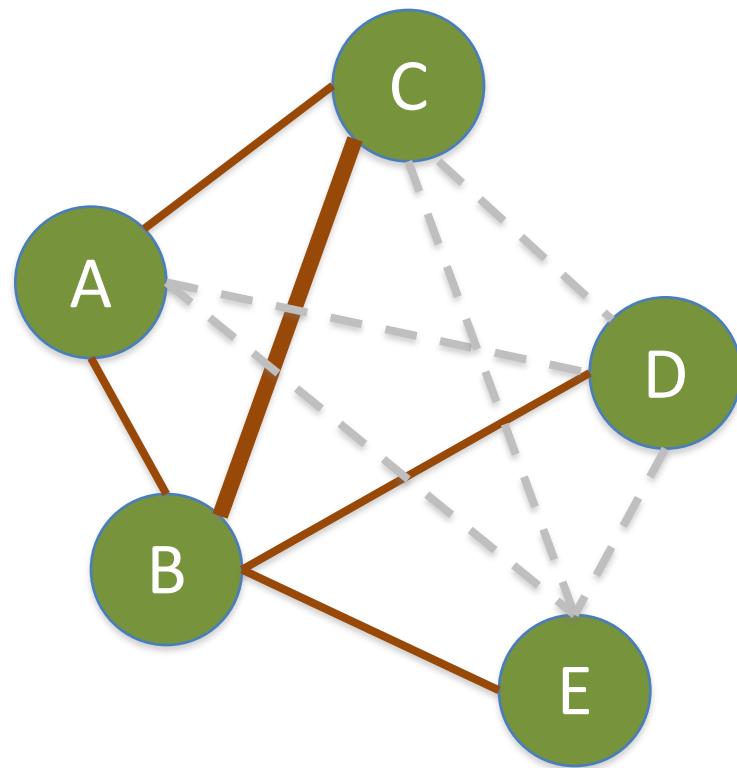


# Degree



A: 2  
B: 4  
C: 2  
D: 1  
E: 1

# Density

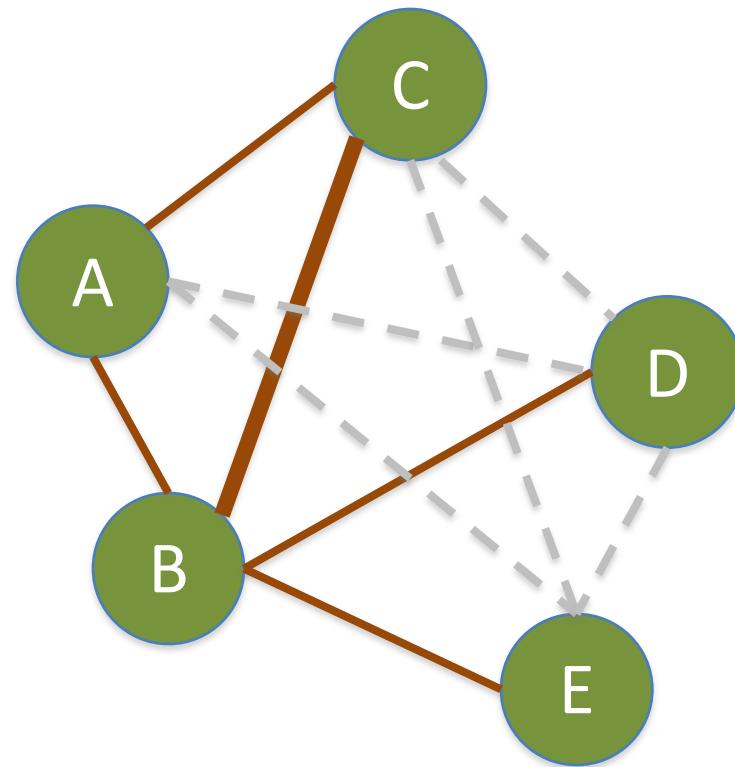


# Density

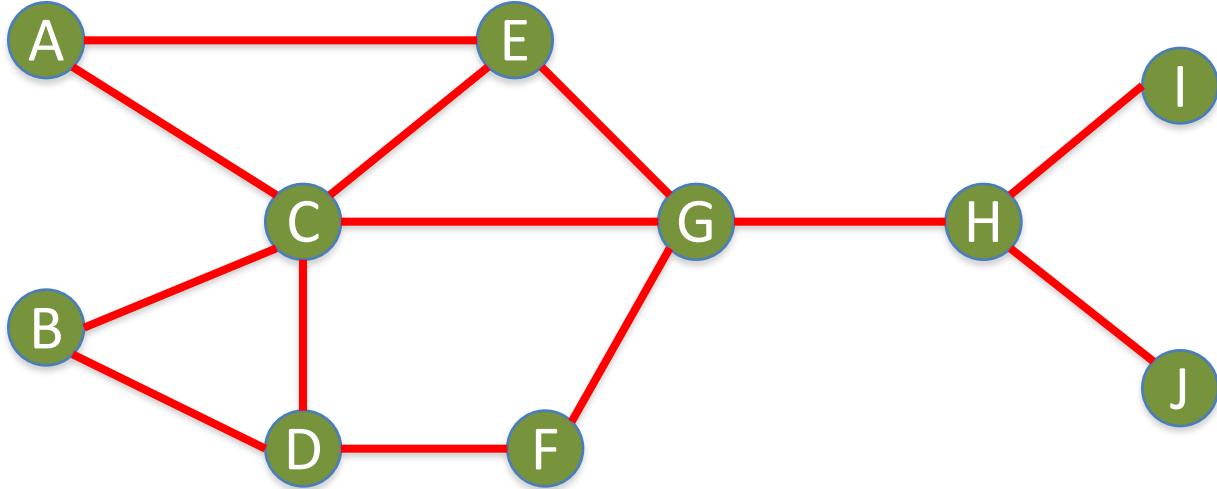
Edges (Links): 5

Total Possible Edges: 10

Density:  $5/10 = 0.5$



# Density



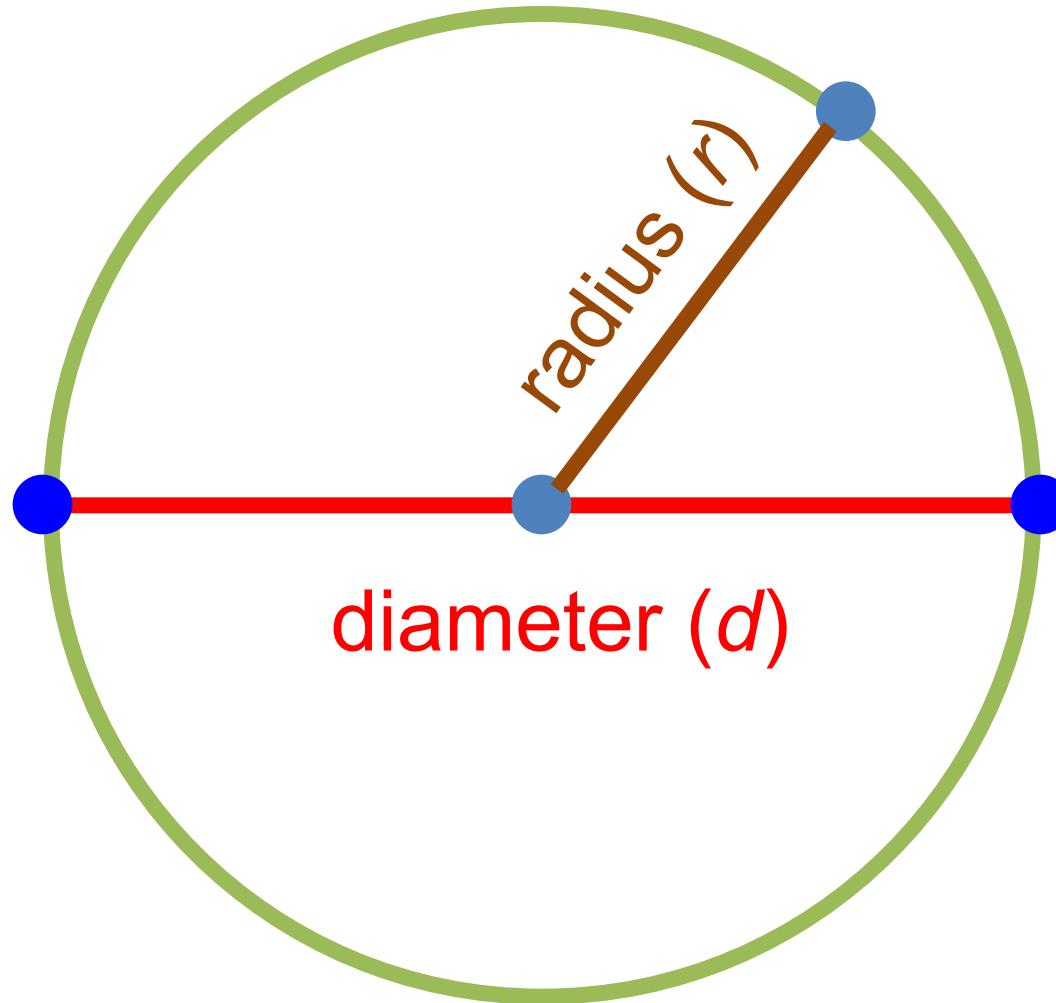
Nodes (n): 10

Edges (Links): 13

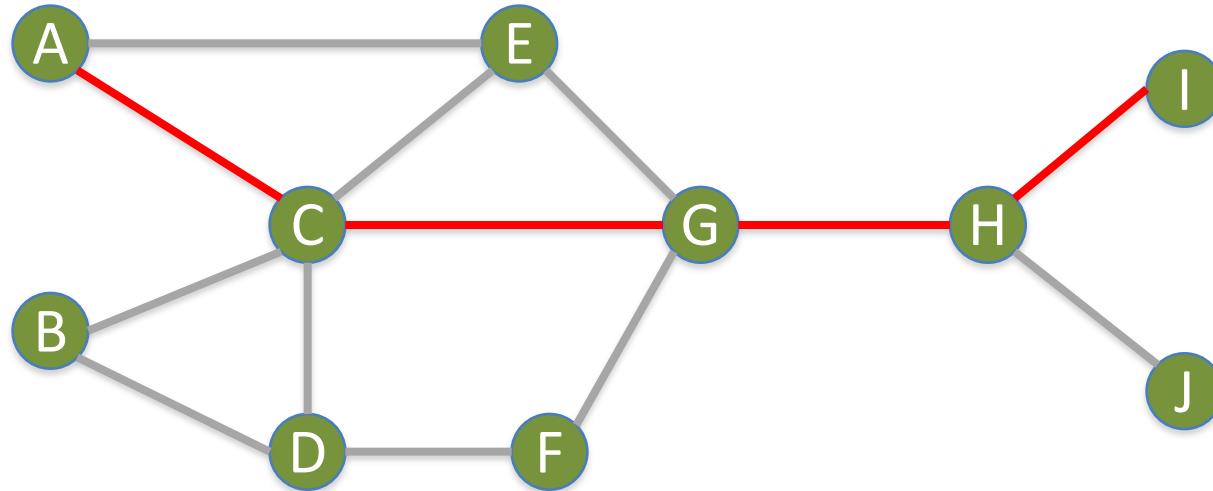
Total Possible Edges:  $(n * (n-1)) / 2 = (10 * 9) / 2 = 45$

Density:  $13/45 = 0.29$

# Diameter

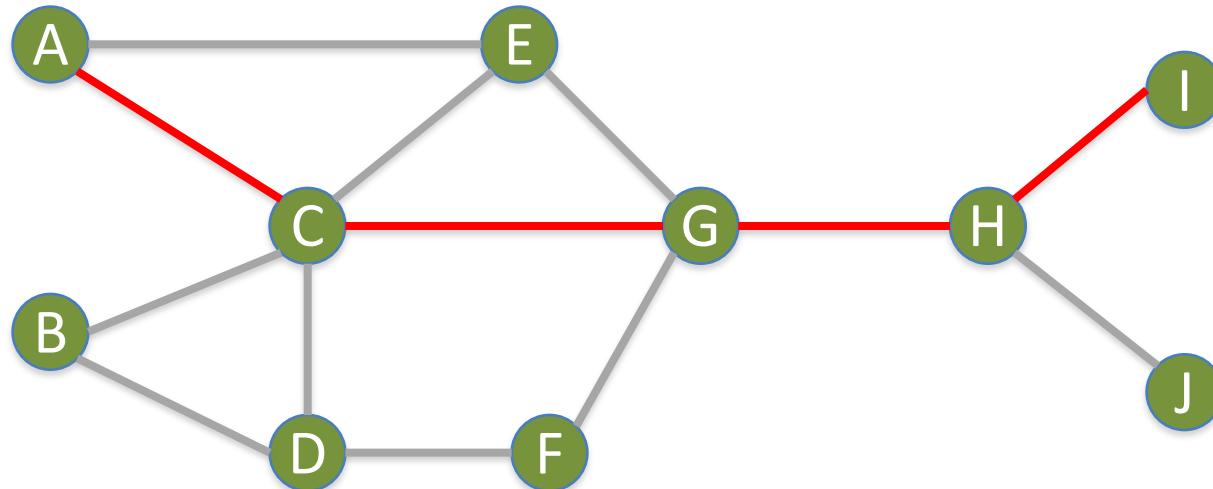


# Diameter



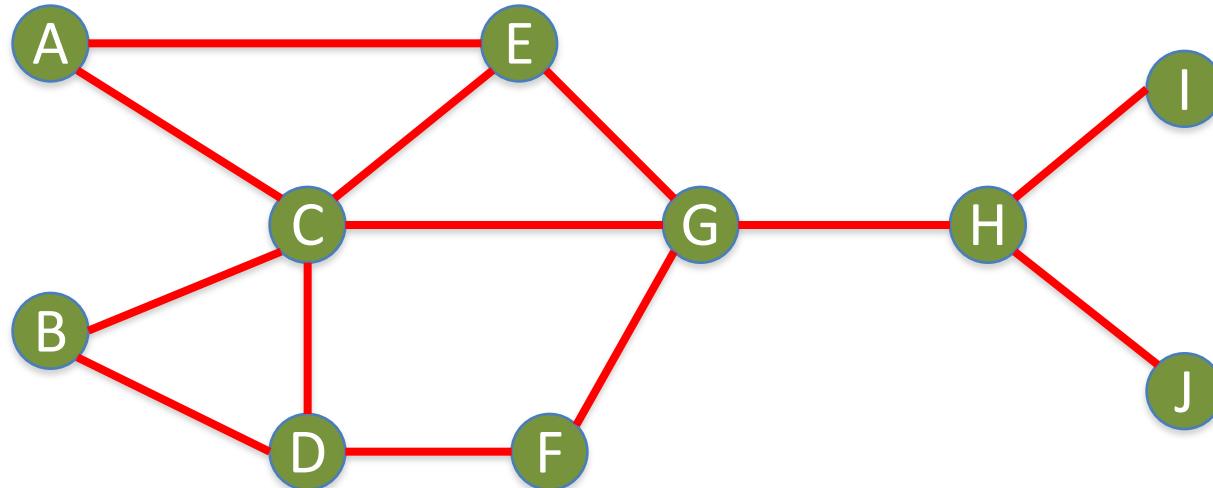
# Diameter

## Geodesic Path (Shortest Path)



$A \rightarrow I$  : Diameter = 4

# Which Node is Most Important?



# Centrality

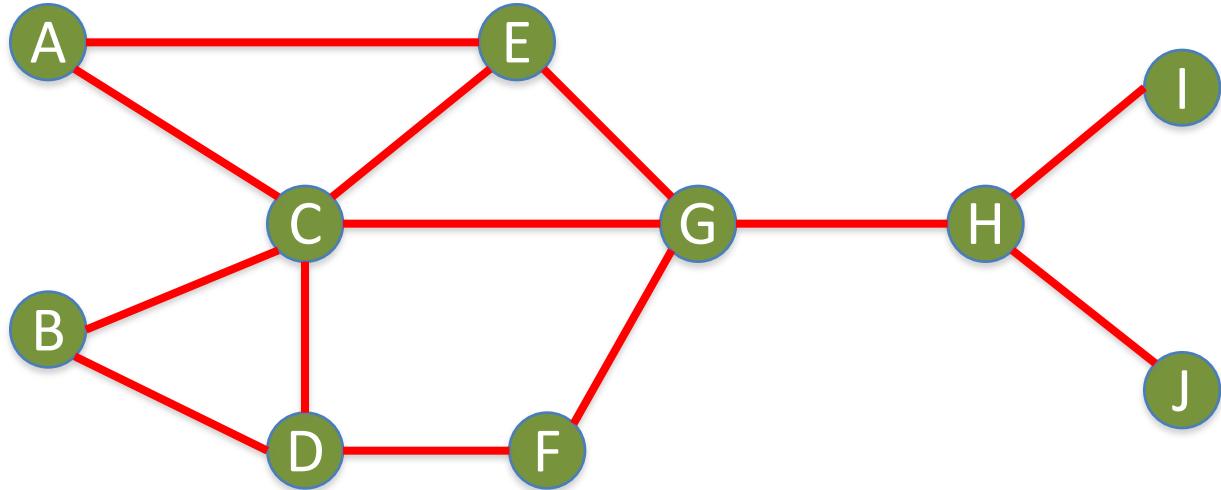
- Important or prominent actors are those that are linked or involved with other actors extensively.
- A person with extensive contacts (links) or communications with many other people in the organization is considered more important than a person with relatively fewer contacts.
- The links can also be called **ties**.  
A **central actor** is one involved in many ties.

# Social Network Analysis (SNA)

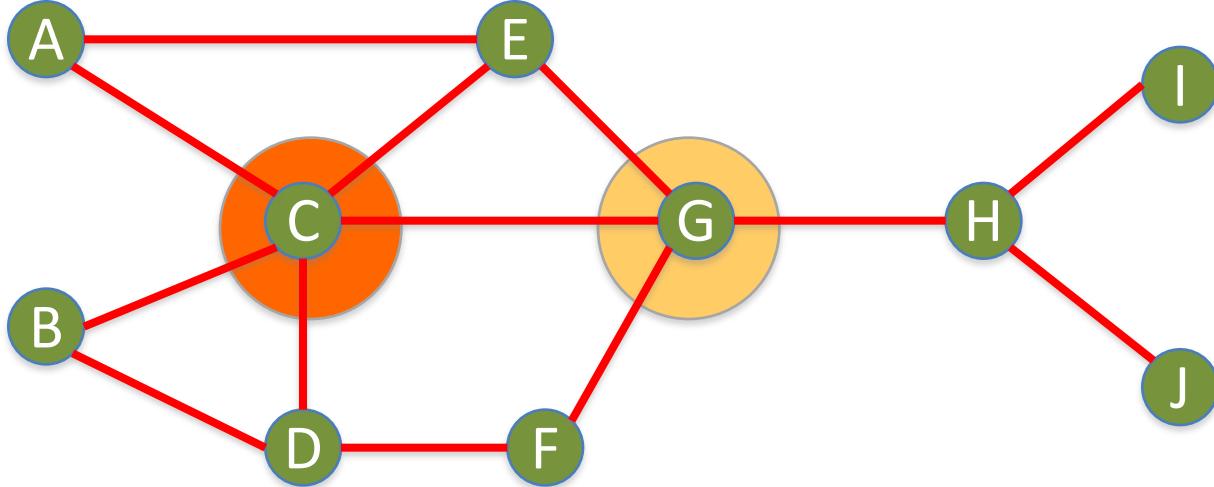
- Degree Centrality
- Betweenness Centrality
- Closeness Centrality

# Degree Centrality

# Social Network Analysis: Degree Centrality



# Social Network Analysis: Degree Centrality



Node	Score	Standardized Score
A	2	$2/10 = 0.2$
B	2	$2/10 = 0.2$
C	<b>5</b>	$5/10 = 0.5$
D	3	$3/10 = 0.3$
E	3	$3/10 = 0.3$
F	2	$2/10 = 0.2$
G	<b>4</b>	$4/10 = 0.4$
H	3	$3/10 = 0.3$
I	1	$1/10 = 0.1$
J	1	$1/10 = 0.1$

# Betweenness Centrality

**Betweenness centrality:**

**Connectivity**

Number of shortest paths  
going through the actor

# Betweenness Centrality

$$C_B(i) = \sum_{j < k} g_{ik}(i) / g_{jk}$$

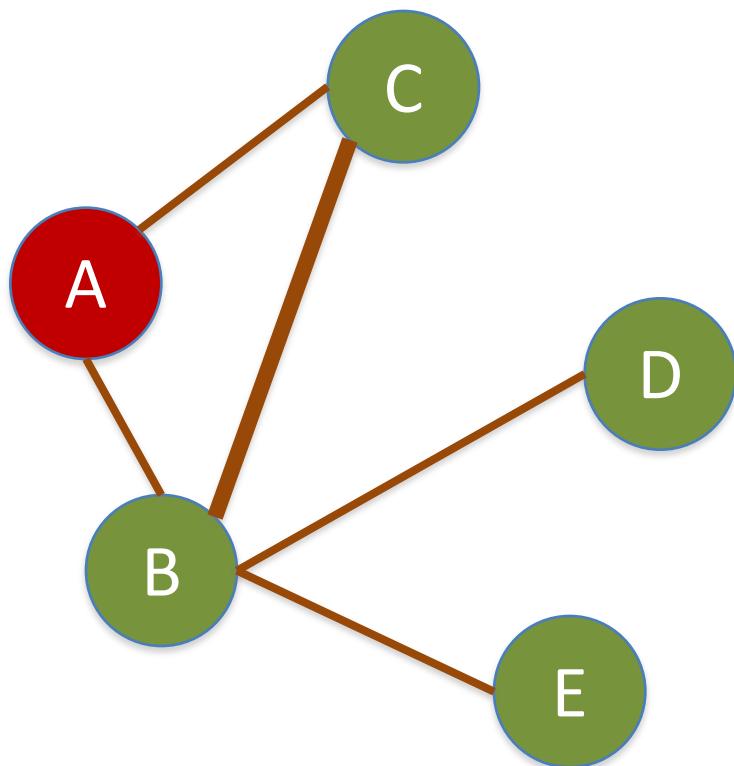
Where  $g_{jk}$  = the number of shortest paths connecting  $jk$   
 $g_{jk}(i)$  = the number that actor  $i$  is on.

## Normalized Betweenness Centrality

$$C'_B(i) = C_B(i) / [((n-1)(n-2)/2)]$$

Number of pairs of vertices  
excluding the vertex itself

# Betweenness Centrality



A:

$$B \rightarrow C: 0/1 = 0$$

$$B \rightarrow D: 0/1 = 0$$

$$B \rightarrow E: 0/1 = 0$$

$$C \rightarrow D: 0/1 = 0$$

$$C \rightarrow E: 0/1 = 0$$

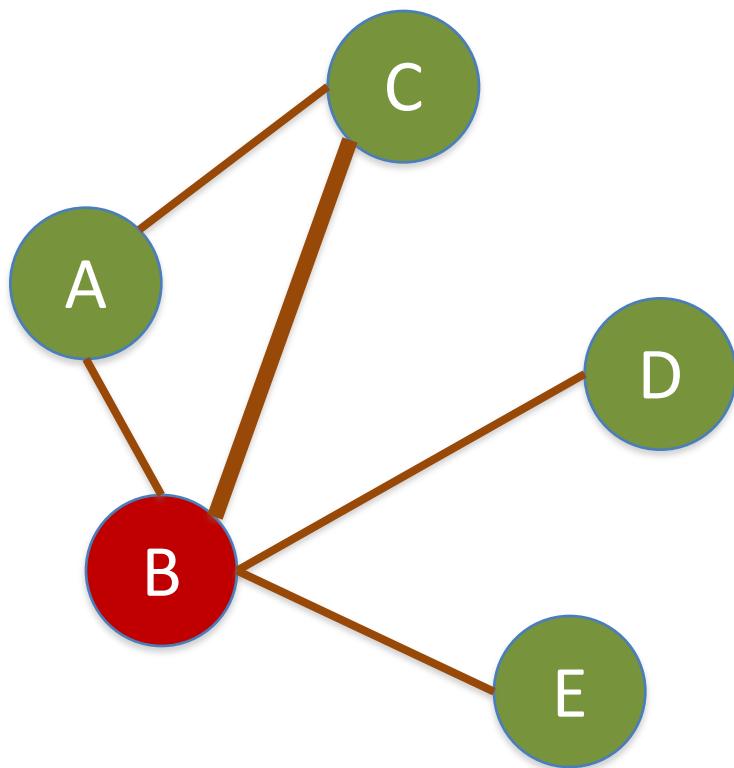
$$D \rightarrow E: 0/1 = 0$$

—

Total: 0

A: Betweenness Centrality = 0

# Betweenness Centrality



B:

$$A \rightarrow C: 0/1 = 0$$

$$A \rightarrow D: 1/1 = 1$$

$$A \rightarrow E: 1/1 = 1$$

$$C \rightarrow D: 1/1 = 1$$

$$C \rightarrow E: 1/1 = 1$$

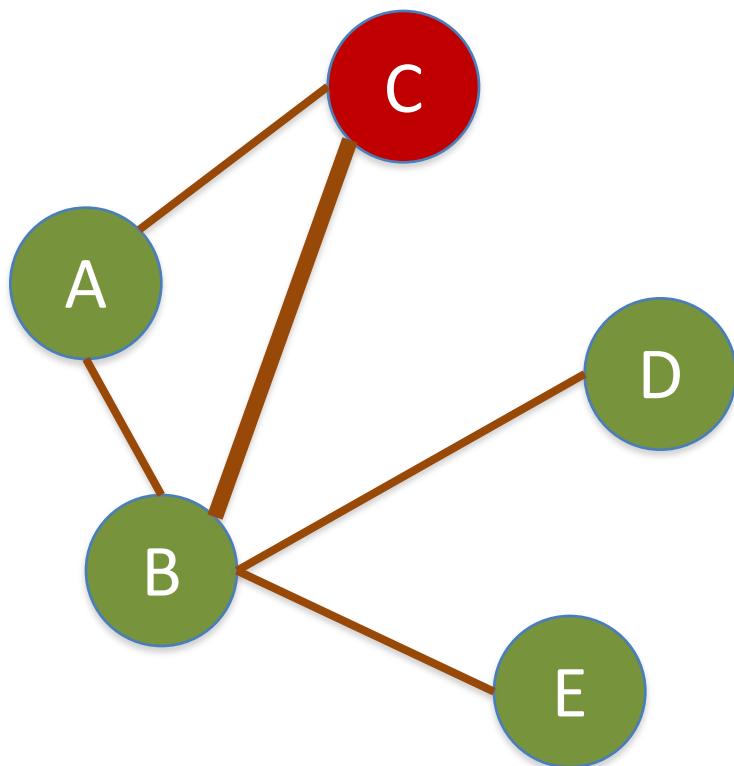
$$D \rightarrow E: 1/1 = 1$$

---

Total: 5

B: Betweenness Centrality = 5

# Betweenness Centrality



C:

$$A \rightarrow B: 0/1 = 0$$

$$A \rightarrow D: 0/1 = 0$$

$$A \rightarrow E: 0/1 = 0$$

$$B \rightarrow D: 0/1 = 0$$

$$B \rightarrow E: 0/1 = 0$$

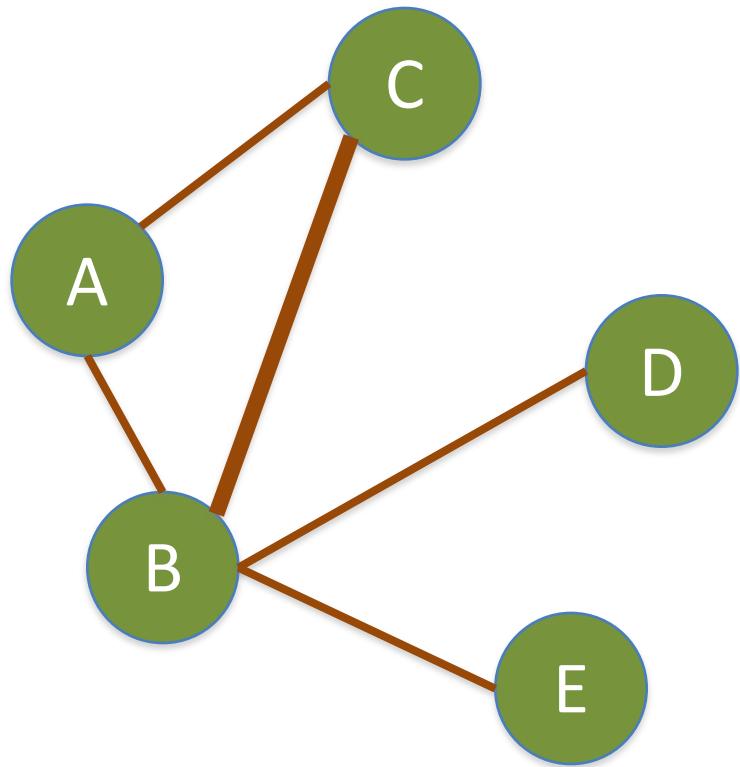
$$D \rightarrow E: 0/1 = 0$$

—

Total: 0

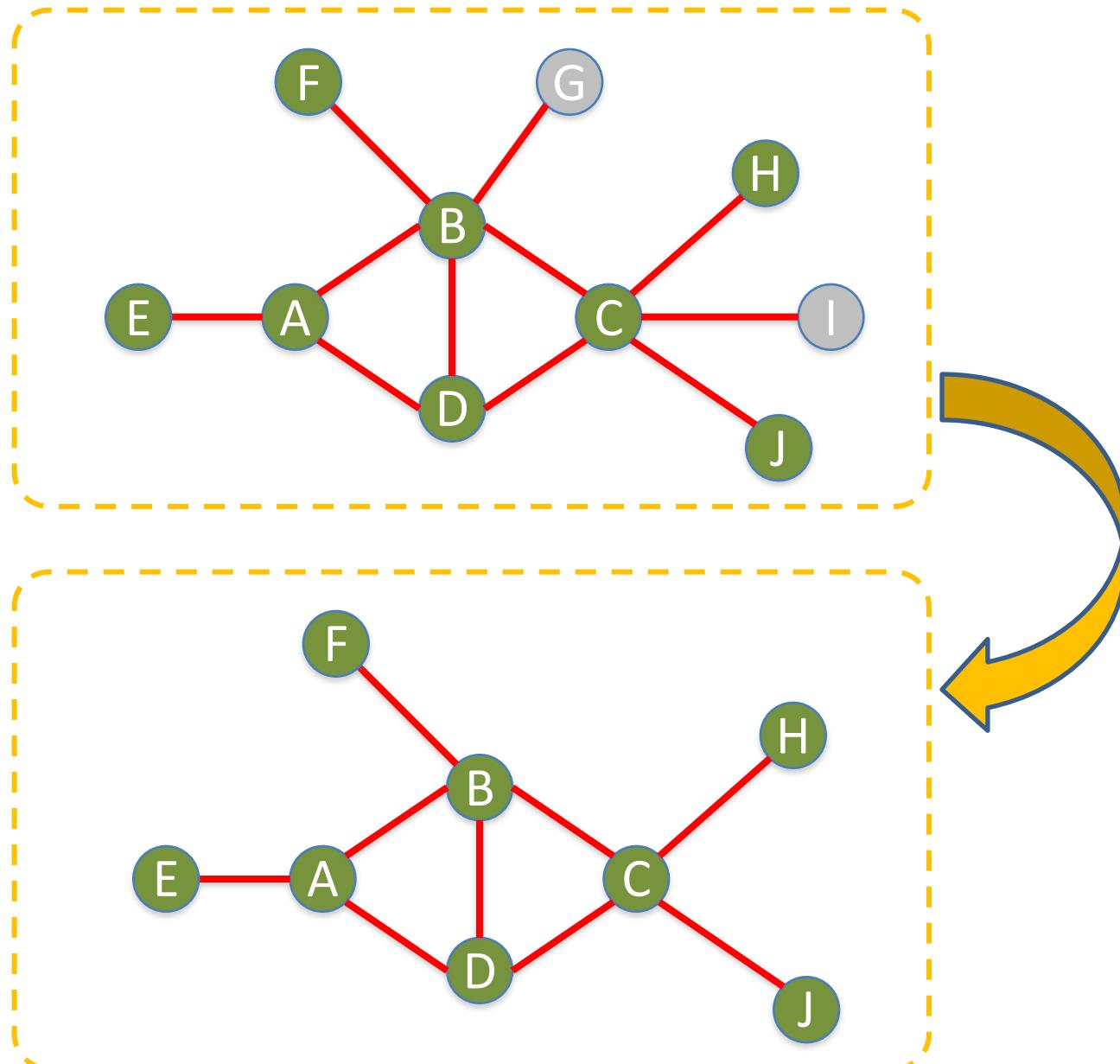
C: Betweenness Centrality = 0

# Betweenness Centrality

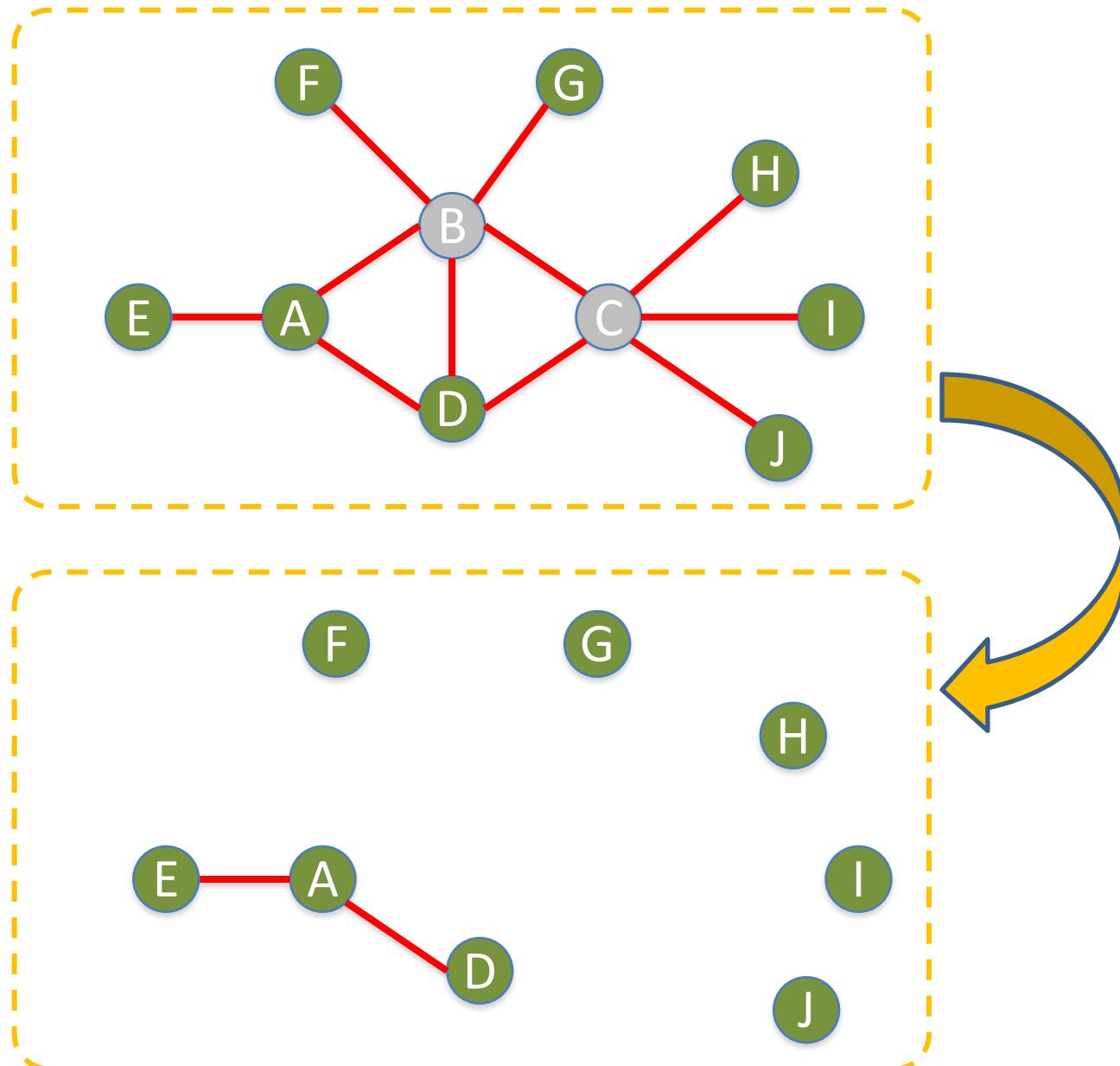


A: 0  
B: 5  
C: 0  
D: 0  
E: 0

# Which Node is Most Important?

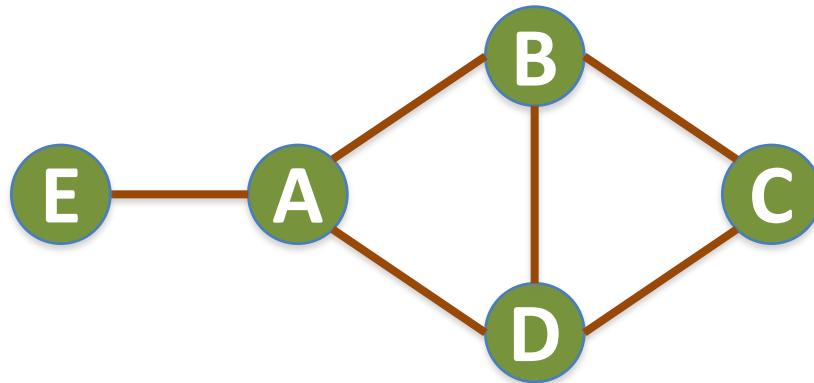


# Which Node is Most Important?

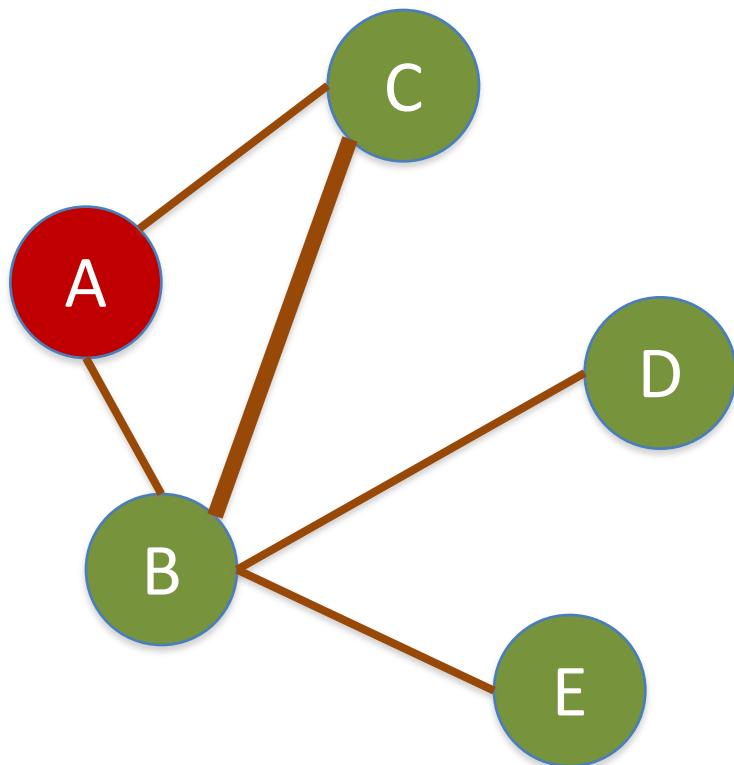


# Betweenness Centrality

$$C_B(i) = \sum_{j < k} g_{ik}(i) / g_{jk}$$



# Betweenness Centrality



A:

$$B \rightarrow C: 0/1 = 0$$

$$B \rightarrow D: 0/1 = 0$$

$$B \rightarrow E: 0/1 = 0$$

$$C \rightarrow D: 0/1 = 0$$

$$C \rightarrow E: 0/1 = 0$$

$$D \rightarrow E: 0/1 = 0$$

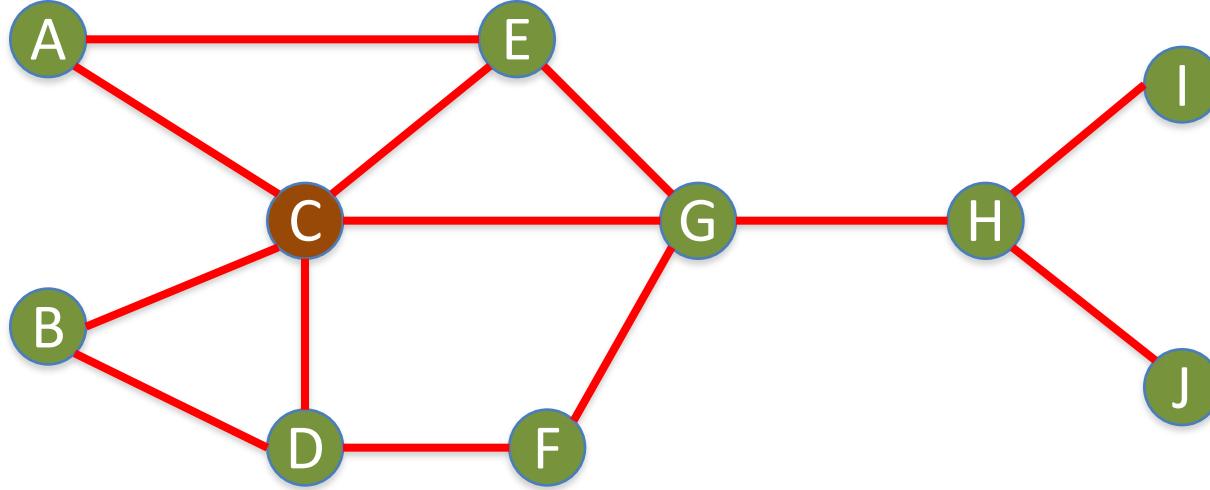
—

Total: 0

A: Betweenness Centrality = 0

# Closeness Centrality

# Social Network Analysis: Closeness Centrality



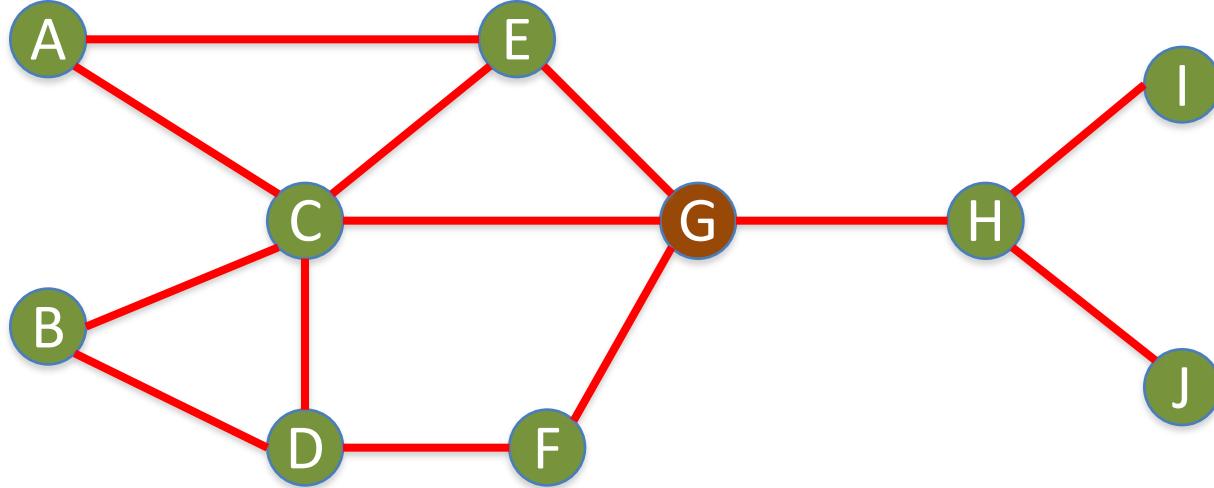
C→A:	1
C→B:	1
C→D:	1
C→E:	1
C→F:	2
C→G:	1
C→H:	2
C→I:	3
C→J:	3

---

Total=15

C: Closeness Centrality =  $15/9 = 1.67$

# Social Network Analysis: Closeness Centrality



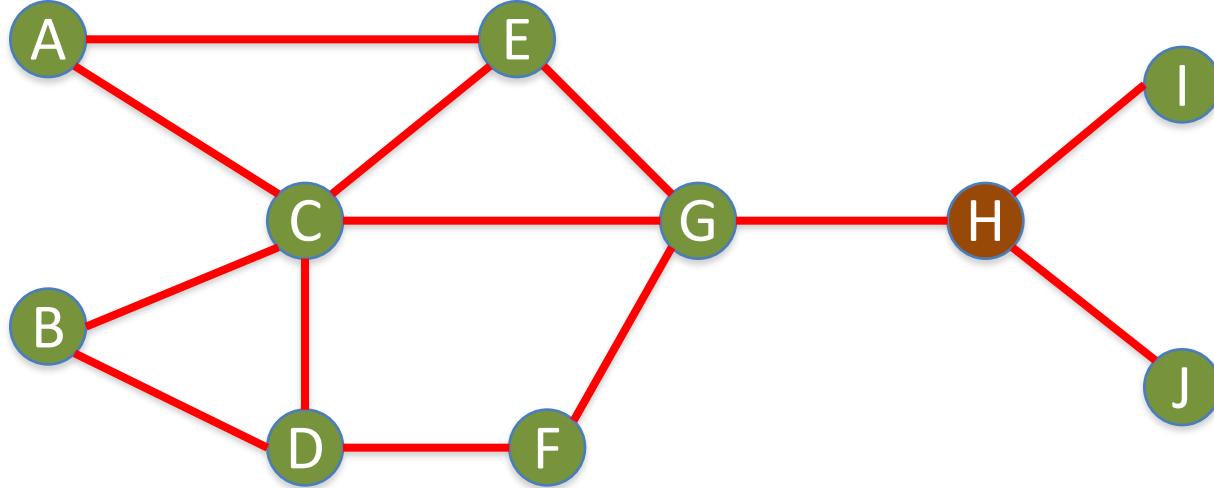
G→A:	2
G→B:	2
G→C:	1
G→D:	2
G→E:	1
G→F:	1
G→H:	1
G→I:	2
G→J:	2

---

Total=14

G: Closeness Centrality =  $14/9 = 1.56$

# Social Network Analysis: Closeness Centrality



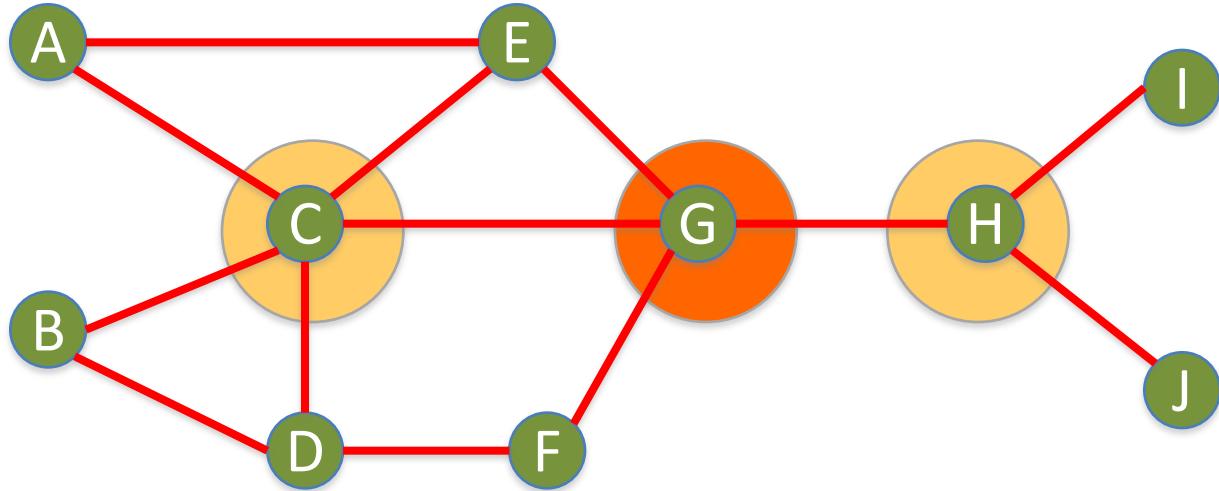
H→A:	3
H→B:	3
H→C:	2
H→D:	2
H→E:	2
H→F:	2
H→G:	1
H→I:	1
H→J:	1

---

Total=17

H: Closeness Centrality =  $17/9 = 1.89$

# Social Network Analysis: Closeness Centrality



G: Closeness Centrality =  $14/9 = 1.56$  1

C: Closeness Centrality =  $15/9 = 1.67$  2

H: Closeness Centrality =  $17/9 = 1.89$  3

# Social Network Analysis (SNA)

## importance of neighbors

# Eigenvector centrality

**Eigenvector centrality:**  
Importance of a node  
depends on  
the importance of its neighbors

# Social Network Analysis: Closeness Centrality

Sum of the reciprocal distances

$$C_C(p_k) = \sum_{i=1}^n d(p_i, p_k)^{-1}$$

where  $d(p_j, p_k)$  is the geodesic distance (shortest paths) linking  $p_j, p_k$

# Social Network Analysis: Betweenness Centrality

$$C_B(p_k) = \sum_{i < j}^n \frac{g_{ij}(p_k)}{g_{ij}}; \quad i \neq j \neq k$$

where  $g_{ij}$  is the geodesic distance (shortest paths) linking  $p_i$  and  $p_j$  and  $g_{ij}(p_k)$  is the geodesic distance linking  $p_i$  and  $p_j$  that contains  $p_k$ .

# Social Network Analysis: Degree Centrality

$$C_D(p_k) = \sum_{i=1}^n a(p_i, p_k)$$

where  $a(p_i, p_k) = 1$  if and only if  $p_i$  and  $p_k$  are connected by a line  
0 otherwise

$$C'_D(p_k) = \frac{\sum_{i=1}^n a(p_i, p_k)}{n-1}$$

Social Networks, 1 (1978/79) 215–239  
©Elsevier Sequoia S.A., Lausanne – Printed in the Netherlands

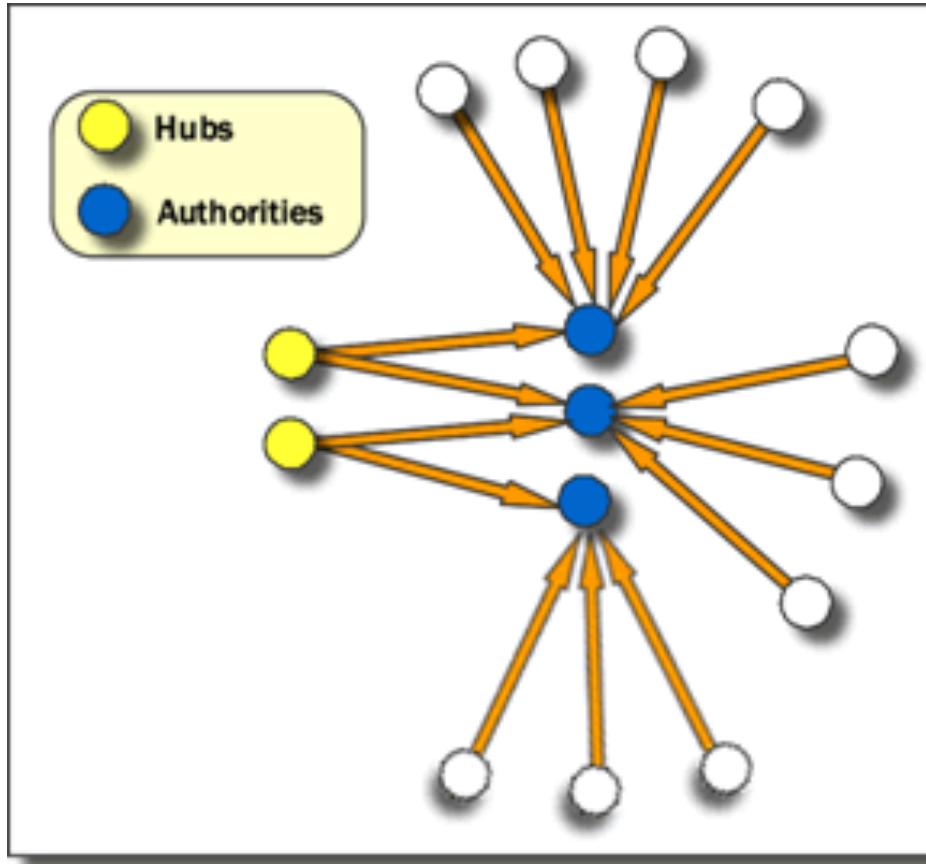
215

## Centrality in Social Networks Conceptual Clarification

Linton C. Freeman

Lehigh University \*

# Social Network Analysis: Hub and Authority

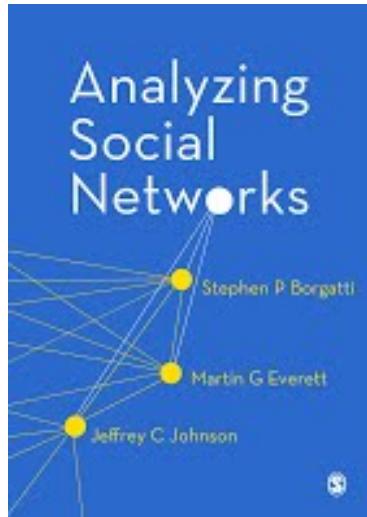


Hubs are entities that point to a relatively large number of authorities. They are essentially the mutually reinforcing analogues to authorities. Authorities point to high hubs. Hubs point to high authorities. You cannot have one without the other.

# Tools of Social Network Analysis

# Social Network Analysis (SNA) Tools

- **NetworkX**
- **igraph**
- **Gephi**
- **UCINet**
- **Pajek**



# Tools of Social Network Analysis

- Focused Desktop Tools

- Gephi**

- Ucinet

- Pajek

- NodeXL

- Cytoscape

# Tools of Social Network Analysis

- Developer Tools
  - NetworkX
  - iGraph
  - SNAP
  - sigma.js

# Gephi



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## The Open Graph Viz Platform

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Runs on Windows, Mac OS X and Linux.

[Learn More on Gephi Platform »](#)

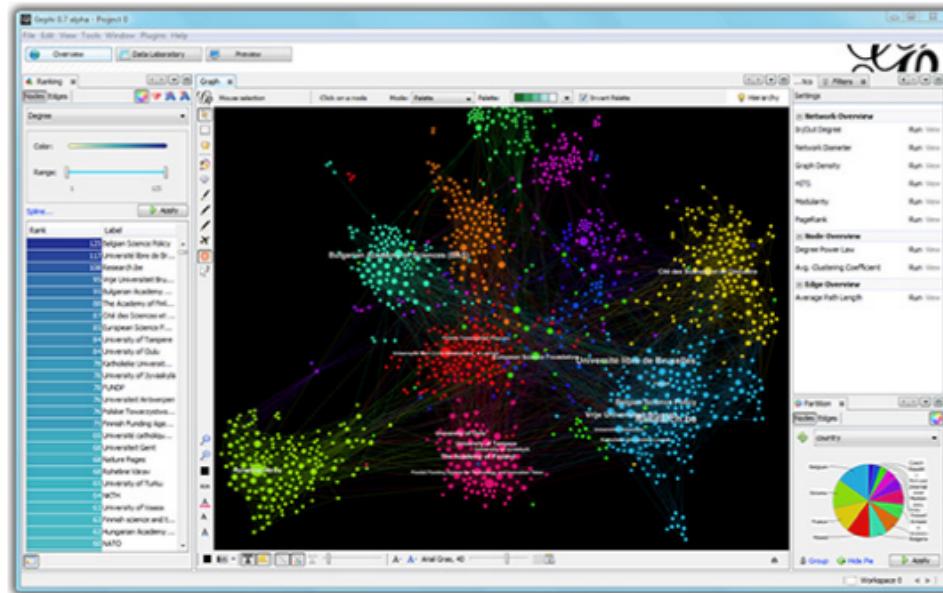


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Gephi 0.9.1

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### APPLICATIONS

- ✓ **Exploratory Data Analysis:** intuition-oriented analysis by networks manipulations in real time.
- ✓ **Link Analysis:** revealing the underlying structures of associations between objects.
- ✓ **Social Network Analysis:** easy creation of social

Like Photoshop™ for graphs.

— the Community

### LATEST NEWS

» [Gephi updates with 0.9.1 version](#)

### PAPERS

[Gephi: An Open Source Software for Exploring and Manipulating Networks](#)

Martes Rodriguez and Sébastien Heyman  
Software engineering, Network mining methods,  
Complex systems, Network Science, Big Data, Machine  
Learning, Data mining, Data visualization, Data mining

Mathieu Jourdan  
Network mining methods,  
Big Data, Network Science, Machine Learning,  
Complex systems, Network Science, Big Data, Machine  
Learning, Data mining, Data visualization, Data mining

Abstract: This manuscript presents an overview of the Gephi software, an open source platform for exploring and manipulating complex networks. The main features of the software are described, as well as some of its strengths and weaknesses. The paper also highlights the potentialities of Gephi for different applications and discusses its role in the field of complex systems research. Finally, the paper concludes with some perspectives for the future development of Gephi.

# UCINET



## UCINET Software

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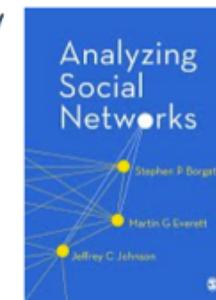
New! UCINET-oriented book on social network analysis now available! See [details](#).

UCINET 6 for Windows is a software package for the analysis of social network data. It was developed by Lin Freeman, Martin Everett and Steve Borgatti. It comes with the NetDraw network visualization tool.

If you use the software, please cite it. Here is a sample citation:

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

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### Download and/or Purchase

- The program can be [downloaded](#) and used for free for 90 days. In addition, students can [purchase](#) the downloaded program for \$40. Faculty and government can purchase the downloaded program for \$150, and all others pay \$250. Site licenses and extremely generous volume discounts are available.
- Note that all purchases are provided as electronic downloads. If necessary you can order a CD from us for an exorbitant fee, but there is no reason to do this. Purchasers of the software are welcome to burn their own CDs at will. They are also free to download the program to all of their computers.
- For more details, including questions about taxes, shipping costs, payment methods, etc., please visit the [Order Info](#) page.

### News

[Week-long workshop on SNA](#)  
The LINKS Center at the University of Kentucky is offering its annual 1-week summer workshop on social network analysis June 6-10, 2016 on the University of Kentucky campus ...  
Posted Mar 15, 2016, 12:54 PM by Steve Borgatti

Showing posts 1 - 1 of 9.  
[View more »](#)

### Current Version

[Version 6.614 | 22 May 2016](#) Changed Network|Compare aggregate proximity matrices|partition to be able to handle missing valuesChanged the CLI's IPF routine to default to treating diagonal values

# Pajek

## Networks / Pajek



## Program for Large Network Analysis

---

In January 2008 this page was replaced by [Pajek Wiki](#).

---

Pajek runs on Windows and is free for noncommercial use.

### [DOWNLOAD Pajek](#)

Data: [test networks](#), [GPHs](#), [GEDs](#), [PDB files](#).

[Screenshots](#); [History](#); [Manual \(pdf\)](#); [Papers/presentations](#); [Applications](#); [in News](#); Examples: [SVG](#), [PDF](#).

[How to ?](#) English / Slovene / Japanese (problems with IE - download and use Acrobat reader).

[Pajek nicely runs on Linux via Wine](#), [Converting Excel/text into Pajek format](#).

[Pajek to SVG animation](#), [WoS to Pajek](#).

[Slides from NICTA workshop](#), Sydney, Australia, June 14-17, 2005.

[Slides from workshop at GD'05](#), Limerick, Ireland, Sept 11-14, 2005.

[Pajek workshop at XXVIII Sunbelt Conference](#), St. Pete Beach, Florida, USA, January 22-27, 2008; [slides](#).

[Network analysis course at ECPR Summer School in Methods and Techniques](#), Ljubljana, Slovenia, July 30 - August 16, 2008.

W. de Nooy, A. Mrvar, V. Batagelj: *Exploratory Social Network Analysis with Pajek*, CUP, January 2005; ESNA page.  
P. Doreian, V. Batagelj, A. Ferligoj: *Generalized Blockmodeling*, CUP, November 2004.

Chapter about Pajek: V. Batagelj, A. Mrvar: *Pajek - Analysis and Visualization of Large Networks*.  
in Jünger, M., Mutzel, P., (Eds.) *Graph Drawing Software*. Springer, Berlin 2003. p. 77-103 / [Amazon](#).

An improved version of the paper presented at [Sunbelt'97](#) was published in [Connections](#) 21(1998)2, 47-57 - V. Batagelj,  
A. Mrvar: *Pajek - Program for Large Network Analysis* ([PDF](#); [PRISON.KIN](#)).

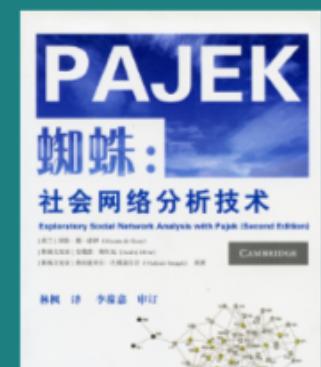
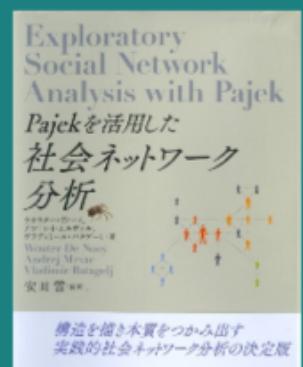
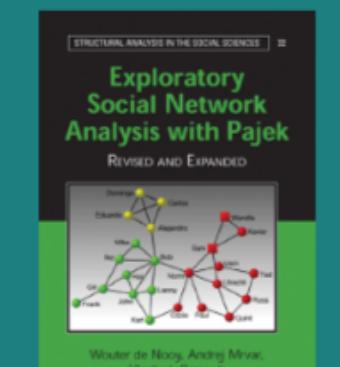
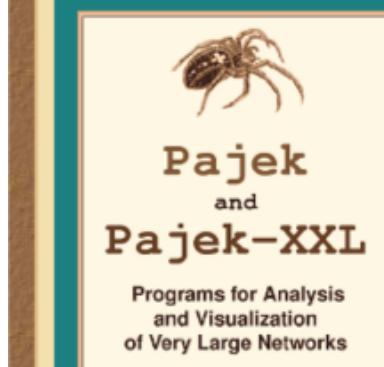
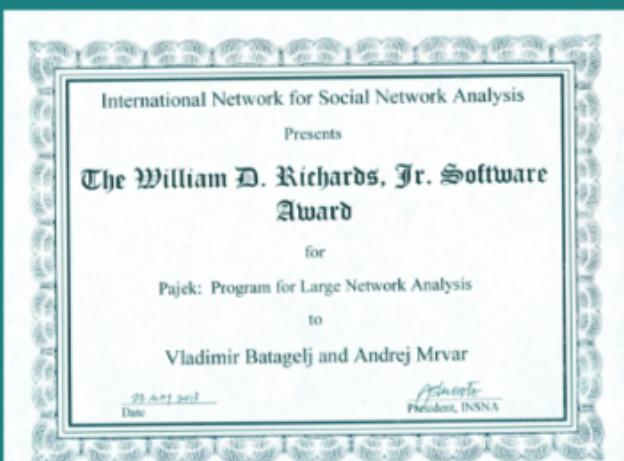
Our layouts for *Graph-Drawing Competitions*: [GD95](#), [GD96](#), [GD97](#), [GD98](#), [GD99](#), [GD00](#), [GD01](#) and [GD05](#).

<http://vlado.fmf.uni-lj.si/pub/networks/pajek/>

# Pajek

## Pajek: analysis and visualization of large networks

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March 1, 2016	4.09	<a href="#">Install Shield</a> <a href="#">Install-Zip</a> <a href="#">Portable</a>	<a href="#">Install Shield</a> <a href="#">Install-Zip</a> <a href="#">Portable</a>
Sept. 25, 2011	2.05	<a href="#">zip</a>	<a href="#">zip</a>
<a href="#">Pajek mailing list</a>		<a href="#">Datasets</a>	



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## NodeXL: Network Overview, Discovery and Exploration for Excel

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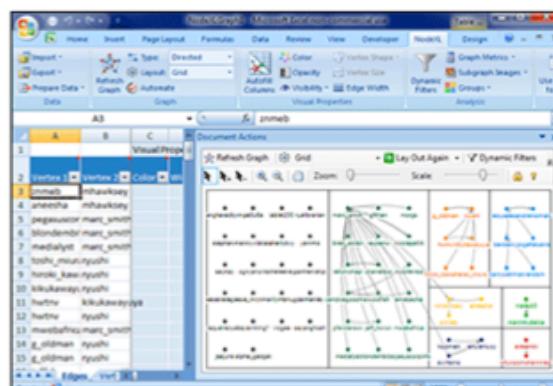


OPEN TOOLS, OPEN DATA, OPEN SCHOLARSHIP FOR SOCIAL MEDIA



NodeXL Basic is a free, open-source template for Microsoft® Excel® 2007, 2010, 2013 and 2016 that makes it easy to explore network graphs. With NodeXL, you can enter a network edge list in a worksheet, click a button and see your graph, all in the familiar environment of the Excel window.

NodeXL Pro offers additional features that extend NodeXL Basic, providing easy access to social media network data streams, advanced network metrics, and text and sentiment analysis, and



<https://nodexl.codeplex.com/>

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The Cytoscape logo features a stylized orange molecular structure on the left, composed of spheres and connecting lines. To its right, the word "Cytoscape" is written in a large, white, sans-serif font. Below the main text, the version number "ZNF 5.2.1" is visible in a smaller font.

Network Data Integration, Analysis, and Visualization in a Box

# Introduction

## Download 3.4.0

<http://www.cytoscape.org/>

# NetworkX

## NetworkX

[NetworkX Home](#) | [Documentation](#) | [Download](#) | [Developer \(Github\)](#)

### High-productivity software for complex networks

NetworkX is a Python language software package for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks.



#### [Documentation](#)

*all documentation*

#### [Examples](#)

*using the library*

#### [Reference](#)

*all functions and methods*

### Features

- Python language data structures for graphs, digraphs, and multigraphs.
- Many standard graph algorithms
- Network structure and analysis measures
- Generators for classic graphs, random graphs, and synthetic networks
- Nodes can be "anything" (e.g. text, images, XML records)
- Edges can hold arbitrary data (e.g. weights, time-series)
- Open source [BSD license](#)
- Well tested: more than 1800 unit tests, >90% code coverage
- Additional benefits from Python: fast prototyping, easy to teach, multi-platform

#### Versions

#### Latest Release

networkx-1.11  
30 January 2016  
[downloads](#) | [docs](#) | [pdf](#)

#### Development

2.0dev  
[github](#) | [docs](#) | [pdf](#)  
build passing  
coverage 94%

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<https://networkx.github.io/>

# igraph

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## igraph – The network analysis package

igraph is a collection of network analysis tools with the emphasis on **efficiency, portability** and ease of use. igraph is **open source** and free. igraph can be programmed in **R, Python** and **C/C++**.

[igraph R package](#)[python-igraph](#)[igraph C library](#)

R/igraph 1.0.0

Repositories at Github

R/igraph 0.7.1

C/igraph 0.7.1

R/igraph 0.7.0

python-igraph 0.7.0

C/igraph 0.7.0

R/igraph 0.6.5

## Recent news

### [R/igraph 1.0.0](#)

June 24, 2015

#### [Release Notes](#)

This is a new major release, with a lot of UI changes. We tried to make it easier to use, with short and easy to remember, consistent function names. Unfortunately

<http://igraph.org/redirect.html>



## Stanford Network Analysis Project

- SNAP for C++ ▶
- SNAP for Python ▶
- SNAP Datasets ▶
- What's new
- People
- Papers
- Citing SNAP
- Links
- About
- Contact us

### Open positions

Open research positions in **SNAP** group are available [here](#).

### • **SNAP for C++: Stanford Network Analysis Platform**

Stanford Network Analysis Platform (**SNAP**) is a general purpose network analysis and graph mining library. It is written in C++ and easily scales to massive networks with hundreds of millions of nodes, and billions of edges. It efficiently manipulates large graphs, calculates structural properties, generates regular and random graphs, and supports attributes on nodes and edges. SNAP is also available through the [NodeXL](#) which is a graphical front-end that integrates network analysis into Microsoft Office and Excel.

### • **Snap.py: SNAP for Python**

Snap.py is a Python interface for SNAP. It provides performance benefits of SNAP, combined with flexibility of Python. Most of the SNAP C++ functionality is available via Snap.py in Python.

### • **Stanford Large Network Dataset Collection**

A collection of more than 50 large network datasets from tens of thousands of nodes and edges to tens of millions of nodes and edges. It includes social networks, web graphs, road networks, internet networks, citation networks, collaboration networks, and communication networks.

### • **Tutorials**

Tutorials on using SNAP, on methods to analyze large network data, on ways how to think about networks and how to model them at the level of network structure, and on methods to study evolution and dynamics of diffusion and cascading behavior in networks.

- Tutorial on [Large Scale Network Analytics with SNAP](#) will be held at [WWW-15](#) conference, Florence, Italy, May 18, 2015. [More info](#).

# sigma.js

@sigmajs

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TUTORIAL

v1.1.0

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Sigma is a JavaScript library **dedicated to graph drawing**. It makes easy to publish networks on Web pages, and allows developers to integrate network exploration in rich Web applications.

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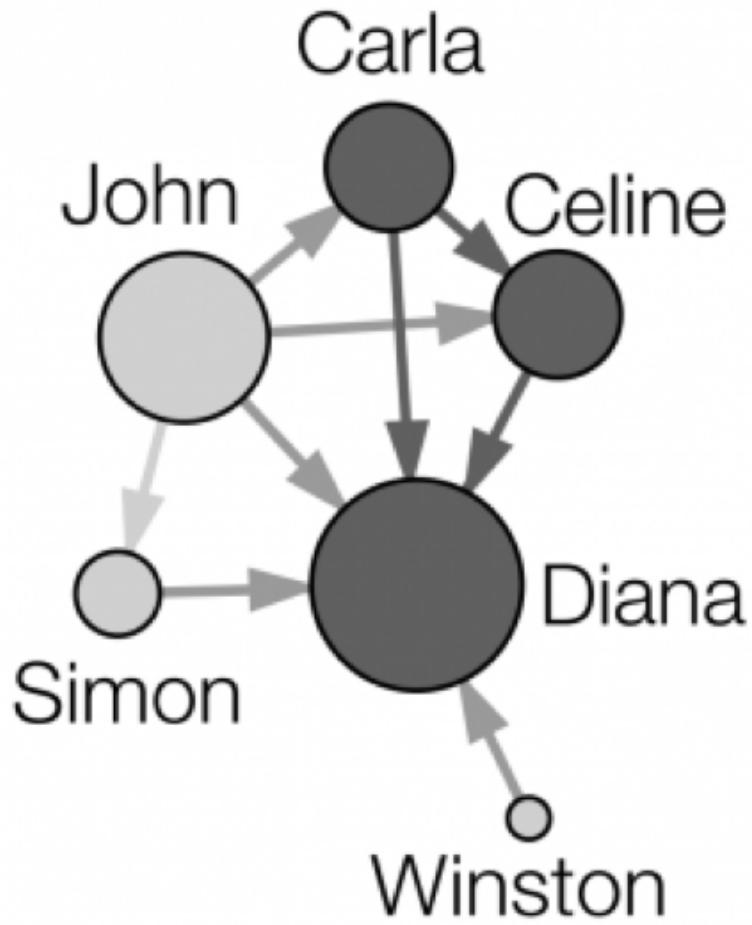
# Gephi



Gephi.app

# Gephi: Social Network Analysis and Visualization

# Network Analysis and Visualization with Gephi



Nodes	Edges
Id,Label,Attribute	Source,Target
1,John,1	1,2
2,Carla,2	1,3
3,Simon,1	1,4
4,Celine,2	1,6
5,Winston,1	2,4
6,Diana,2	2,6
	3,6
	4,6
	5,6

# Nodes and Edges

## CSV Text Data for Gephi

### Nodes1.csv

Id	Label	Attribute
1	John	1
2	Carla	2
3	Simon	1
4	Celine	2
5	Winston	1
6	Diana	2

Nodes1.csv



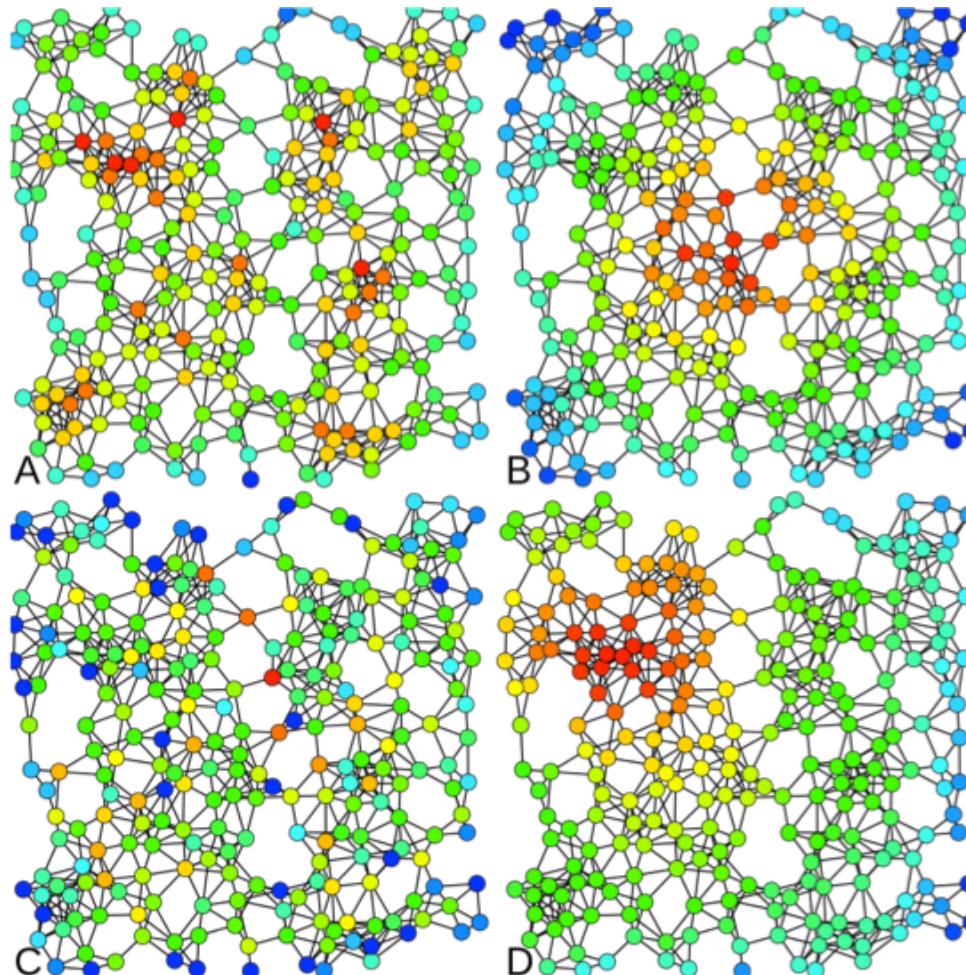
Id	Label	Attribute
1	John	1
2	Carla	2
3	Simon	1
4	Celine	2
5	Winston	1
6	Diana	2

### Edges1.csv

Source	Target
1	2
1	3
1	4
1	6
2	4
2	6
3	6
4	6
5	6

A = Degree centrality  
number of connexions

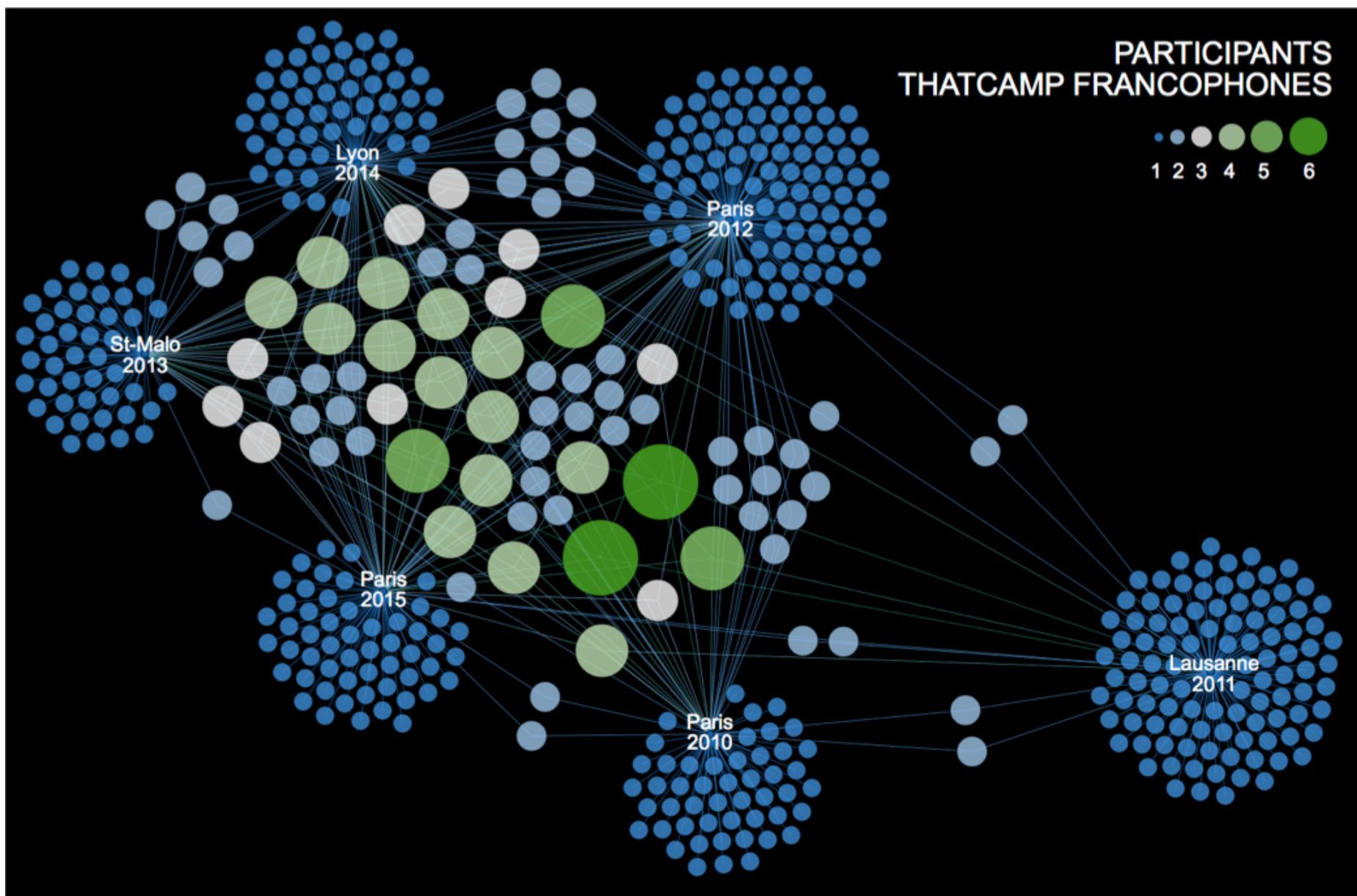
B = Closeness centrality  
closeness to the entire network



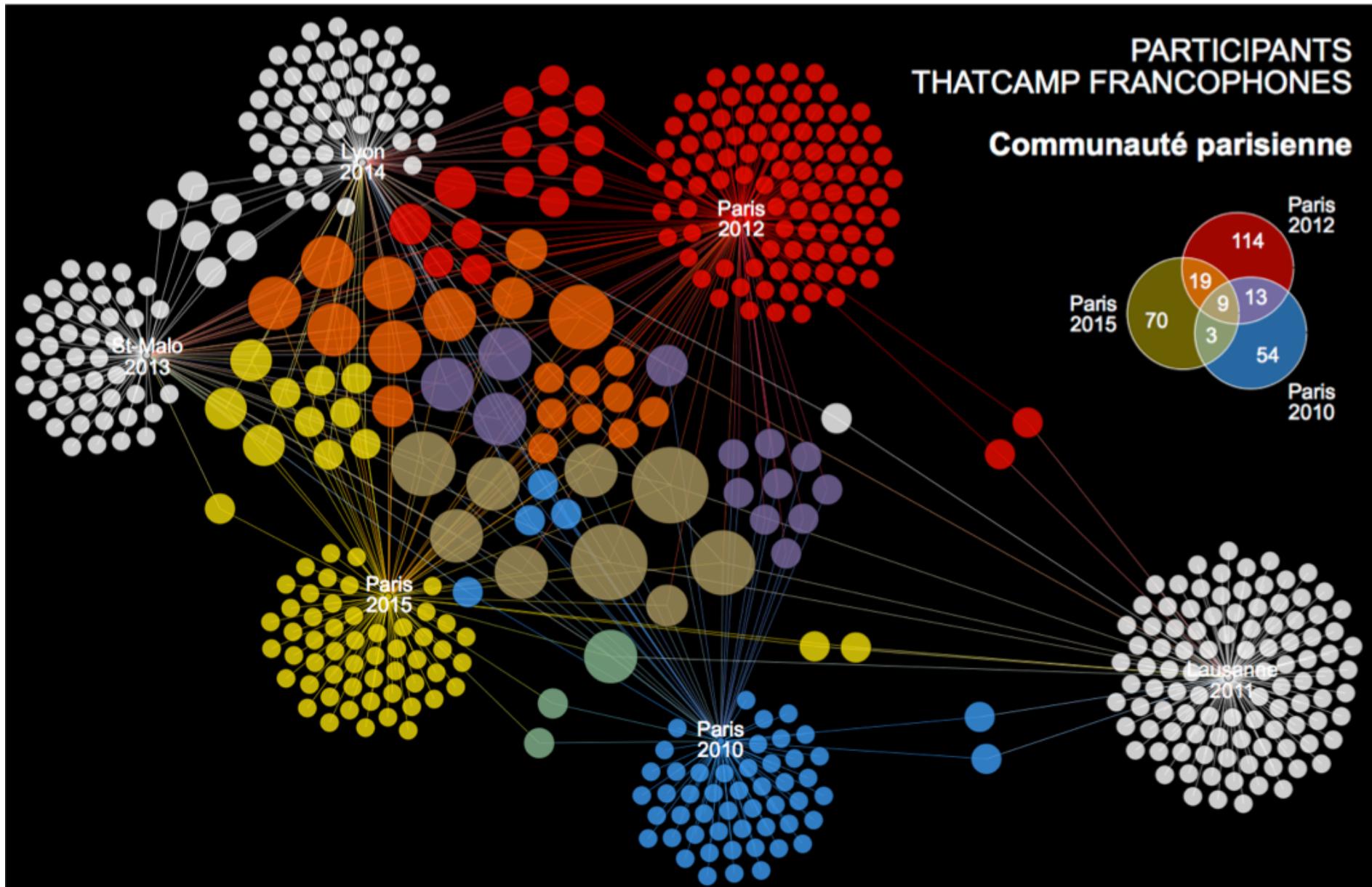
C = Betweenness centrality  
bridges nodes

D = Eigenvector centrality  
connection to well-connected nodes

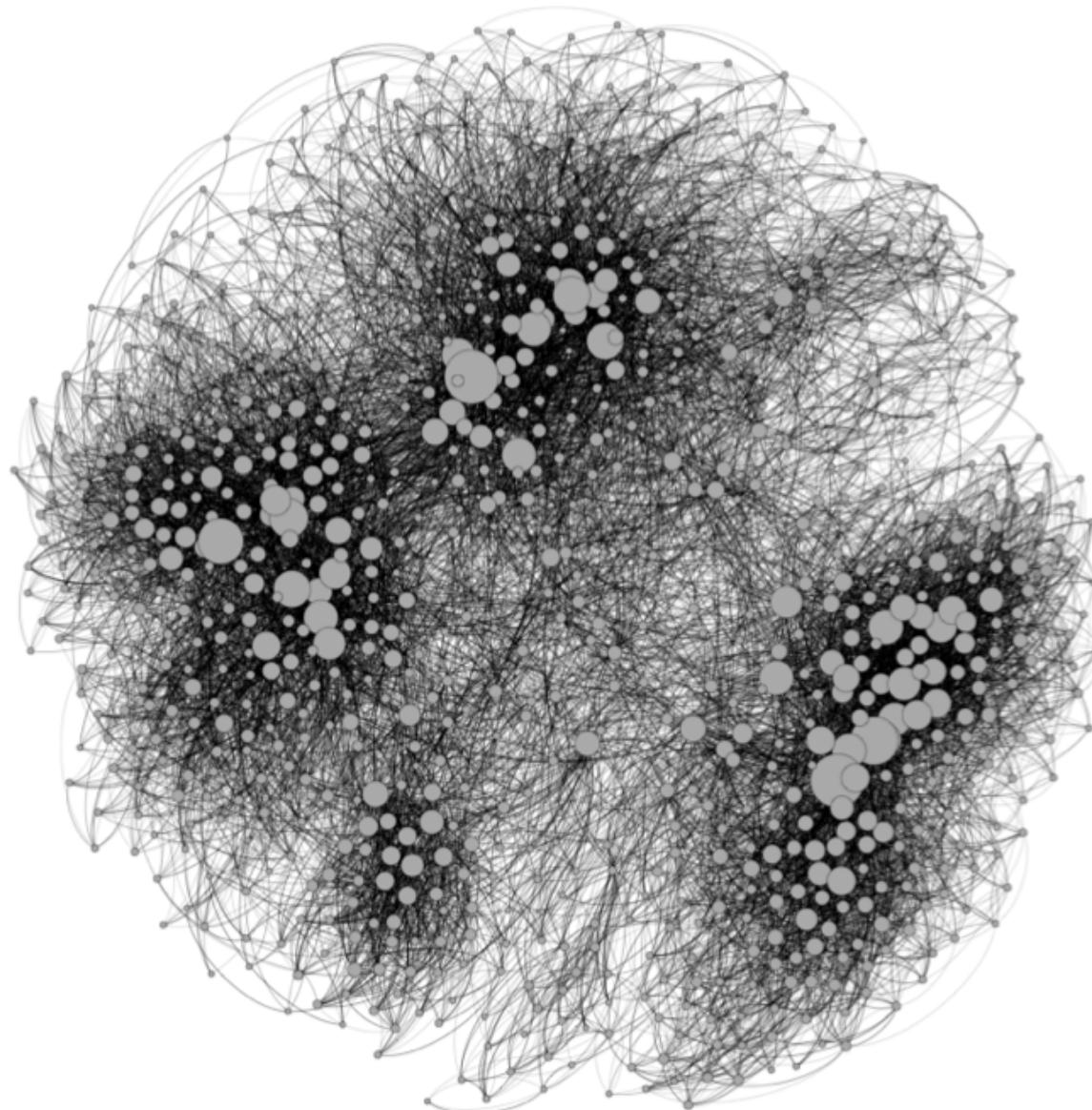
# Conference Participants



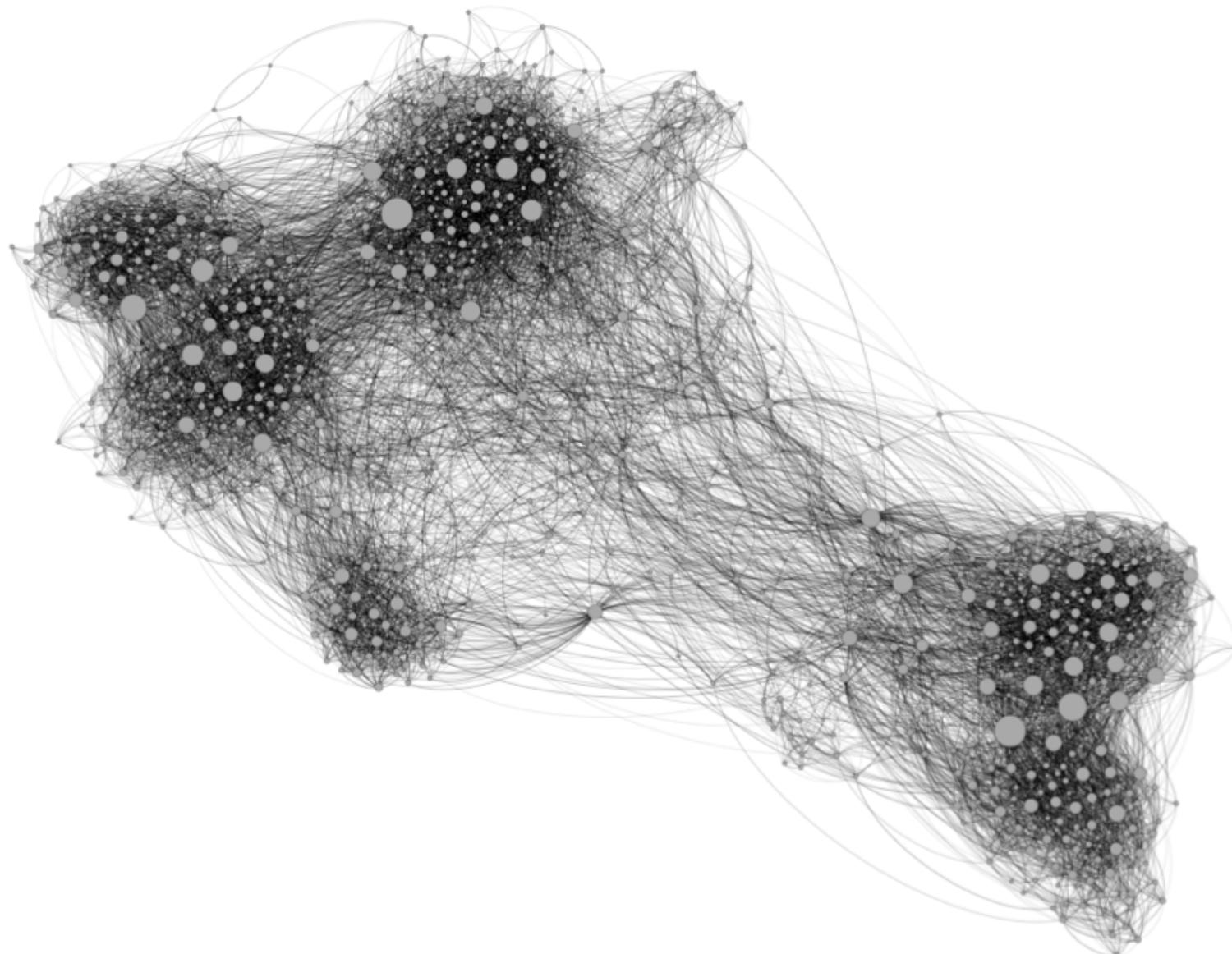
# Conference Participants



# Fruchterman Reingold

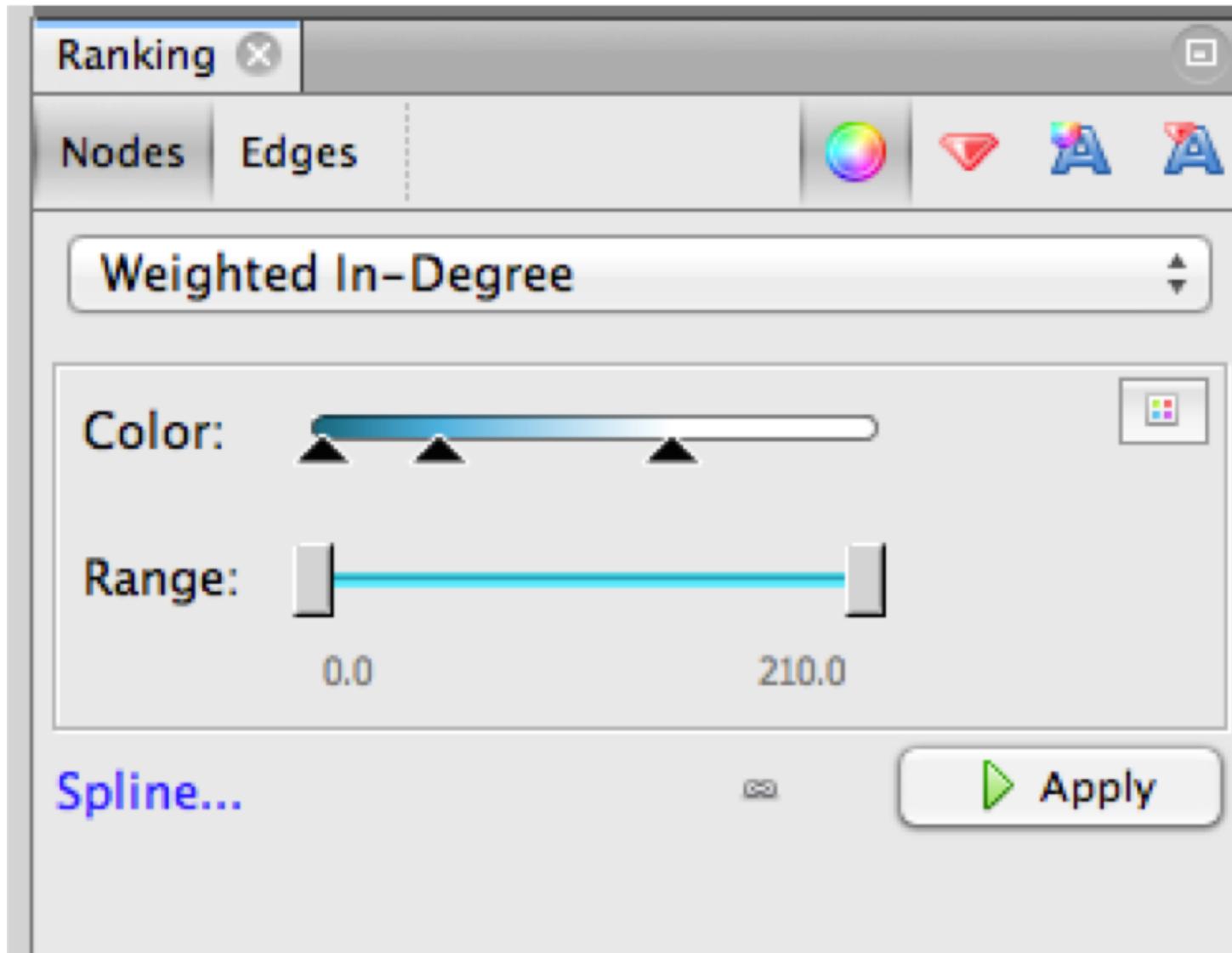


# Force Atlas 2



# Nodes' color

## Weighted In-Degree



# Weighted In-Degree



# Network Diameter

## Betweenness Centrality

## Closeness Centrality

Graph Distance settings

**Distance**  
The average graph-distance between all pairs of nodes. Connected nodes have graph distance 1. The diameter is the longest graph distance between any two nodes in the network. (i.e. How far apart are the two most distant nodes).

Directed       Normalize Centralities in [0,1]

UnDirected

**Betweenness Centrality:** Measures how often a node appears on shortest paths between nodes in the network.

**Closeness Centrality:** The average distance from a given starting node to all other nodes in the network.

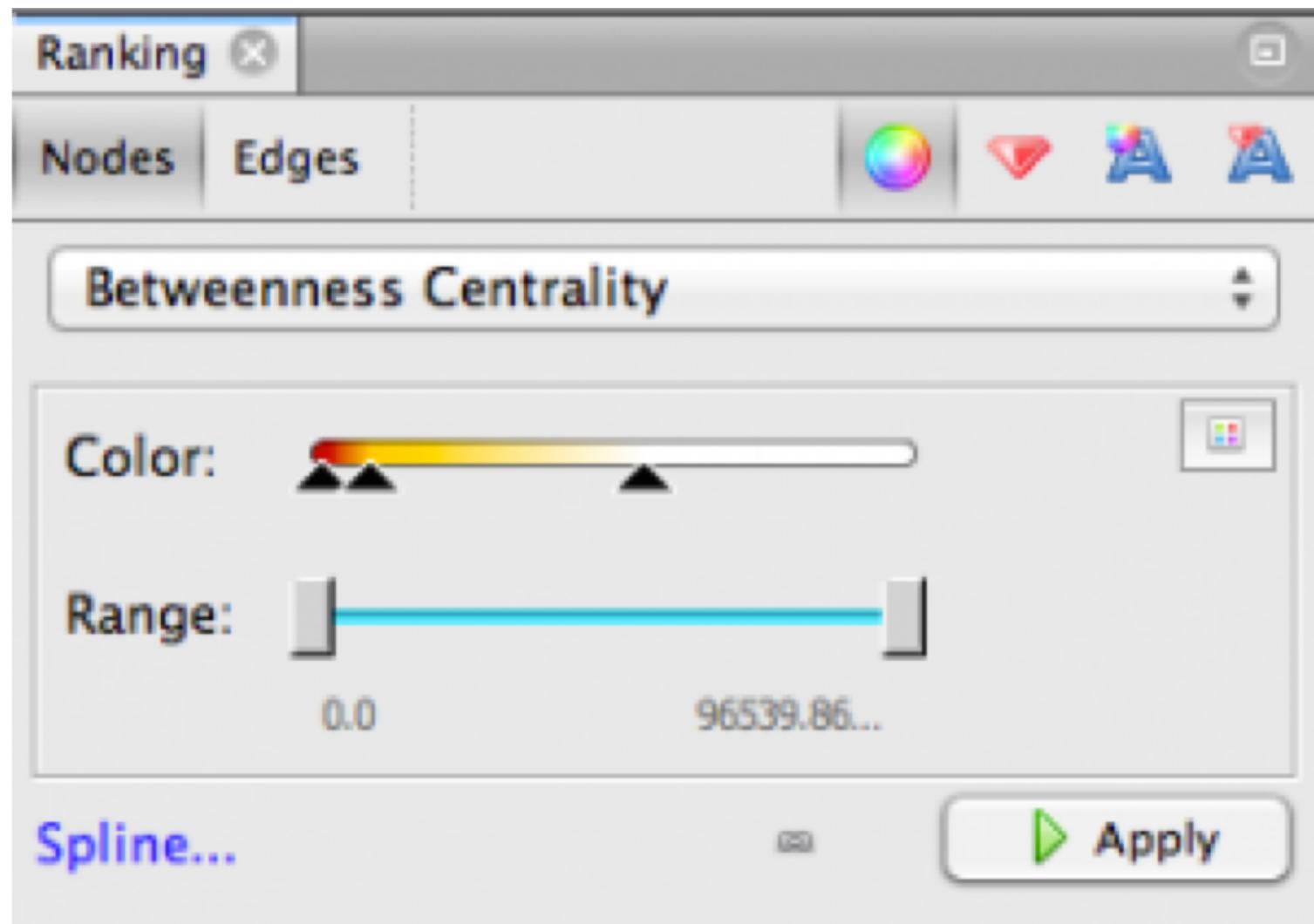
**Eccentricity:** The distance from a given starting node to the farthest node from it in the network.

Cancel      OK

Statistics    Filters  
Settings

Network Overview  
Average Degree      Run        
Avg. Weighted Degree      25.486      Run        
Network Diameter      Run         
Graph Density      Run        
HITS      Run        
Modularity      0.57      Run        
PageRank      Run        
Connected Components      Run        
 Node Overview  
Avg. Clustering Coefficient      Run        
Eigenvector Centrality      Run        
 Edge Overview

# Nodes' color Betweenness Centrality

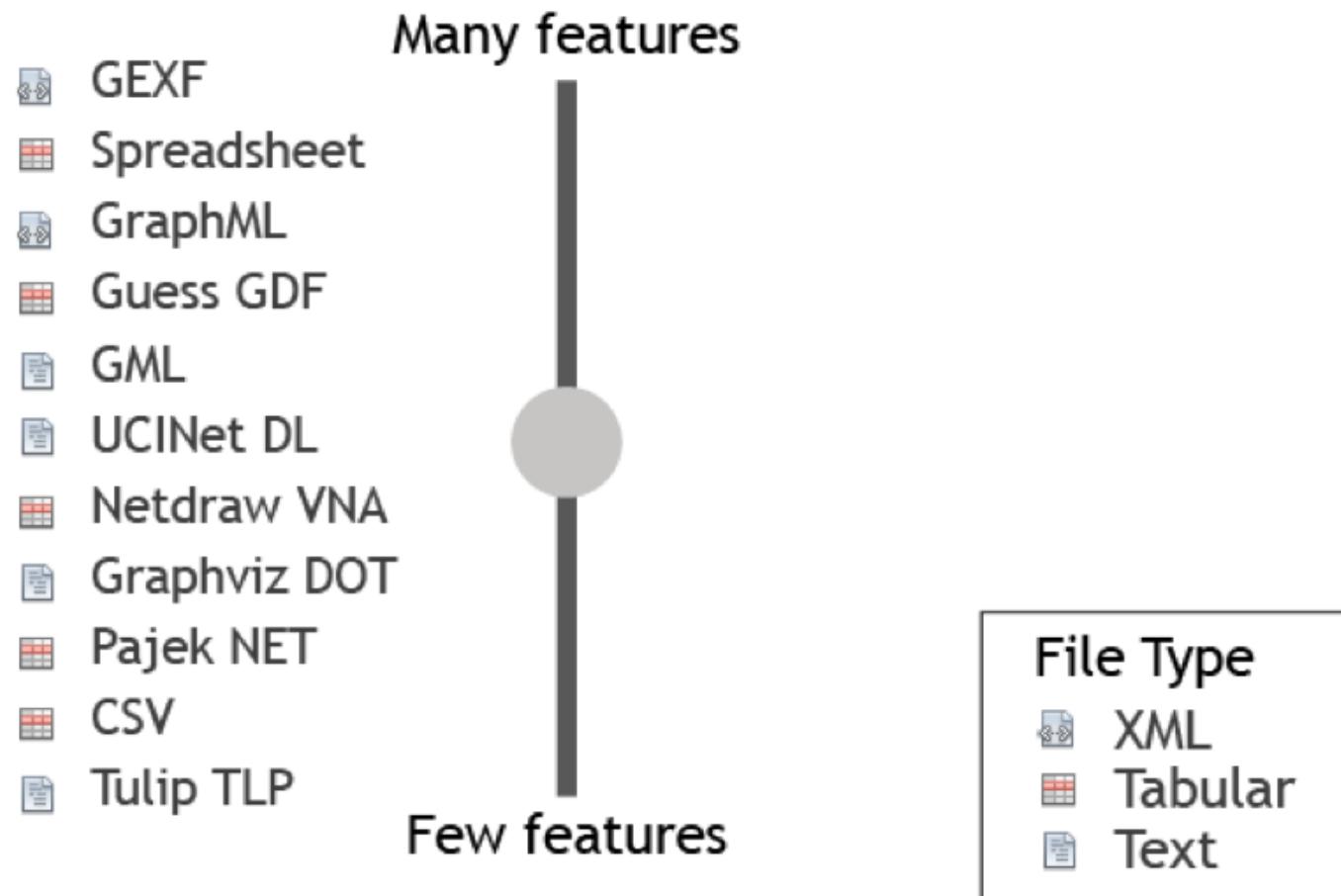


# Gephi Supported Graph Formats

	Edge List/Matrix Structure	XML Structure	Edge Weight	Attributes	Visualization Attributes	Attribute Default Value	Hierarchical Graphs	Dynamics
CSV	■							
DL Ucinet	■		■					
DOT Graphviz		■		■				
GDF			■	■	■			
GEXF		■			■	■	■	
GML			■	■				
GraphML		■	■	■	■			
NET Pajek	■			■				
TLP Tulip								
VNA Netdraw		■	■					
Spreadsheet*						■		

# Gephi Supported Graph Formats

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## The Open Graph Viz Platform

Gephi is the leading visualization and exploration software for all kinds of graphs and networks. Gephi is open-source and free.

Runs on Windows, Mac OS X and Linux.

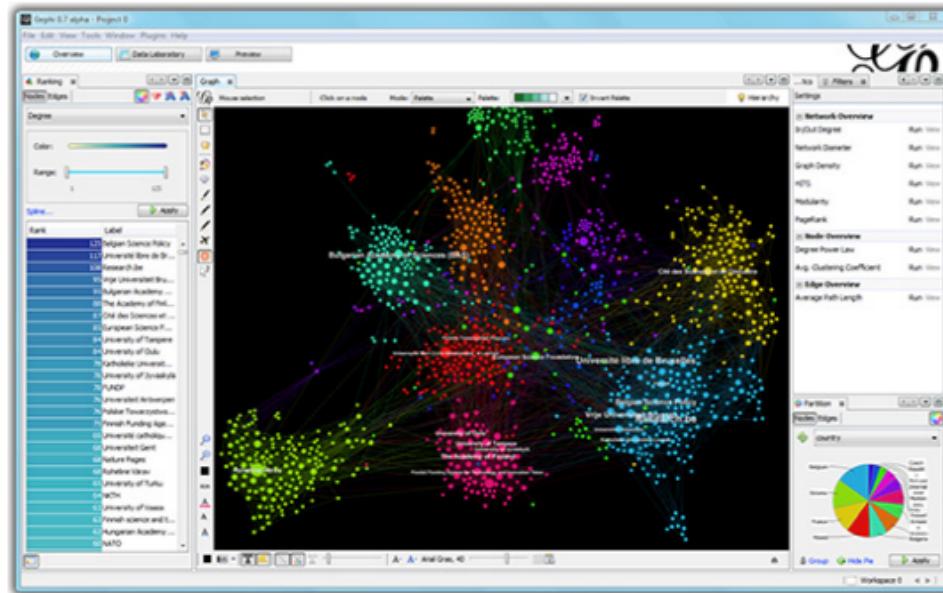
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### APPLICATIONS

- ✓ **Exploratory Data Analysis:** intuition-oriented analysis by networks manipulations in real time.
- ✓ **Link Analysis:** revealing the underlying structures of associations between objects.
- ✓ **Social Network Analysis:** easy creation of social

Like Photoshop™ for graphs.

— the Community

### LATEST NEWS

» [Gephi updates with 0.9.1 version](#)

### PAPERS



<https://gephi.org/>

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makes graphs handy

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## Download

Gephi is an open-source and multiplatform software distributed under the dual license [CDDL 1.0](#) and [GNU General Public License v3](#).

### Official Releases

[Release Notes](#) | [System Requirements](#) | [Installation instructions](#)

Gephi 0.9.1 is the latest stable release.

[Download Gephi for Mac OSX](#)

Version 0.9.1

If you have an older Gephi on your computer, you should uninstall it first, [see the installation instructions](#).

#### All downloads:

[Download Gephi 0.9.1 for Mac OS X](#)

[Download Gephi 0.9.1 for Windows](#)

[Download Gephi 0.9.1 for Linux](#)

[Download Gephi 0.9.1 sources](#)

[Download Older Versions](#)

#### Sources:

Gephi uses [GitHub](#) to host the source code and track issues. The [trunk](#) repository is the most up-to-date version but may be unstable. The last stable version is located in the release tab on GitHub.

## Localization

Localization is available in **French, Spanish, Japanese, Brazilian Portuguese, Russian, Chinese, Czech and German**. In Gephi, simply go to **Tools -> Languages** to switch.

<https://gephi.org/users/download/>

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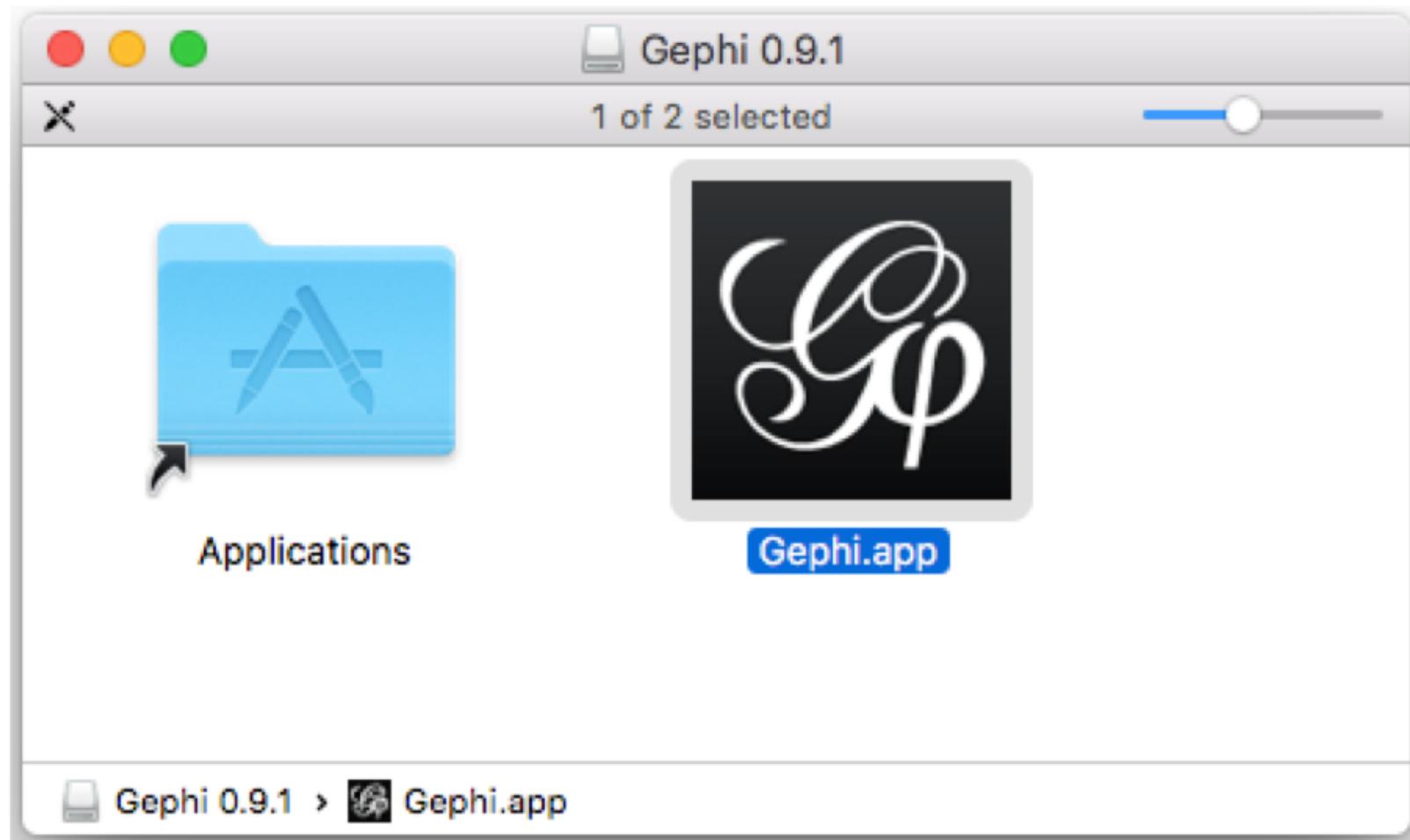
# Download Gephi



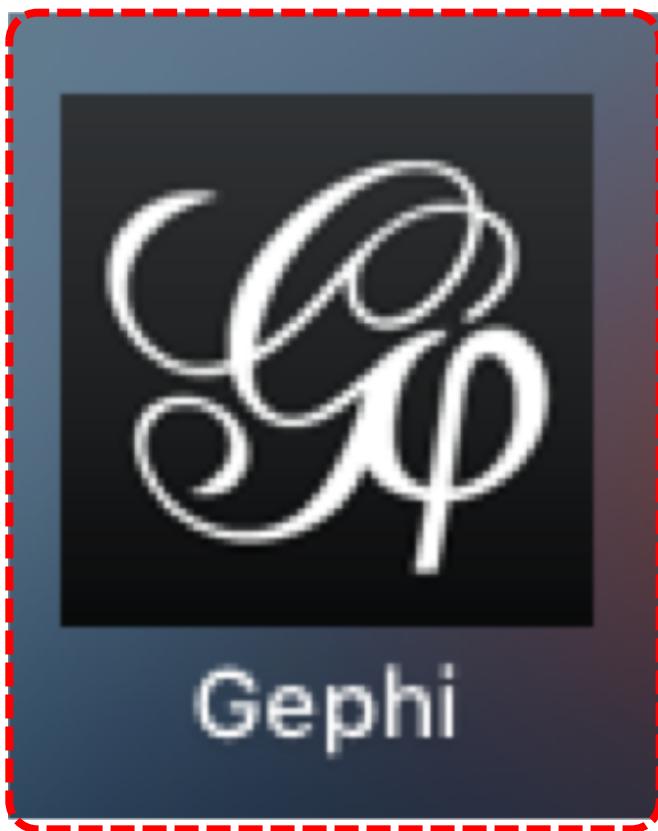
[\*\*gephi-0.9.1-macos.dmg\*\*](#)

Disk Image - 121.1 MB

# Gephi 0.9.1



# Gephi



Gephi



Gephi.app

# Gephi: New Project

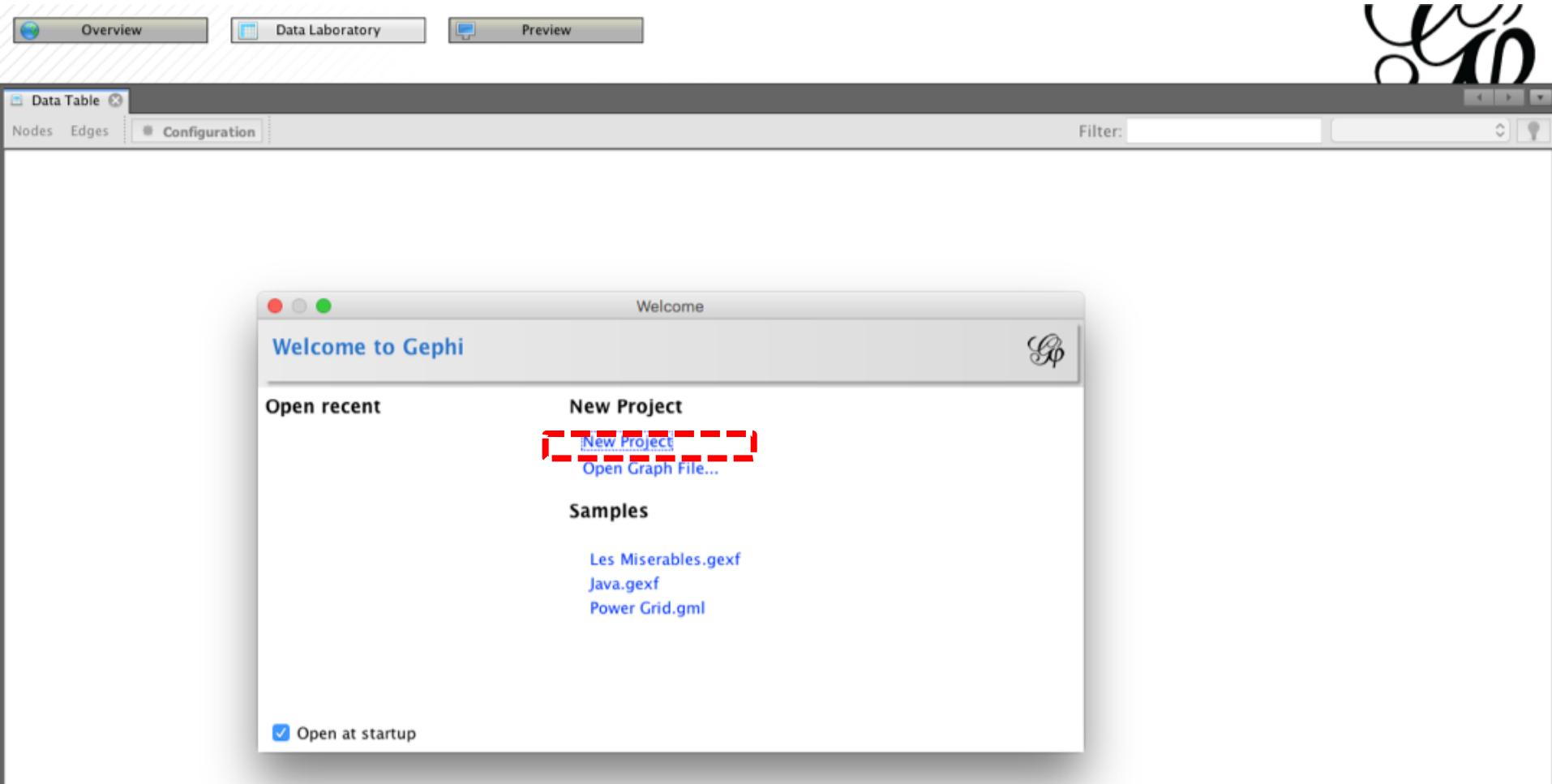
Import

Nodes1.csv and

Edges1.csv

to Gephi

# Gephi New Project



# Gephi Overview

The screenshot shows the Gephi interface with several panels:

- Appearance Panel (Left):** Contains tabs for Nodes, Edges, Unique, and Attribute. A color preview is shown (#c0c0c0). Buttons for Nodes and Edges are highlighted.
- Layout Panel (Second Left):** Shows a dropdown menu for "Choose a layout" and a "Run" button.
- Graph Panel (Center):** Displays a graph area with a toolbar above it. A message says "Dragging (Configure)".
- Context Panel (Right):** Shows network statistics: Nodes: 0, Edges: 0, and Type: Directed Graph. A section titled "4. Context" is overlaid in red.

**Red Overlays:**

- 1. Appearance** is overlaid on the Appearance panel.
- 2. Layout** is overlaid on the Layout panel.
- 3. Graph** is overlaid on the Graph panel.
- 4. Context** is overlaid on the Context panel.
- 5. Statistics** is overlaid on the Context panel, covering the bottom half of the panel.

Filters

# Gephi Data Laboratory: Import Spreadsheet



Screenshot of the Gephi Data Laboratory interface showing the "Import Spreadsheet" feature highlighted with a red box.

The interface includes:

- Top navigation bar with tabs: Overview, Data Laboratory (highlighted), Preview.
- Left sidebar: Workspace 1, Data Table, Nodes, Edges, Configuration, Add node, Add edge, Search/Replace, Import Spreadsheet (highlighted), Export table, More actions, Filter, Id.
- Main area: A large empty workspace labeled "Label" and "Interval".
- Bottom toolbar: Add column, Merge columns, Delete column, Clear column, Copy data to other column, Fill column with a value, Duplicate column, Create a boolean column from regex match, Create column with list of regex matching groups.

# Gephi Data Laboratory: Import Spreadsheet

The screenshot shows the Gephi Data Laboratory interface. At the top, there are tabs: Overview, Data Laboratory (which is selected and highlighted with a red dashed box), and Preview. Below the tabs is a toolbar with various icons: Nodes, Edges, Configuration, Add node, Add edge, Search/Replace, Import Spreadsheet (highlighted with a red dashed box), Export table, More actions, Filter, and an Id column selector.

The main area displays a dialog box titled "Import spreadsheet". The dialog has two sections: "Steps" and "General options". The "Steps" section lists "1. General options" and "2. Import settings". The "General options" section contains fields for "Choose a CSV file to import:" (with a browse button), "Separator:" (set to "Comma"), "As table:" (set to "Edges table"), "Charset:" (set to "UTF-8"), and a "Preview:" window which displays the message "Invalid CSV file" with a red exclamation mark icon. At the bottom of the dialog are buttons for Help, < Back, Next >, Finish, and Cancel.

At the very bottom of the interface, there is a row of icons with labels:

- Add column
- Merge columns
- Delete column ▾
- Clear column ▾
- Copy data to other column ▾
- Fill column with a value ▾
- Duplicate column ▾
- Create a boolean column from regex match ▾
- Create column with list of regex matching groups ▾

# Import Nodes1.csv to Gephi

The screenshot shows the Gephi interface with the 'Data Laboratory' tab selected (indicated by a red dashed box). A file browser window is open, showing a folder named 'SNA\_Data' containing two files: 'Edges1.csv' and 'Nodes1.csv'. The 'Nodes1.csv' file is highlighted with a red dashed box. The 'Import Spreadsheet' button in the toolbar is also highlighted with a red dashed box. The 'Import spreadsheet' dialog box is open, showing the 'General options' section with the file path set to '/imyday/Documents/SCDBA/SNA\_Data/Nodes1.csv'. The 'Open' button at the bottom right of the dialog is also highlighted with a red dashed box.

Nodes1.csv

Id	Label	Attribute
1	John	1
2	Carla	2
3	Simon	1
4	Celine	2
5	Winston	1
6	Diana	2

# Import Nodes1.csv to Gephi

Screenshot of the Gephi Data Laboratory interface showing the "Import spreadsheet" dialog.

The dialog displays the following information:

- Steps:** 1. General options, 2. Import settings.
- General options:** Choose a CSV file to import: /imyday/Documents/SCDBA/SNA\_Data/Nodes1.csv
- Separator:** Co... (dropdown menu)
- As table:** Nodes ta... (dropdown menu)
- Charset:** UTF-8
- Preview:** A table showing the data from the imported CSV file.

ID	Label	Attribute
1	John	1
2	Carla	2
3	Simon	1
4	Celine	2
5	Winston	1
6	Diana	2

Buttons at the bottom of the dialog include: Help, < Back, Next > (highlighted with a red dashed box), Finish, and Cancel.

Below the dialog, a toolbar contains the following icons:

- Add column
- Merge columns
- Delete column ▾
- Clear column ▾
- Copy data to other column ▾
- Fill column with a value ▾
- Duplicate column ▾
- Create a boolean column from regex match ▾
- Create column with list of regex matching groups ▾

# Import Nodes1.csv to Gephi

Screenshot of the Gephi Data Laboratory interface showing the "Import spreadsheet" dialog.

The dialog is titled "Import settings" and displays the following information:

- New columns are created with the specified type.
- A generated id is assigned if missing.
- Unless the option 'Force nodes to be created as new ones' is en

Imported columns:

- Id (String)
- Label (String)
- Attribute (String)

Force nodes to be created as new ones

Buttons at the bottom: Help, < Back, Next >, **Finish** (highlighted with a red dashed box), and Cancel.

Below the dialog, a toolbar contains the following icons:

- Add column
- Merge columns
- Delete column ▾
- Clear column ▾
- Copy data to other column ▾
- Fill column with a value ▾
- Duplicate column ▾
- Create a boolean column from regex match ▾
- Create column with list of regex matching groups ▾

# Import Nodes1.csv to Gephi

The screenshot shows the Gephi Data Laboratory interface with the following details:

- Top Bar:** Overview, Data Laboratory, Preview.
- Workspace 1:** Data Table.
- Toolbar:** Nodes, Edges, Configuration, Add node, Add edge, Search/Replace, Import Spreadsheet, Export table, More actions, Filter.
- Data Table:** A table with columns: Id, Label, Interval, Attribute. The data is as follows:

Id	Label	Interval	Attribute
1	John		1
2	Carla		2
3	Simon		1
4	Celine		2
5	Winston		1
6	Diana		2

- Nodes1.csv Content:** A yellow box labeled "Nodes1.csv" contains the CSV data:

Id	Label	Attribute
1	John	1
2	Carla	2
3	Simon	1
4	Celine	2
5	Winston	1
6	Diana	2
- Bottom Row Buttons:** Add column, Merge columns, Delete column, Clear column, Copy data to other column, Fill column with a value, Duplicate column, Create a boolean column from regex match, Create column with list of regex matching groups.

# Import Edges1.csv to Gephi

The screenshot shows the Gephi Data Laboratory interface. At the top, there are three tabs: Overview, Data Laboratory (selected), and Preview. Below the tabs is a toolbar with various icons and buttons. The 'Data Table' tab is open. The main area displays a table with columns: Source, Target, Type, Id, Label, Interval, and Weight. The 'Edges' tab is selected, and the 'Import Spreadsheet' button is highlighted with a red box. Other buttons in the toolbar include Add node, Add edge, Search/Replace, Export table, More actions, Filter, and Source. At the bottom, there is a row of buttons for column operations: Add column, Merge columns, Delete column, Clear column, Copy data to other column, Fill column with a value, Duplicate column, Create a boolean column from regex match, and Create column with list of regex matching groups.

# Import Edges1.csv to Gephi

Edges1.csv

Source,Target

1,2  
1,3  
1,4  
1,6  
2,4  
2,6  
3,6  
4,6  
5,6

The screenshot shows the Gephi interface with the 'Data Laboratory' tab selected. A 'Data Table' window is open, showing columns for Source, Target, Type, Id, Label, Interval, and Weight. The 'Edges' tab is selected. At the top, there are buttons for Overview, Data Laboratory, Preview, Configuration, Add node, Add edge, Search/Replace, Import Spreadsheet (which is highlighted with a red box), Export table, More actions, Filter, and Source. A 'Workspace 1' tab is also visible.

A 'Import spreadsheet' dialog is open, showing 'General options' and 'Steps' (1. General options, 2. Import settings). It asks to choose a CSV file to import, with the path '/Documents/SCDBA/SNA\_Data/Edges1.csv' selected. A file selection dialog is overlaid on the main window, showing a folder 'SNA\_Data' containing 'Edges1.csv' and 'Nodes1.csv'. The 'Edges1.csv' file is highlighted with a red dashed box. The 'Open' button at the bottom right of the file selection dialog is also highlighted with a red box.

Below the file selection dialog, there are several toolbar buttons: Clear column, Copy data to other column, Fill column with a value, Duplicate column, Create a boolean column from regex match, and Create column with list of regex matching groups.

# Import Edges1.csv to Gephi

Screenshot of the Gephi Data Laboratory interface showing the import of 'Edges1.csv'.

The 'Edges' tab is selected in the main toolbar. A modal dialog titled 'Import spreadsheet' is open, showing the 'General options' step. The 'Separator' dropdown is set to 'Comma' and the 'Charset' is set to 'UTF-8'. The 'Tables' dropdown shows 'Nodes table' and 'Edges table', with 'Edges table' checked. A red box highlights the 'Edges table' selection. The 'Preview' section shows the edge data:

Source	Target
1	2
1	3
1	4
1	6
2	4
2	6
3	6
4	6

Buttons at the bottom of the dialog include 'Help', '< Back', 'Next >', 'Finish', and 'Cancel'. The 'Next >' button is highlighted in blue.

Below the dialog, a toolbar provides various data manipulation functions:

- Add column
- Merge columns
- Delete column ▾
- Clear column ▾
- Copy data to other column ▾
- Fill column with a value ▾
- Duplicate column ▾
- Create a boolean column from regex match ▾
- Create column with list of regex matching groups ▾

Edges table

# Import Edges1.csv to Gephi

Screenshot of the Gephi Data Laboratory interface showing the import of 'Edges1.csv'.

The 'Data Table' tab is selected in the main menu. The 'Configuration' tab is active in the sub-menu.

The 'Import spreadsheet' dialog is open, showing the following configuration:

- General options:** Choose a CSV file to import: /Documents/SCDBA/SNA\_Data/Edges1.csv
- Separator:** Comma (Co...)
- As table:** Edges table (highlighted with a red dashed box)
- Charset:** UTF-8

**Preview:**

Source	Target
1	2
1	3
1	4
1	6
2	4
2	6
3	6
4	6

**Buttons at the bottom:**

- Help
- < Back
- Next > (highlighted with a red dashed box)
- Finish
- Cancel

**Toolbar icons at the bottom:**

- Add column
- Merge columns
- Delete column ▾
- Clear column ▾
- Copy data to other column ▾
- Fill column with a value ▾
- Duplicate column ▾
- Create a boolean column from regex match ▾
- Create column with list of regex matching groups ▾

**Red text overlay:** Edges table

# Import Edges1.csv to Gephi

Screenshot of the Gephi Data Laboratory interface showing the import process for 'Edges1.csv'.

The main window shows a 'Data Table' with columns: Source, Target, Type, Id, Label, Interval, and Weight.

A modal dialog titled 'Import spreadsheet' is open, showing the 'Import settings' step.

**Import settings:**

- New columns are created with the specified type.
- A generated id is assigned if missing or already existing.
- Edges need 'Source' and 'Target' columns with the id of the node.
- If no 'Type' column is provided, all edges will be directed.
- If an edge already exists, attributes will be ignored, but the edge will be updated.

**Imported columns:**

- Source: String
- Target: String
- Create missing nodes

Buttons at the bottom of the dialog: Help, < Back, Next >, **Finish** (highlighted with a red border), and Cancel.

Bottom toolbar icons (from left to right): Add column, Merge columns, Delete column, Clear column, Copy data to other column, Fill column with a value, Duplicate column, Create a boolean column from regex match, and Create column with list of regex matching groups.

# Import Edges1.csv to Gephi

Overview Data Laboratory Preview

Workspace 1

Data Table

Nodes Edges Configuration Add node Add edge Search/Replace Import Spreadsheet Export table More actions Filter: Source

Source	Target	Type	Id	Label	Interval	Weight
1	2	Directed	0			1.0
1	3	Directed	1			1.0
1	4	Directed	2			1.0
1	6	Directed	3			1.0
2	4	Directed	4			1.0
2	6	Directed	5			1.0
3	6	Directed	6			1.0
4	6	Directed	7			1.0
5	6	Directed	8			1.0

Add column Merge columns Delete column Clear column Copy data to other column Fill column with a value Duplicate column Create a boolean column from regex match Create column with list of regex matching groups

# Gephi Overview

Overview Data Laboratory Preview

Workspace 1

Appearance

Nodes Edges Unique Attribute

#c0c0c0

Apply

Layout

---Choose a layout Run

<No Properties>

Presets... Reset

Graph Dragging (Configure)

Context

Nodes: 6  
Edges: 9  
Directed Graph

Filters Statistics

Settings

Network Overview

- Average Degree
- Avg. Weighted Degree
- Network Diameter
- Graph Density
- Modularity
- PageRank
- Connected Components

Node Overview

- Avg. Clustering Coefficient
- Eigenvector Centrality

Edge Overview

- Avg. Path Length

Dynamic

- # Nodes
- # Edges
- Degree
- Clustering Coefficient

The screenshot shows the Gephi interface with a network graph containing 6 nodes and 9 edges. The graph is currently set to 'Dragging' mode. The left sidebar includes sections for Appearance (Nodes, Edges, Unique, Attribute), Layout (Choose a layout, Run), and Presets... Reset. The right sidebar displays network statistics (Nodes: 6, Edges: 9, Directed Graph) and various metrics like Average Degree, Eigenvector Centrality, and Clustering Coefficient, each with a Run button.

# Gephi Overview: Graph

The screenshot shows the Gephi software interface with a red dashed box highlighting the central workspace. The workspace displays a graph with 6 nodes and 9 edges. The nodes are black dots, and the edges are thin grey lines. The graph is a complex network structure with many connections between nodes.

**Graph Panel:** Shows the graph structure with 6 nodes and 9 edges. The status bar indicates "Dragging (Configure)".

**Appearance Panel:** Contains tabs for Nodes, Edges, Unique, and Attribute. A color swatch is set to #c0c0c0. Buttons for Apply, Layout, and Run are present.

**Layout Panel:** A dropdown menu says "Choose a layout" with options like Circular, Fruchterman-Reingold, and Kamada-Kawai.

**Context Panel:** Displays network statistics: Nodes: 6, Edges: 9, and it identifies the graph as a Directed Graph. It also lists various network metrics with checkboxes and run buttons.

- Network Overview
  - Average Degree
  - Avg. Weighted Degree
  - Network Diameter
  - Graph Density
  - Modularity
  - PageRank
  - Connected Components
- Node Overview
  - Avg. Clustering Coefficient
  - Eigenvector Centrality
- Edge Overview
  - Avg. Path Length
- Dynamic
  - # Nodes
  - # Edges
  - Degree
  - Clustering Coefficient

**Bottom Tools:** Includes a lightbulb icon, a text input field, a pencil icon, a color palette, and font settings (Arial-BoldMT, 32).

# Gephi Overview: Layout

The screenshot illustrates the Gephi interface, specifically focusing on the layout process. A red dashed box highlights the **Layout** panel on the left, which contains a dropdown menu for choosing a layout algorithm. The "Yifan Hu Proportional" option is selected. Other available layout options include Fruchterman Reingold, Label Adjust, Noverlap, OpenOrd, Random Layout, Rotate, and Yifan Hu.

The main workspace displays a network graph with several nodes and edges. The graph consists of approximately 6 nodes and 9 edges, forming a complex web of connections. The nodes are represented by black dots, and the edges are thin grey lines.

The **Context** panel on the right provides a summary of the network's properties:

- Nodes: 6
- Edges: 9
- Directed Graph

The panel also includes sections for Network Overview, Node Overview, Edge Overview, and Dynamic metrics, each with a "Run" button to execute calculations.

# Gephi Overview: Layout

## Yifan Hu Proportional

Screenshot of the Gephi software interface showing the "Yifan Hu Proportional" layout algorithm.

The layout panel on the left is highlighted with a red dashed border. It contains the following settings:

- Layout: Yifan Hu Proportional
- Run button (highlighted with a red box)
- Yifan Hu's properties:
  - Optimal Distance: 100.0
  - Relative Strength: 0.2
  - Initial Step size: 20.0
  - Step ratio: 0.95
  - Adaptive Cooling:
  - Convergence Thresl: 1.0E-4
- Barnes-Hut's properties:
  - Quadtree Max Level: 10
  - Theta: 1.2
- Presets... and Reset buttons

The central workspace displays a directed graph with 6 nodes and 9 edges. The nodes are black circles, and the edges are directed black lines. One node is isolated at the bottom left, while the other five form a cluster at the top right.

The Context panel on the right shows the following statistics for the graph:

- Nodes: 6
- Edges: 9
- Directed Graph

The Network Overview section includes the following metrics with "Run" buttons:

- Average Degree
- Avg. Weighted Degree
- Network Diameter
- Graph Density
- Modularity
- PageRank
- Connected Components

The Node Overview section includes the following metrics with "Run" buttons:

- Avg. Clustering Coefficient
- Eigenvector Centrality

The Edge Overview section includes the following metric with a "Run" button:

- Avg. Path Length

The Dynamic section includes the following metrics with "Run" buttons:

- # Nodes
- # Edges
- Degree
- Clustering Coefficient

Top navigation bar buttons: Overview, Data Laboratory, Preview.

# Gephi Overview: Layout

Yifan Hu

The screenshot shows the Gephi software interface with a directed graph displayed in the center. The graph consists of six nodes arranged in a roughly circular pattern, with directed edges connecting them. One node is isolated on the left.

The left sidebar contains the "Layout" panel, which is highlighted with a red dashed border. Inside this panel, under the "Yifan Hu" tab, the "Run" button is also highlighted with a red box. Other parameters shown include:

- Optimal Distance: 100.0
- Relative Strength: 0.2
- Initial Step size: 20.0
- Step ratio: 0.95
- Adaptive Cooling:
- Convergence Thresh: 1.0E-4
- Barnes-Hut's properties:
  - Quadtree Max Level: 10
  - Theta: 1.2

The top navigation bar includes tabs for "Overview", "Data Laboratory", "Preview", and "Workspace 1". The right side of the interface features the "Context" panel, which displays statistics for the graph: Nodes: 6, Edges: 9, and it identifies the graph as a "Directed Graph". Below this are sections for "Network Overview", "Node Overview", "Edge Overview", and "Dynamic" metrics, each with a "Run" button.

# Appearance: Nodes Color

Overview Data Laboratory Preview

Workspace 1

Appearance  Nodes  Edges Unique Attribute Color #c0c0c0  Apply

Graph  Dragging  Configure

Context Nodes: 6 Edges: 9 Directed Graph

Filters Statistics  Settings

Network Overview Average Degree Run  Avg. Weighted Degree Run Network Diameter Run Graph Density Run Modularity Run PageRank Run Connected Components Run Node Overview Avg. Clustering Coefficient Run Eigenvector Centrality Run Edge Overview Avg. Path Length Run Dynamic # Nodes Run # Edges Run Degree Run Clustering Coefficient Run

Layout  Yifan Hu  Run  ?

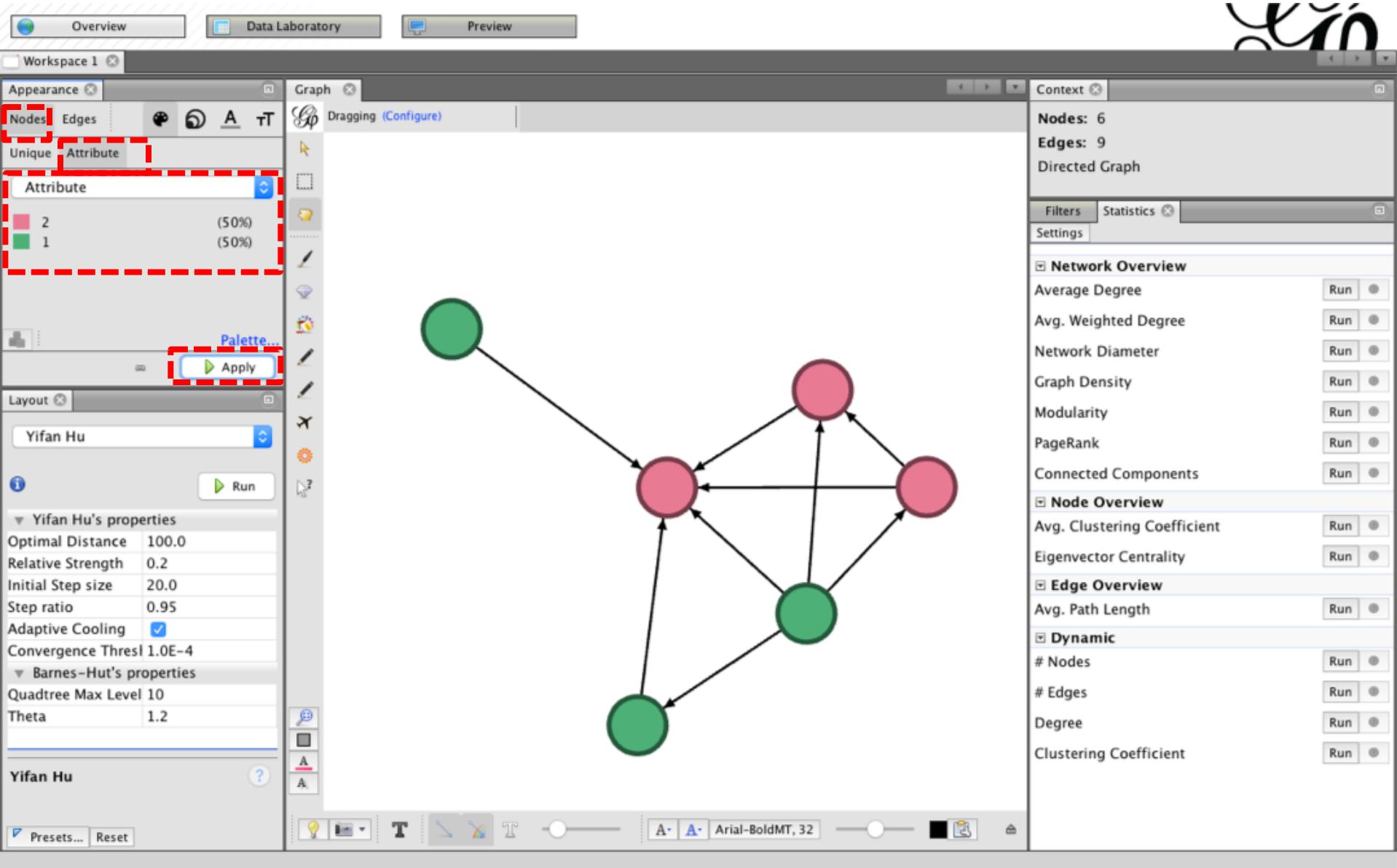
Yifan Hu's properties  
Optimal Distance 100.0  
Relative Strength 0.2  
Initial Step size 20.0  
Step ratio 0.95  
Adaptive Cooling   
Convergence Thresl 1.0E-4  
Barnes-Hut's properties  
Quadtree Max Level 10  
Theta 1.2

Yifan Hu  Presets... Reset

T T A A Arial-BoldMT, 32

```
graph TD; N1(( )) --> N2(( )); N1 --> N3(( )); N1 --> N4(( )); N1 --> N5(( )); N1 --> N6(( )); N2 --> N3; N2 --> N4; N2 --> N5; N2 --> N6; N3 --> N4; N3 --> N5; N3 --> N6; N4 --> N5; N4 --> N6; N5 --> N6;
```

# Nodes Color / Attribute / Apply



# Show Node Labels

Overview Data Laboratory Preview

Workspace 1

Appearance Nodes Edges Unique Attribute

Attribute  
2 (50%)  
1 (50%)

Palette... Apply

Layout Yifan Hu Run

Yifan Hu's properties  
Optimal Distance 100.0  
Relative Strength 0.2  
Initial Step size 20.0  
Step ratio 0.95  
Adaptive Cooling   
Convergence Thresh 1.0E-4  
Barnes-Hut's properties  
Quadtree Max Level 10  
Theta 1.2

Yifan Hu Presets... Reset

Graph Dragging (Configure)

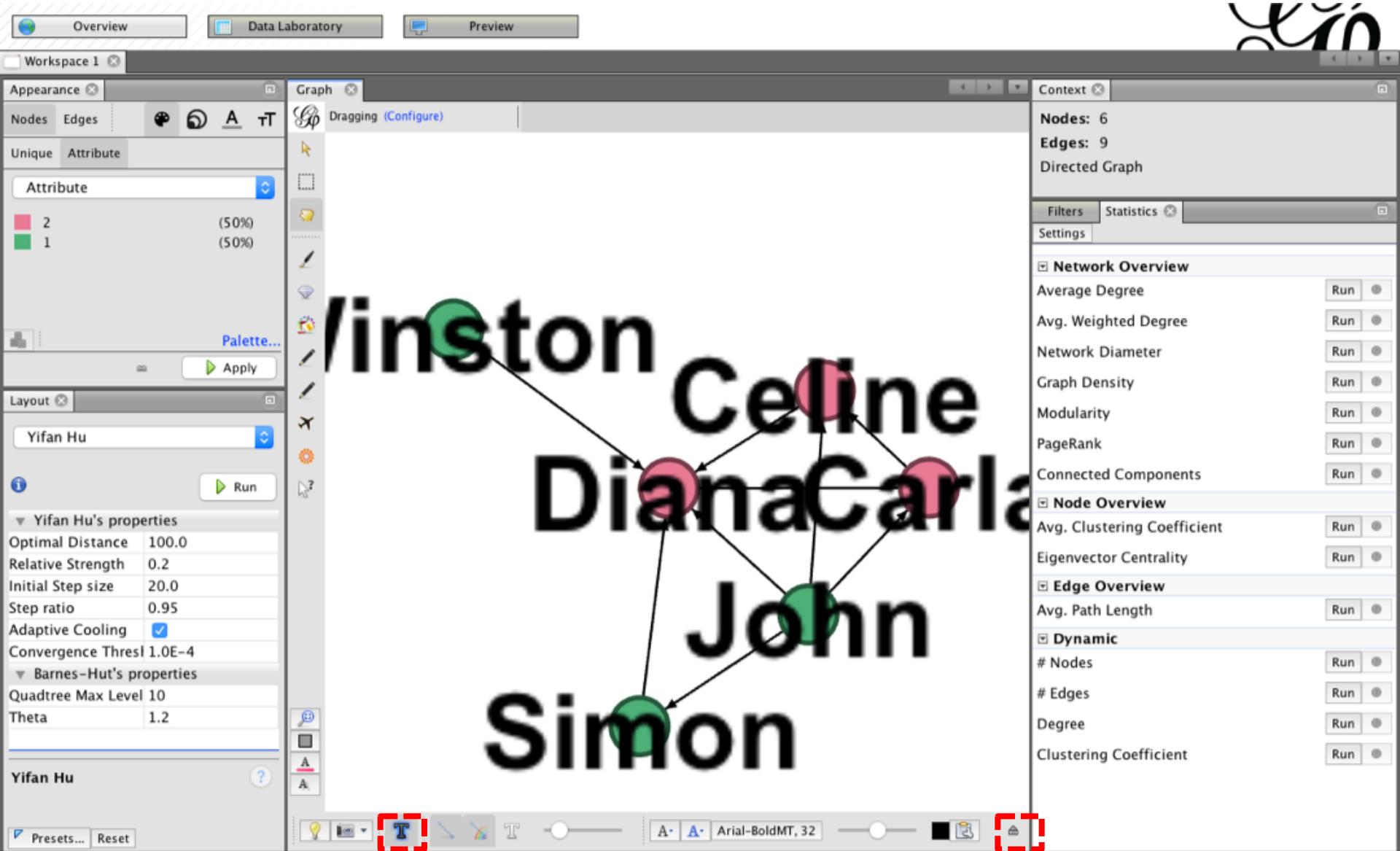
Context Nodes: 6  
Edges: 9  
Directed Graph

Filters Statistics Settings

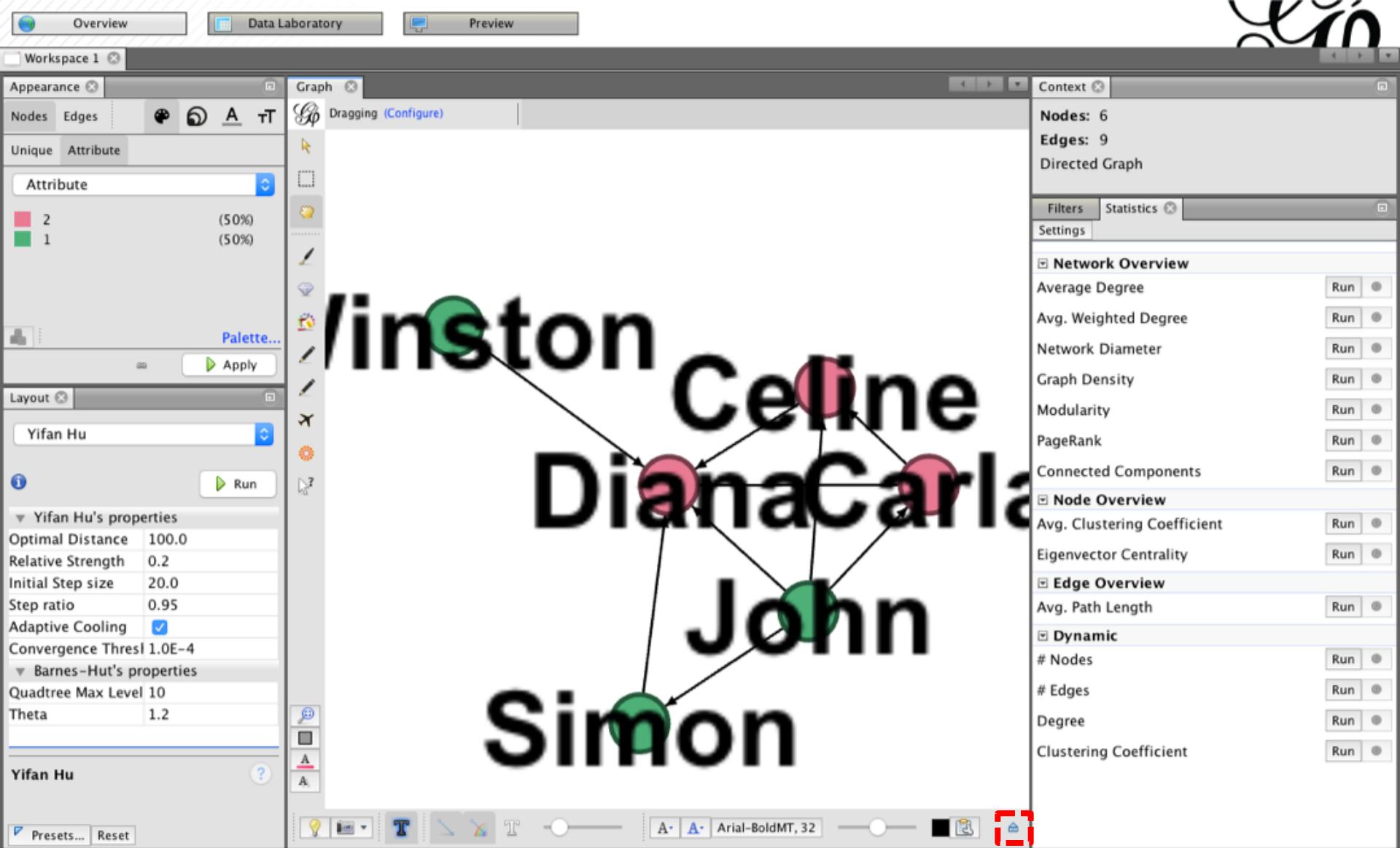
Network Overview  
Average Degree Run  
Avg. Weighted Degree Run  
Network Diameter Run  
Graph Density Run  
Modularity Run  
PageRank Run  
Connected Components Run  
Node Overview Avg. Clustering Coefficient Run  
Eigenvector Centrality Run  
Edge Overview Avg. Path Length Run  
Dynamic # Nodes Run  
# Edges Run  
Degree Run  
Clustering Coefficient Run

Show Node Labels

# Show Node Labels



# Show Labels



# Global Edges Labels



Overview Data Laboratory Preview

Workspace 1

Appearance

Nodes Edges Unique Attribute

Attribute: 2 (50%) 1 (50%)

Palette... Apply

Layout Yifan Hu Run

Yifan Hu's properties:

- Optimal Distance 100.0
- Relative Strength 0.2
- Initial Step size 20.0
- Step ratio 0.95
- Adaptive Cooling
- Convergence Thresh 1.0E-4

Barnes-Hut's properties:

- Quadtree Max Level 10
- Theta 1.2

Yifan Hu Presets... Reset

Graph Dragging (Configure)

Context Nodes: 6 Edges: 9 Directed Graph

Filters Statistics Settings

Network Overview

- Average Degree Run
- Avg. Weighted Degree Run
- Network Diameter Run
- Graph Density Run
- Modularity Run
- PageRank Run
- Connected Components Run

Node Overview

- Avg. Clustering Coefficient Run
- Eigenvector Centrality Run

Edge Overview

- Avg. Path Length Run

Dynamic

- # Nodes Run
- # Edges Run
- Degree Run
- Clustering Coefficient Run

Background color:  Zoom Highlight selection   
Autoselect neighbor

Global Edges Labels

```
graph TD; Winston --- Celine; Winston --- Diana; Winston --- Carla; Celine --- Diana; Diana --- Carla; John --- Simon;
```

# Labels

The screenshot shows the NetworkX Data Laboratory interface with the following components:

- Top Bar:** Overview, Data Laboratory, Preview.
- Left Sidebar (Appearance):**
  - Nodes, Edges, Unique, Attribute tabs.
  - Attribute dropdown: 2 (50%) and 1 (50%).
  - Palette... button.
- Middle Section (Graph View):** A network graph with nodes labeled Winston, Celine, Diana, Carla, John, and Simon. Some nodes have green circular markers, while others have pink ones. Edges connect the nodes.
- Bottom Tools:** Node (checked), Edge, Labels tabs; Font (Arial-BoldMT, 32), Color, Size sliders.
- Right Sidebar (Context):**
  - Nodes: 6, Edges: 9, Directed Graph.
  - Filters, Statistics tabs.
  - Network Overview: Average Degree, Avg. Weighted Degree, Network Diameter, Graph Density, Modularity, PageRank, Connected Components.
  - Node Overview: Avg. Clustering Coefficient, Eigenvector Centrality.
  - Edge Overview: Avg. Path Length.
  - Dynamic: # Nodes, # Edges, Degree, Clustering Coefficient.

# Labels Node Size

Screenshot of a network analysis software interface showing a graph with nodes labeled "Winston", "Diana", "Celine", "Carla", "John", and "Simon". The nodes are colored green and pink, representing different categories. The graph shows various connections between these nodes.

The software has several panels:

- Appearance** panel:
  - Nodes: 2 (50%)
  - Edges: 1 (50%)
- Graph** panel: Shows the network structure with nodes and edges.
- Context** panel:
  - Nodes: 6
  - Edges: 9
  - Directed Graph
- Filters** and **Statistics** panels.
- Network Overview** section with metrics: Average Degree, Avg. Weighted Degree, Network Diameter, Graph Density, Modularity, PageRank, Connected Components.
- Node Overview** section with metrics: Avg. Clustering Coefficient, Eigenvector Centrality.
- Edge Overview** section with metrics: Avg. Path Length.
- Dynamic** section with metrics: # Nodes, # Edges, Degree, Clustering Coefficient.
- Layout** panel: Set to "Yifan Hu".
- Palette...** panel: Shows node and edge editing tools.
- Toolbar**: Includes icons for selection, zoom, and other operations.
- Labeling Tools**: A panel at the bottom right with tabs for Global, Edges, and Labels. The Labels tab is selected. It includes settings for Node (Font: Arial-BoldMT, 32, Size: 32) and Edge (Font: Arial-BoldMT, 32, Size: 32).

A red dashed box highlights the Node labeling settings in the Labels tab.

# Labels Node Font Size

The screenshot shows a network visualization interface with various tools and settings.

**Appearance Panel:** Shows node and edge counts: Nodes (2 pink, 1 green), Edges (50% pink, 50% green). Buttons for Unique and Attribute selection, and a Palette... button.

**Graph Panel:** Shows a network graph with nodes labeled Winston, Diana, Simon, John, Celine, and Carla. Winston is green, while others are pink. Edges connect Winston to Diana, Diana to Simon, Simon to John, John to Celine, and Celine to Carla.

**Context Panel:** Displays the number of nodes (6) and edges (9).

**Font Dialog (highlighted with a red dashed box):**

- Family:** Arial (selected)
- Style:** Bold (selected)
- Size:** 24 (selected)

**Preview:** Shows the text "Aa Bb Yy Zz" in the chosen font style.

**Bottom Panel:** Shows global settings for nodes and edges. For nodes, the font is set to Arial-BoldMT, 24, color black, and size 24. For edges, the font is set to Arial-BoldMT, 32, color black, and size 32.

**Dynamic Options:** Includes buttons for # Nodes, # Edges, Degree, and Clustering Coefficient, each with a Run button.

# Labels Node Size

This screenshot shows a network graph visualization interface with various tools and metrics.

**Appearance Panel:** Shows Nodes (2) and Edges (1) selected. Buttons for Nodes, Edges, Unique, Attribute, and a color palette are present. A "Apply" button is at the bottom.

**Layout Panel:** Set to "Yifan Hu". Properties include: Optimal Distance (100.0), Relative Strength (0.2), Initial Step size (20.0), Step ratio (0.95), Adaptive Cooling (checked), Convergence Thresh (1.0E-4), Barnes-Hut's properties (Quadtree Max Level 10, Theta 1.2).

**Graph Panel:** Displays a directed graph with nodes: Winston (green), Celine (pink), Diana (pink), John (green), Carla (pink), and Simon (green). Winston has an outgoing edge to Diana. Diana has outgoing edges to Celine and John. John has an outgoing edge to Simon. Celine has an incoming edge from Diana and an outgoing edge to Carla. Carla has an incoming edge from John.

**Labels Panel:** Shows node labels in Arial-BoldMT, 24pt. A red dashed box highlights the "Size" slider for nodes, which is currently set to 24pt.

**Context Panel:** Shows the graph has 6 nodes and 9 edges, and is a Directed Graph. It includes sections for Network Overview, Node Overview, Edge Overview, and Dynamic metrics like # Nodes, # Edges, Degree, and Clustering Coefficient.

**Toolbar:** Includes icons for Undo, Redo, New, Open, Save, Print, Copy, Paste, and a magnifying glass.

**Page Number:** 138

# Labels Scaled

Overview Data Laboratory Preview

Workspace 1

Graph Dragging (Configure)

Nodes: 6  
Edges: 9  
Directed Graph

Attribute

Nodes Edges Unique Attribute

Attribute

2 (50%)  
1 (50%)

Palette... Apply

Layout Yifan Hu Run

Yifan Hu's properties

- Optimal Distance 100.0
- Relative Strength 0.2
- Initial Step size 20.0
- Step ratio 0.95
- Adaptive Cooling
- Convergence Thresl 1.0E-4

Barnes-Hut's properties

- Quadtree Max Level 10
- Theta 1.2

Yifan Hu Presets... Reset

Context

Nodes: 6  
Edges: 9  
Directed Graph

Filters Statistics Settings

Network Overview

- Average Degree
- Avg. Weighted Degree
- Network Diameter
- Graph Density
- Modularity
- PageRank
- Connected Components

Node Overview

- Avg. Clustering Coefficient
- Eigenvector Centrality

Edge Overview

- Avg. Path Length

Dynamic

- # Nodes
- # Edges
- Degree
- Clustering Coefficient

Run Run Run Run Run Run Run Run Run Run

Winston

Celine

Diana

Carla

John

Simon

Labels

Font: Arial-BoldMT, 24  
Color: Black  
Size: 20px

Font: Arial-BoldMT, 32  
Color: Black  
Size: 24px

Node Edge

AA Fixed  
✓ % Scaled  
AA Node size  
Labels

139

# Labels Color

The screenshot shows a network visualization interface with a central graph and various configuration panels.

**Graph View:** A network graph with nodes labeled "Winston", "Diana", "Ce", "Jo", and "Simon". "Winston" is green, "Diana" is pink, and "Simon" is green. "Ce" and "Jo" are partially visible. Arrows indicate connections between the nodes.

**Appearance Panel:** Shows node and edge counts (2 and 1 respectively, each at 50%), and a color palette section with a red square preview.

**Layout Panel:** Set to "Yifan Hu".

**Properties Panel:** Details Yifan Hu's properties, including Optimal Distance (100.0), Relative Strength (0.2), Initial Step size (20.0), Step ratio (0.95), Adaptive Cooling (checked), and Convergence Thresh (1.0E-4). It also lists Barnes-Hut's properties: Quadtree Max Level (10) and Theta (1.2).

**Color Selection Dialog:** A modal titled "Choose a Color" with a circular color wheel. The current selection is a red hue (Hue: 2, Sat: 96, Bri: 99, Red: 252, Green: 17, Blue: 9). The dialog includes sliders for Opacity, Alpha (set to 128), and a preview window showing a red and white checkered pattern. Buttons for "Cancel" and "OK" are at the bottom.

**Bottom Navigation:** Buttons for Global, Edges, and Labels, along with checkboxes for Show, Edge default color, Scale, Selection color, and Use node color.

# Labels Color

This screenshot shows a network graph visualization interface with various tools and settings for labeling nodes.

**Appearance** panel:

- Nodes: 2 (50%)
- Edges: 1 (50%)

**Layout** panel:

- Yifan Hu
- Run
- Yifan Hu's properties
  - Optimal Distance: 100.0
  - Relative Strength: 0.2
  - Initial Step size: 20.0
  - Step ratio: 0.95
  - Adaptive Cooling:
  - Convergence Thresh: 1.0E-4
- Barnes-Hut's properties
  - Quadtree Max Level: 10
  - Theta: 1.2

**Graph** panel:

- Dragging (Configure)

**Context** panel:

- Nodes: 6
- Edges: 9
- Directed Graph

**Filters** and **Statistics** panels are also visible.

**Labels** panel settings:

- Font: Arial-BoldMT, 24
- Color: Red
- Size: 10px

The graph displays six nodes with directed edges:

- Winston (green node) has an edge to Diana (pink node).
- Diana (pink node) has edges to John (green node), Celine (pink node), and Simon (green node).
- John (green node) has edges to Diana (pink node) and Carla (pink node).
- Celine (pink node) has an edge from Diana (pink node).
- Carla (pink node) has an edge from John (green node).
- Simon (green node) has an edge from Diana (pink node).

```
graph TD; Winston((Winston)) --> Diana((Diana)); Diana --> John((John)); Diana --> Celine((Celine)); Diana --> Simon((Simon)); John --> Carla((Carla)); Celine --> Diana;
```

# Gephi Statistics: Average Degree

Screenshot of the Gephi interface showing the results of a Degree Report.

The main window displays the following:

- Appearance:** Nodes (2), Edges (1), Unique, Attribute.
- Graph:** Dragging (Configure).
- Context:** Nodes: 6, Edges: 9, Directed Graph.
- Statistics:** Network Overview (Average Degree highlighted with a red dashed box), Avg. Weighted Degree, Network Diameter, Graph Density, Modularity, PageRank, Connected Components, Node Overview (Avg. Clustering Coefficient), Edge Overview (Avg. Path Length), Dynamic (Nodes, Edges, Degree, Clustering Coefficient).
- Degree Report Results:** Average Degree: 3.000.
- Degree Distribution Plot:** A scatter plot showing the distribution of node degrees. The X-axis is labeled "Value" and ranges from 0 to 6. The Y-axis is labeled "Count" and ranges from 0.00 to 2.00. The data points are at (1, 1.00), (2, 1.00), (3, 2.00), (4, 1.00), and (5, 1.00).
- Layout:** Yifan Hu, Barnes-Hut's properties (Optimal Distance: 100.0, Relative Strength: 0.2, Initial Step size: 20.0, Step ratio: 0.95, Adaptive Cooling checked, Convergence Thresl: 1.0E-4).
- Presets:** Presets..., Reset.

# Gephi Statistics: Average Degree

Screenshot of the Gephi interface showing the In-Degree and Out-Degree distributions and the Statistics panel.

**Appearance** (Nodes: 2, Edges: 1, Unique: 6, Attribute: 9)

**Graph** (Dragging (Configure))

**Context** (Nodes: 6, Edges: 9, Directed Graph)

**Statistics** (Filters: Network Overview, Node Overview, Edge Overview, Dynamic; Settings: Run 3)

**In-Degree Distribution** (Count vs Value):

Value	Count
0	2.00
1	2.00
2	1.00
5	1.00

**Out-Degree Distribution** (Count vs Value):

Value	Count
1.2	2.00
1.75	1.75

**HTML Report**

**Yifan Hu** (Layout, Properties, Presets..., Reset)

**Yifan Hu's properties**: Optimal Distance 100.0, Relative Strength 0.2, Initial Step size 20.0, Step ratio 0.95, Adaptive Cooling checked, Convergence Thresh 1.0E-4.

**Barnes-Hut's properties**: Quadtree Max Level 10, Theta 1.2.

**Print, Copy, Save**

**Page Number**: 143

# Gephi Statistics: Avg. Weighted Degree

Overview Data Laboratory Preview

Workspace 1

Appearance Graph Context

Nodes Edges Unique Attribute

Attribute

2 (50%) 1 (50%)

Palett Apply

Layout Yifan Hu Run

Yifan Hu's properties

- Optimal Distance 100.0
- Relative Strength 0.2
- Initial Step size 20.0
- Step ratio 0.95
- Adaptive Cooling
- Convergence Thresl 1.0E-4

Barnes-Hut's properties

- Quadtree Max Level 10
- Theta 1.2

Yifan Hu

Presets... Reset

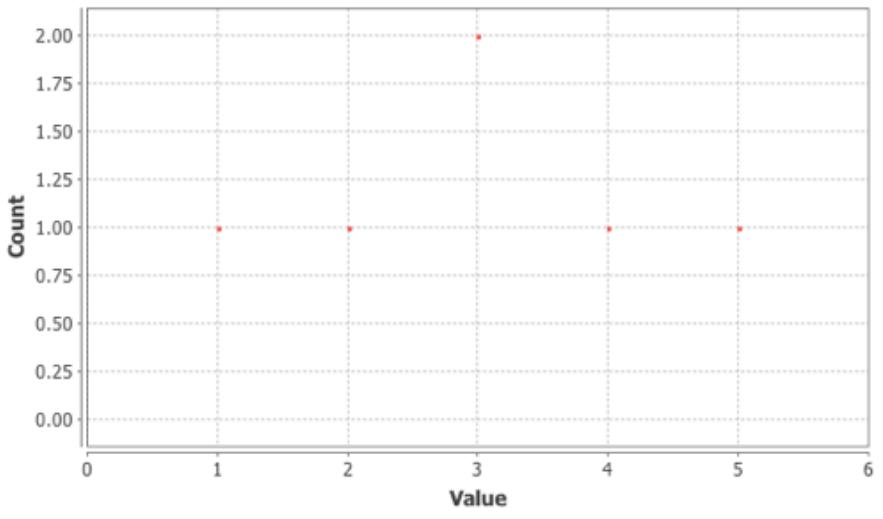
HTML Report

## Weighted Degree Report

### Results:

Average Weighted Degree: 1.500

### Degree Distribution



Value	Count
1	1.00
2	1.00
3	2.00
4	1.00
5	1.00

Print Copy Save Close

Filters Statistics Settings

Nodes: 6  
Edges: 9  
Directed Graph

Network Overview

- Average Degree 3 Run
- Avg. Weighted Degree 1.5 Run
- Network Diameter Run
- Graph Density Run
- Modularity Run
- PageRank Run
- Connected Components Run

Node Overview

- Avg. Clustering Coefficient Run
- Eigenvector Centrality Run

Edge Overview

- Avg. Path Length Run

Dynamic

- # Nodes Run
- # Edges Run
- Degree Run
- Clustering Coefficient Run



# Gephi Statistics: Network Diameter

The screenshot shows the Gephi interface with various panels and a central dialog box.

**Appearance Panel:** Shows node and edge counts (2 nodes, 1 unique, 9 edges). Buttons for Nodes, Edges, Unique, Attribute, and a color palette.

**Graph Panel:** Shows a small preview of the network graph.

**Context Panel:** Displays network statistics: Nodes: 6, Edges: 9, Directed Graph.

**Statistics Panel:** A red box highlights the "Network Overview" section, specifically the "Network Diameter" statistic, which is listed as 1.5.

**Graph Distance settings Dialog:** A modal window with the following content:

- Distance:** Description: The average graph-distance between all pairs of nodes. Connected nodes have graph distance 1. The diameter is the longest graph distance between any two nodes in the network. (i.e. How far apart are the two most distant nodes).
- Directed:** Radio button selected.
- Undirected:** Radio button unselected.
- Normalize Centralities in [0,1]:** Check box unselected.
- Buttons:** Cancel and OK.

**Layout Panel:** Shows current layout: Yifan Hu.

**Properties Panel:** Shows properties for Yifan Hu's layout, including Optimal Distance (100.0), Relative Strength (0.2), Initial Step size (20.0), Step ratio (0.95), Adaptive Cooling (checked), and Convergence Thresh (1.0E-4).

**Barnes-Hut's properties:** Shows Quadtree Max Level (10) and Theta (1.2).

**Labels Panel:** Shows font settings for Node (Arial-BoldMT, 24), Edge (Arial-BoldMT, 32), and Size (滑块).

# Gephi Statistics: Network Diameter



Overview Data Laboratory Preview

Workspace 1

Appearance

Nodes Edges Unique Attribute

Attribute: 2 (50%) 1 (50%)

Palett Apply

Layout Yifan Hu Run

Yifan Hu's properties:

- Optimal Distance: 100.0
- Relative Strength: 0.2
- Initial Step size: 20.0
- Step ratio: 0.95
- Adaptive Cooling:
- Convergence Thresh: 1.0E-4

Barnes-Hut's properties:

- Quadtree Max Level: 10
- Theta: 1.2

Yifan Hu Presets... Reset

Graph Dragging (Configure)

HTML Report

## Graph Distance Report

Parameters:

Network Interpretation: directed

Results:

Diameter: 1  
Radius: 0  
Average Path length: 1.0

### Betweenness Centrality Distribution

Count

Betweenness

Print Copy Save Close

Context

Nodes: 6  
Edges: 9  
Directed Graph

Filters Statistics Settings

Network Overview

- Average Degree: 3 Run
- Avg. Weighted Degree: 1.5 Run
- Network Diameter: 1 Run
- Graph Density: Run
- Modularity: Run
- PageRank: Run
- Connected Components: Run

Node Overview

- Avg. Clustering Coefficient: Run
- Eigenvector Centrality: Run

Edge Overview

- Avg. Path Length: 1 Run

Dynamic

- # Nodes: Run
- # Edges: Run
- Degree: Run
- Clustering Coefficient: Run

# Gephi Statistics: Graph Density

The screenshot shows the Gephi software interface with a central modal window titled "Graph Density Report".

**Parameters:**  
Network Interpretation: directed

**Results:**  
Density: 0.300

The background workspace displays a network graph with 6 nodes and 9 edges, identified as a Directed Graph. The "Statistics" panel on the right is highlighted with a red dashed border and contains the following data:

Statistic	Value	Run Status
Average Degree	3	Run
Avg. Weighted Degree	1.5	Run
Network Diameter	1	Run
Graph Density	0.3	Run
Modularity		Run
PageRank		Run
Connected Components		Run
Node Overview		Run
Avg. Clustering Coefficient		Run
Eigenvector Centrality		Run
Edge Overview		Run
Avg. Path Length	1	Run
Dynamic		Run
# Nodes		Run
# Edges		Run
Degree		Run
Clustering Coefficient		Run

At the bottom of the Gephi interface, there are buttons for Print, Copy, Save, Presets..., and Reset.

# Gephi Statistics: Modularity

The screenshot shows the Gephi software interface with the following details:

- Top Bar:** Overview, Data Laboratory, Preview.
- Left Sidebar:** Appearance (Nodes, Edges, Unique, Attribute), Layout (Yifan Hu, Barnes-Hut's properties), Presets..., Reset.
- Graph Area:** Dragging (Configure).
- Context Panel:** Nodes: 6, Edges: 9, Directed Graph.
- Statistics Panel (highlighted with a red dashed border):**
  - Filters:** Statistics, Settings.
  - Network Overview:** Average Degree (Run), Avg. Weighted Degree (Run), Network Diameter (Run), Graph Density (Run, value: 0.3).
  - Modularity:** Modularity (Run).
  - PageRank:** PageRank (Run).
  - Connected Components:** Connected Components (Run).
  - Node Overview:** Avg. Clustering Coefficient (Run), Eigenvector Centrality (Run).
  - Edge Overview:** Avg. Path Length (Run, value: 1).
  - Dynamic:** # Nodes (Run), # Edges (Run), Degree (Run), Clustering Coefficient (Run).
- Modularity Settings Dialog:** Shows "Modularity Community detection algorithm." with checked options for Randomize and Use weights, a Resolution input field set to 1.0, and OK/Cancel buttons.
- Bottom Tools:** Node/Edge/Labels tabs, Font/Arial-BoldMT, 24, Color (red), Size sliders.

# Gephi Statistics: Modularity

Overview Data Laboratory Preview

Workspace 1

Appearance Graph Context

Nodes Edges Unique Attribute

Attribute

2 (50%) 1 (50%)

Dragging (Configure)

HTML Report

## Modularity Report

**Parameters:**

Randomize: On  
Use edge weights: On  
Resolution: 1.0

**Results:**

Modularity: 0.000  
Modularity with resolution: 0.000  
Number of Communities: 1

**Size Distribution**

Yifan Hu

Layout

Palett Apply

Yifan Hu's properties

- Optimal Distance 100.0
- Relative Strength 0.2
- Initial Step size 20.0
- Step ratio 0.95
- Adaptive Cooling
- Convergence Thresh 1.0E-4

Barnes-Hut's properties

- Quadtree Max Level 10
- Theta 1.2

Yifan Hu

Presets... Reset Print Copy Save Close

Filters Statistics Settings

Network Overview

- Average Degree 3 Run
- Avg. Weighted Degree 1.5 Run
- Network Diameter 1 Run
- Graph Density 0.3 Run
- Modularity 0 Run
- PageRank Run
- Connected Components Run

Node Overview

- Avg. Clustering Coefficient Run
- Eigenvector Centrality Run

Edge Overview

- Avg. Path Length 1 Run

Dynamic

- # Nodes Run
- # Edges Run
- Degree Run
- Clustering Coefficient Run

Nodes: 6  
Edges: 9  
Directed Graph

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# Gephi Statistics: Connected Components

The screenshot shows the Gephi interface with the following components:

- Top Bar:** Overview, Data Laboratory, Preview.
- Left Sidebar:** Appearance (Nodes, Edges, Unique, Attribute), Layout (Yifan Hu), Presets..., Reset.
- Graph Area:** Dragging (Configure).
- Context Panel:** Nodes: 6, Edges: 9, Directed Graph.
- Statistics Panel:** Filters, Statistics, Settings. It lists various network metrics with "Run" buttons:
  - Network Overview: Average Degree (Run), Avg. Weighted Degree (Run), Network Diameter (Run), Graph Density (Run), Modularity (Run), PageRank (Run).
  - Connected Components (highlighted with a red dashed border) (Run).
  - Node Overview: Avg. Clustering Coefficient (Run), Eigenvector Centrality (Run).
  - Edge Overview: Avg. Path Length (Run).
  - Dynamic: # Nodes (Run), # Edges (Run), Degree (Run), Clustering Coefficient (Run).
- Connected Components Dialog:** Title: Connected Components settings. Subtitle: Connected Components. Description: Determines the number of connected components in the network. Options:
  - Directed: Detects strongly & weakly connected components.
  - Undirected: Detects only weakly connected components.Buttons: Cancel, OK.
- Bottom Appearance Panel:** Global, Node, Edge, Labels tabs. Node tab settings: Font: Arial-BoldMT, 24, Color: red, Size: 10px. Edge tab settings: Font: Arial-BoldMT, 32, Color: gray, Size: 10px.

# Gephi Statistics: Connected Components

Screenshot of the Gephi interface showing the results of a Connected Components analysis.

The main window displays the "Connected Components Report".

**Parameters:**  
Network Interpretation: directed

**Results:**  
Number of Weakly Connected Components: 1  
Number of Strongly Connected Components: 6

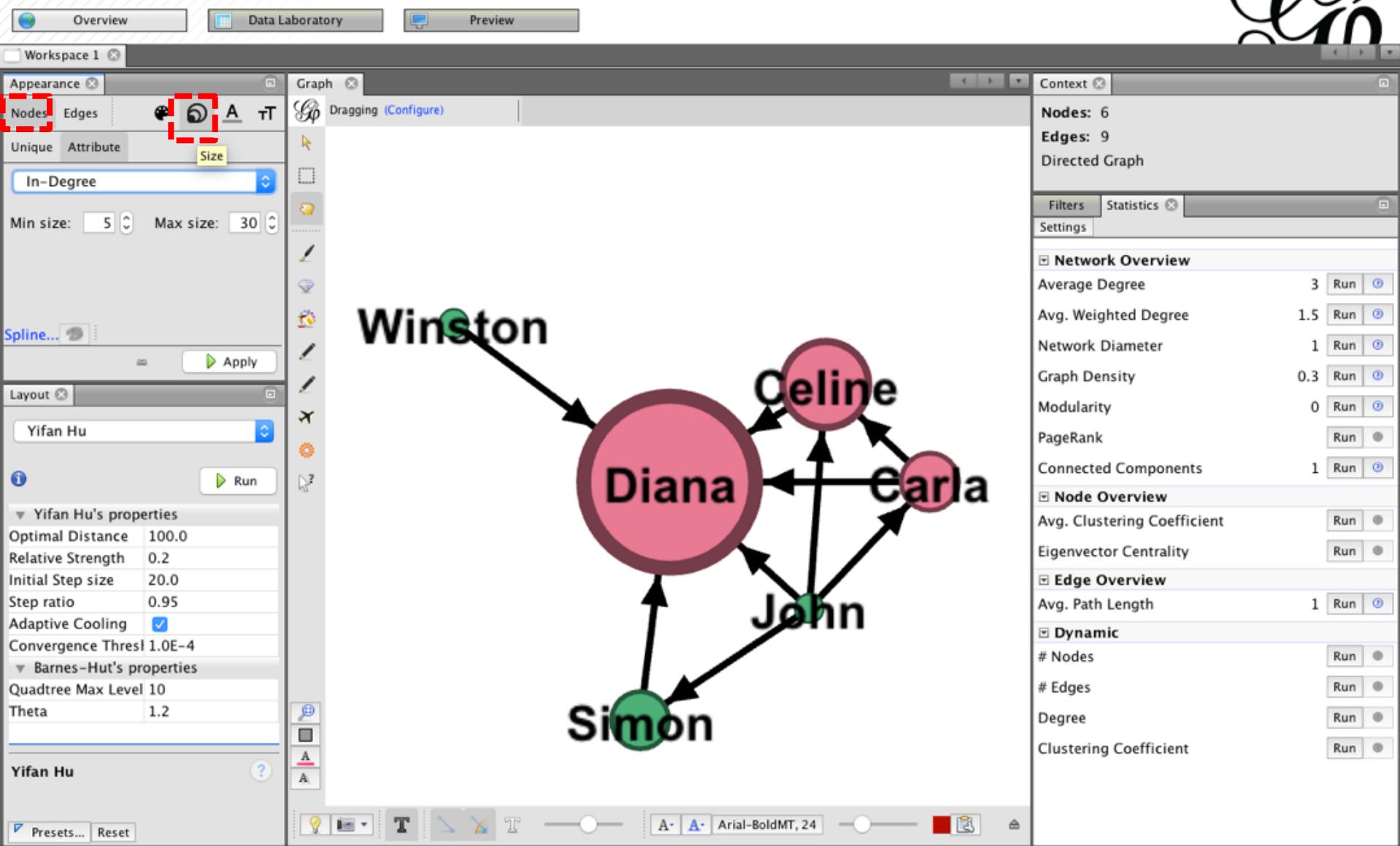
**Size Distribution**

A red dashed box highlights the "Connected Components" section in the Statistics panel.

**Statistics Panel:**

- Network Overview:**
  - Average Degree: 3 (Run)
  - Avg. Weighted Degree: 1.5 (Run)
  - Network Diameter: 1 (Run)
  - Graph Density: 0.3 (Run)
  - Modularity: 0 (Run)
  - PageRank: Run
- Connected Components:** 1 (Run)
- Node Overview:**
  - Avg. Clustering Coefficient: Run
  - Eigenvector Centrality: Run
- Edge Overview:**
  - Avg. Path Length: 1 (Run)
- Dynamic:**
  - # Nodes: Run
  - # Edges: Run
  - Degree: Run
  - Clustering Coefficient: Run

# Appearance Nodes Size



# Appearance Nodes Size

## Attribute / In-Degree



Overview Data Laboratory Preview

Workspace 1

Appearance X

Nodes Edges Unique Attribute

In-Degree ---Choose an attribute Degree In-Degree Out-Degree Out-Degree Weighted Out-Degree In-Degree Closeness Centrality

Apply

Graph X Dragging (Configure)

Context X

Nodes: 6  
Edges: 9  
Directed Graph

Filters Statistics

Settings

Network Overview

- Average Degree 3 Run
- Avg. Weighted Degree 1.5 Run
- Network Diameter 1 Run
- Graph Density 0.3 Run
- Modularity 0 Run
- PageRank Run
- Connected Components 1 Run

Node Overview

- Avg. Clustering Coefficient Run
- Eigenvector Centrality Run

Edge Overview

- Avg. Path Length 1 Run

Dynamic

- # Nodes Run
- # Edges Run
- Degree Run
- Clustering Coefficient Run

Yifan Hu

Run

Yifan Hu's properties

- Optimal Distance 100.0
- Relative Strength 0.2
- Initial Step size 20.0
- Step ratio 0.95
- Adaptive Cooling
- Convergence Thresh 1.0E-4

Barnes-Hut's properties

- Quadtree Max Level 10
- Theta 1.2

Yifan Hu

Presets... Reset

Winston

Diana

Celine

Carla

John

Simon

# Appearance Nodes Size

Attribute / In-Degree / Min size / Max size / Apply

Screenshot of a network visualization tool interface showing a directed graph with nodes Diana, Celine, Carla, John, and Simon. The node Diana is highlighted with a large pink circle, while the other nodes are smaller green circles. Arrows indicate directed edges from Winston to Diana, and from Diana to Celine, Carla, and Simon.

The left sidebar shows the "Appearance" panel with "Nodes" selected, and the "In-Degree" filter applied with "Min size: 5" and "Max size: 30". The "Layout" panel shows "Yifan Hu" selected. The right sidebar displays network statistics and metrics like Average Degree, Avg. Weighted Degree, Network Diameter, Graph Density, Modularity, PageRank, and Connected Components.

Graph Statistics:

- Nodes: 6
- Edges: 9
- Directed Graph

Metrics:

- Average Degree: 3 (Run)
- Avg. Weighted Degree: 1.5 (Run)
- Network Diameter: 1 (Run)
- Graph Density: 0.3 (Run)
- Modularity: 0 (Run)
- PageRank (Run)
- Connected Components: 1 (Run)
- Node Overview (Run)
- Edge Overview (Run)
- Avg. Path Length: 1 (Run)
- Dynamic (Run)
- # Nodes (Run)
- # Edges (Run)
- Degree (Run)
- Clustering Coefficient (Run)

# Appearance Edges

## Attribute / Weight / Color

Appearance Edges Attribute / Weight / Color

Overview Data Laboratory Preview

Workspace 1

Graph Dragging (Configure)

Nodes Edges A T

Unique Attribute

Weight

Color: Default Invert Recent

Spline... Layout Yifan Hu

Yifan Hu's properties

- Optimal Distance 100.0
- Relative Strength 0.2
- Initial Step size 20.0
- Step ratio 0.95
- Adaptive Cooling
- Convergence Thresh 1.0E-4

Barnes-Hut's properties

- Quadtree Max Level 10
- Theta 1.2

Yifan Hu Presets... Reset

Context Nodes: 6 Edges: 9 Directed Graph

Filters Statistics Settings

Network Overview

- Average Degree 3 Run
- Avg. Weighted Degree 1.5 Run
- Network Diameter 1 Run
- Graph Density 0.3 Run
- Modularity 0 Run
- PageRank Run
- Connected Components 1 Run

Node Overview

- Avg. Clustering Coefficient Run
- Eigenvector Centrality Run

Edge Overview

- Avg. Path Length 1 Run

Dynamic

- # Nodes Run
- # Edges Run
- Degree Run
- Clustering Coefficient Run

Winston

Diana

Celine

Carla

John

Simon

```
graph TD; Diana --> Celine; Diana --> Carla; Diana --> Simon; Celine <--> Carla; Winston --> Diana;
```

# Appearance Edges

## Attribute / Weight / Color / Apply

Overview Data Laboratory Preview

Workspace 1

Appearance  Nodes  Edges  A  T

Unique Attribute

Weight

Color:

Spline...  Apply

Layout  Yifan Hu

Yifan Hu's properties

- Optimal Distance 100.0
- Relative Strength 0.2
- Initial Step size 20.0
- Step ratio 0.95
- Adaptive Cooling
- Convergence Thresh 1.0E-4

Barnes-Hut's properties

- Quadtree Max Level 10
- Theta 1.2

Yifan Hu

Graph Dragging (Configure)

Context

Nodes: 6  
Edges: 9  
Directed Graph

Filters Statistics

Network Overview

- Average Degree 3
- Avg. Weighted Degree 1.5
- Network Diameter 1
- Graph Density 0.3
- Modularity 0
- PageRank
- Connected Components 1

Node Overview

- Avg. Clustering Coefficient
- Eigenvector Centrality

Edge Overview

- Avg. Path Length 1

Dynamic

- # Nodes
- # Edges
- Degree
- Clustering Coefficient

```
graph TD; Winston --> Diana; Celine --> Diana; Carla --> Diana; John --> Diana; Simon --> Diana; Diana --> Celine; Diana --> Carla; Diana --> John; Diana --> Simon;
```

# Gephi Data Laboratory

The screenshot shows the Gephi Data Laboratory interface. At the top, there are three tabs: 'Overview' (selected), 'Data Laboratory' (highlighted with a red dashed border), and 'Preview'. Below the tabs, the title 'Workspace 1' is visible. The main area is a 'Data Table' containing a list of nodes with their properties and network metrics.

**Data Table Headers:**

Nodes	Edges	Configuration	Add node	Add edge	Search/Replace	Import Spreadsheet	Export table	More actions	Filter:	Id		
-------	-------	---------------	----------	----------	----------------	--------------------	--------------	--------------	---------	----	--	--

**Data Table Rows:**

1	John	1	0	4	4	0.0	4.0	4.0	1.0	1.0	1.0	0.0	0	0	4
2	Carla	2	1	2	3	1.0	2.0	3.0	1.0	1.0	1.0	0.0	0	0	3
3	Simon	1	1	1	2	1.0	1.0	2.0	1.0	1.0	1.0	0.0	0	0	2
4	Celine	2	2	1	3	2.0	1.0	3.0	1.0	1.0	1.0	0.0	0	0	1
5	Winston	1	0	1	1	0.0	1.0	1.0	1.0	1.0	1.0	0.0	0	0	5
6	Diana	2	5	0	5	5.0	0.0	5.0	0.0	0.0	0.0	0.0	0	0	0

At the bottom, there is a toolbar with various icons for column operations: Add column, Merge columns, Delete column, Clear column, Copy data to other column, Fill column with a value, Duplicate column, Create a boolean column from regex match, and Create column with list of regex matching groups.

# Gephi Preview

Overview Data Laboratory **Preview**

Workspace 1

Preview Settings Presets Default

Settings Manage renderers

Nodes

Border Width	1.0
Border Color	custom [0,0,0]
opacity	100.0

Node Labels

Show Labels	<input type="checkbox"/>
Font	Arial 12 Plain
Proportional size	<input checked="" type="checkbox"/>
Color	custom [0,0,0]
Shorten label	<input type="checkbox"/>
Max characters	30
Outline size	0.0
Outline color	custom [25,25,25]
Outline opacity	80.0
Box	<input type="checkbox"/>
Box color	parent
Box opacity	100.0

Edges

Show Edges	<input checked="" type="checkbox"/>
Thickness	1.0
Rescale weight	<input type="checkbox"/>
Color	mixed
Opacity	100.0
Curved	<input checked="" type="checkbox"/>

Preview ratio: 100%

Background Refresh Export: SVG/PDF/PNG

Preview



# Gephi Preview: Show Labels

Screenshot of the Gephi software interface showing the Preview tab selected. The left panel displays the Preview Settings dialog with the Nodes section open, specifically the Node Labels settings. A red dashed box highlights the 'Show Labels' checkbox, which is checked. Other settings shown include Border Width (1.0), Border Color (custom [0,0,...]), and Opacity (100.0). The Edges section is also visible. The main preview area shows a network graph where nodes are labeled with their names: Winston, Celine, Diana, Carla, John, and Simon. Diana is the central node, colored pink, with large black text. Other nodes are smaller green circles with their names. Edges connect Diana to Celine, Carla, John, and Simon, and Winston is connected to Diana.

# Gephi Preview: Default Straight

Screenshot of the Gephi software interface showing the Preview window and its settings.

The Preview window displays a network graph with nodes labeled "Winston", "Diana", "Celine", "Carla", "John", and "Simon". The node "Diana" is the central, largest node, colored pink with black text. Other nodes are smaller green circles with black text. Edges connect "Winston" to "Diana", "Diana" to "Celine", "Diana" to "Carla", "Diana" to "John", and "Diana" to "Simon".

The left sidebar shows the "Preview Settings" panel with the "Presets" dropdown set to "Default Straight". The "Settings" tab is selected, displaying various node and edge properties:

- Node Labels:
  - Show Labels: checked
  - Font: Arial 8 Plain
  - Proportional size: checked
  - Color: custom [0,0,0]
  - Shorten label: checked
  - Max characters: 14
  - Outline size: 2.0
  - Outline color: custom [25,25,25]
  - Outline opacity: 80.0
  - Box: unchecked
  - Box color: parent
  - Box opacity: 100.0
- Edges:
  - Show Edges: checked
  - Thickness: 1.0
  - Rescale weight: unchecked
  - Color: mixed
  - Opacity: 100.0
  - Curved: unchecked
  - Radius: 0.0
- Edge Arrows:
  - Size: 3.0

At the bottom of the sidebar, the "Refresh" button is highlighted with a red box.

At the bottom of the main window, there are buttons for "Background" and "Reset zoom", and zoom controls (- +).

# Gephi Preview: Default Straight

Screenshot of the Gephi software interface showing the Preview tab. The left panel displays the Preview Settings dialog with the "Default Straight" preset selected. The main area shows a network graph with nodes labeled Winston, Diana, Celine, Carla, John, and Simon. The edges between nodes are straight lines, demonstrating the "Default Straight" edge style.

Preview Settings Presets Default Straight

Settings Manage renderers

Node Labels

- Show Labels
- Font Arial 12 Plain
- Proportional size
- Color custom [0,0,0]
- Shorten label
- Max characters 30
- Outline size 0.0
- Outline color custom [255,0,0]
- Outline opacity 80.0
- Box
- Box color parent
- Box opacity 100.0

Edges

- Show Edges
- Thickness 1.0
- Rescale weight
- Color mixed
- Opacity 100.0
- Curved
- Radius 0.0

Edge Arrows

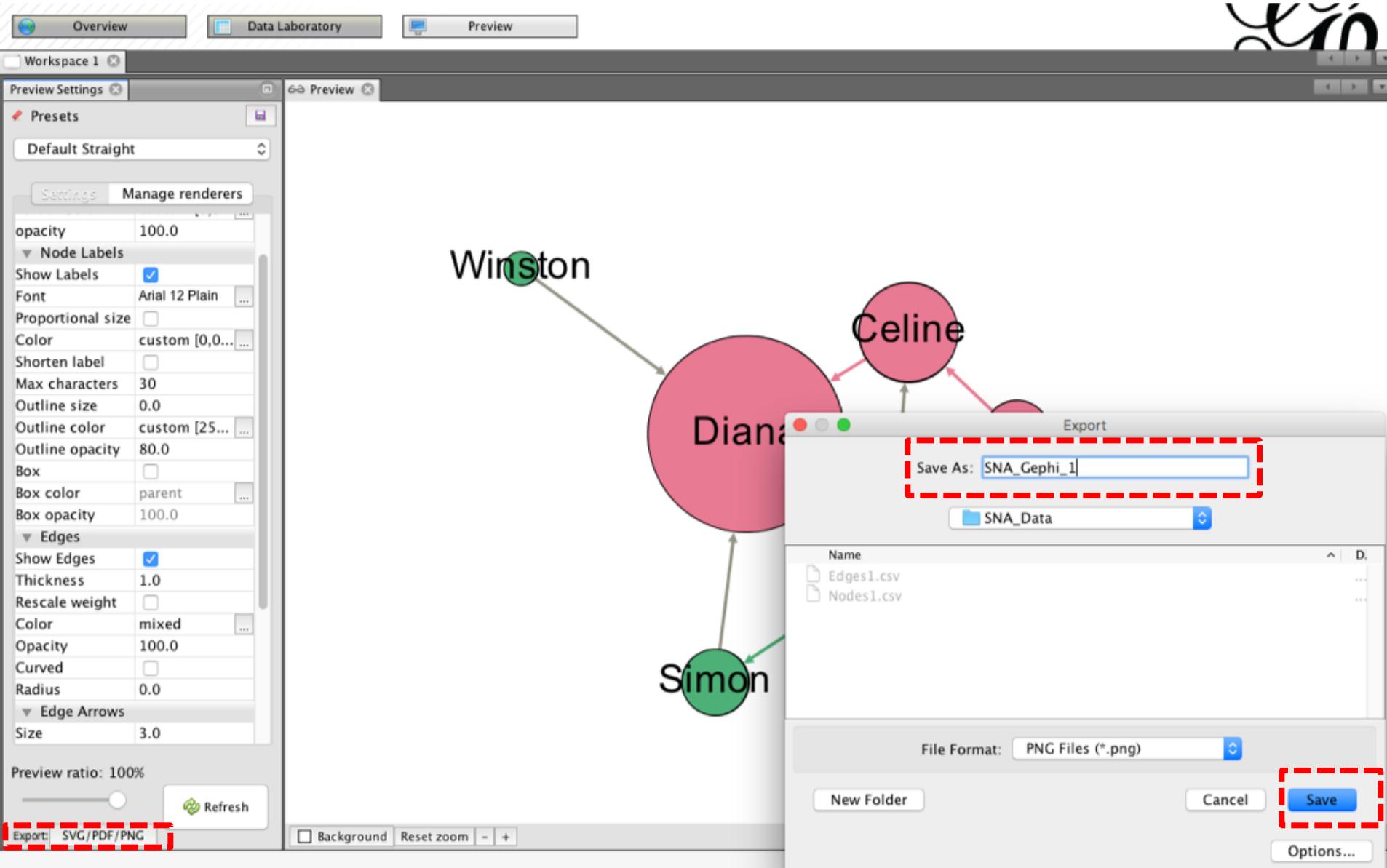
- Size 3.0

Preview ratio: 100%

Export: SVG/PDF/PNG Refresh

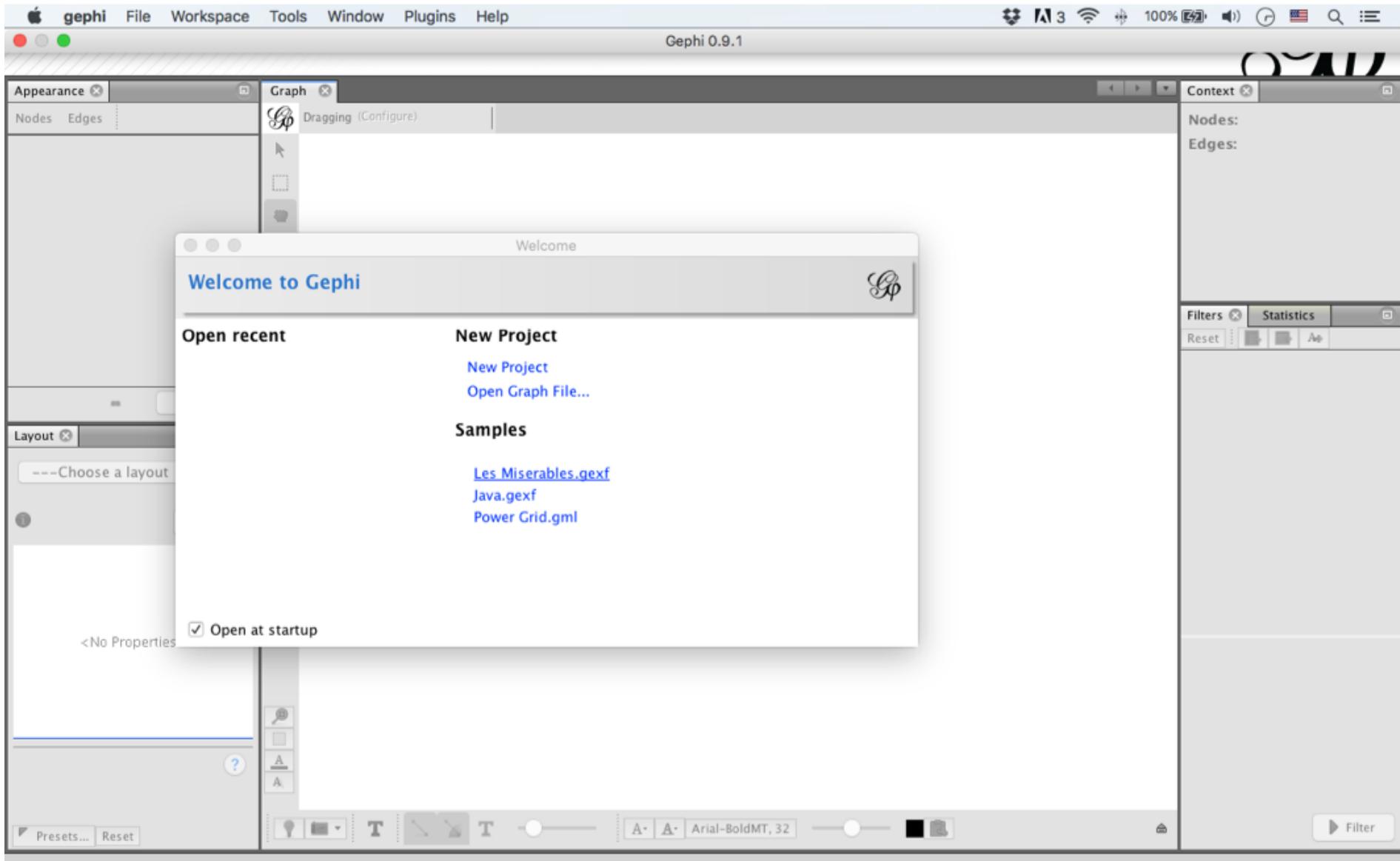
```
graph TD; Winston((Winston)) --> Diana((Diana)); Diana --> Simon((Simon)); Simon --> John((John)); John --> Celine((Celine)); Celine --> Carla((Carla)); Carla --> Diana;
```

# Gephi Preview: Export SVG/PDF/PNG



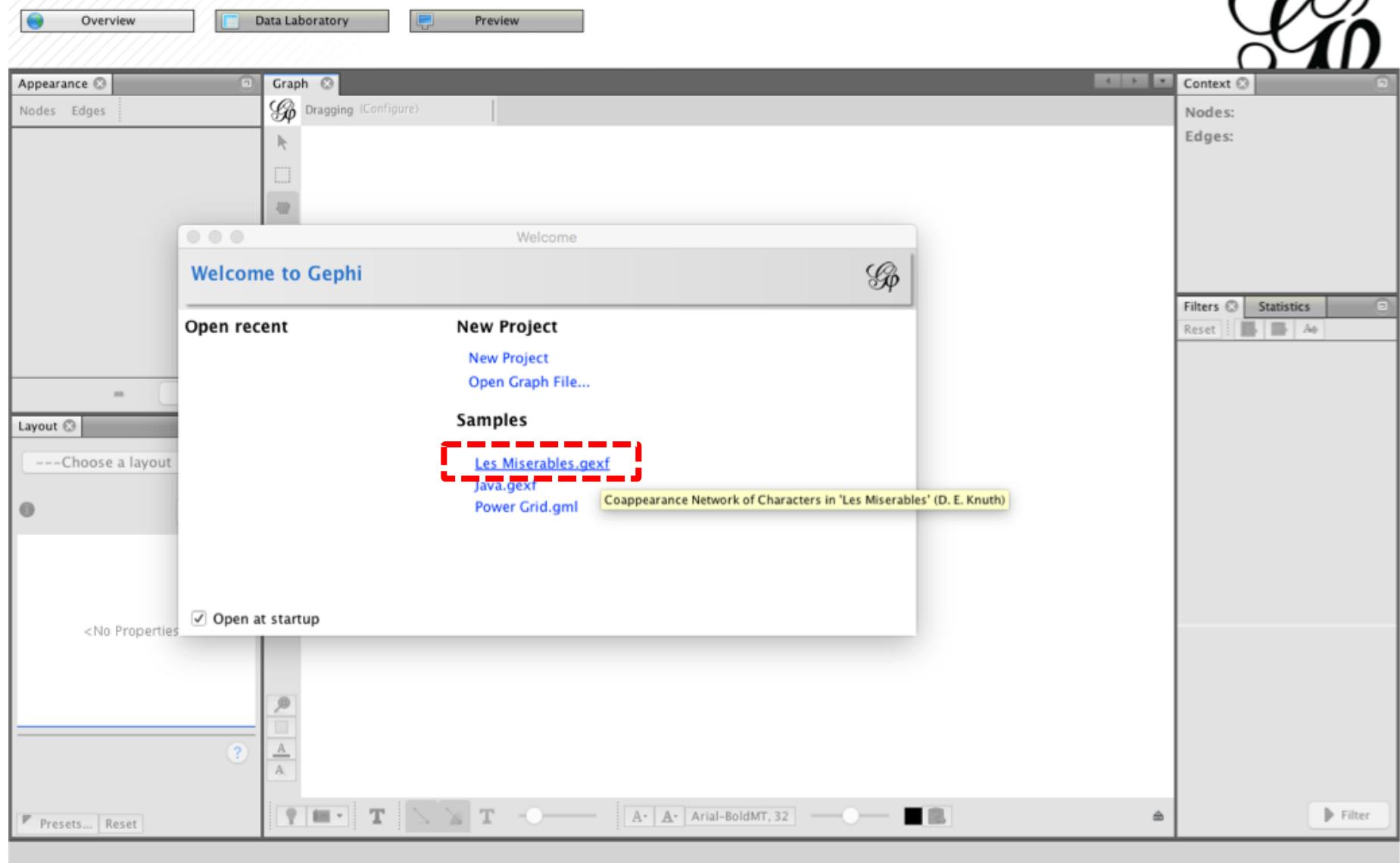
# Open Gephi Samples

# Gephi Samples

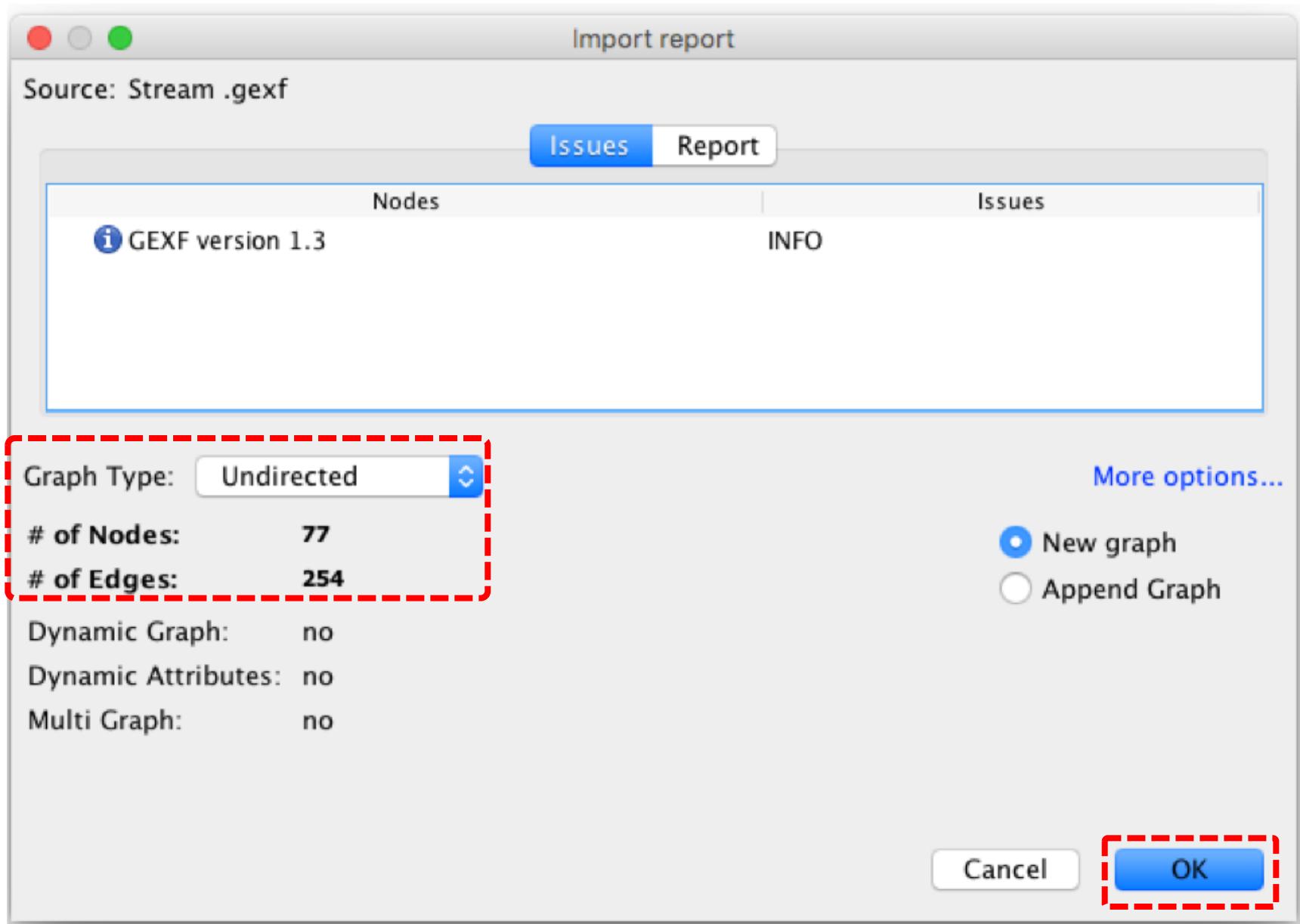


# Gephi Samples

## Les Miserables.gexf



# Gephi Import Report



# Gephi Overview

The screenshot shows the Gephi interface with a network graph displayed in the center. The graph consists of several clusters of nodes, with a prominent red central node and other nodes in various colors (blue, green, purple, yellow). Edges connect the nodes between clusters.

**Top Bar:**

- Overview (selected)
- Data Laboratory
- Preview

**Left Sidebar (Appearance):**

- Nodes
- Edges
- Unique
- Attribute

Color palette: #c0c0c0

Buttons: Apply, Run

Layout:

- Choose a layout
- Run

<No Properties>

**Right Sidebar (Context):**

- Nodes: 77
- Edges: 254
- Undirected Graph

**Bottom Tools:**

- Presets...
- Reset
- Lightbulb icon
- T icon
- Pencil icon
- Rainbow icon
- T icon
- Font size slider: Arial-BoldMT, 32
- Color picker
- Save icon

**Bottom Right:**

- Filter

**Bottom Left:**

- Queries
- Drag filter here

**Bottom Center:**

- Library
- Attributes
- Dynamic
- Edges
- Operator
- Topology
- Saved queries

# Gephi Layout

The screenshot shows the Gephi software interface with a network graph displayed in the center. The graph consists of several clusters of nodes, with a prominent red central node and other nodes colored in blue, green, purple, and yellow. The nodes are interconnected by a variety of colored edges.

The interface includes the following components:

- Top Bar:** Overview, Data Laboratory, Preview.
- Left Panel:**
  - Appearance:** Nodes, Edges, Unique, Attribute, color palette (#c0c0c0).
  - Layout:** A dropdown menu titled "Choose a layout" containing the following options: Contraction, Expansion, Force Atlas, ForceAtlas 2, Fruchterman Reingold, Label Adjust, Noverlap, OpenOrd. This menu is highlighted with a red border.
  - Bottom Left:** Presets..., Reset.
- Center Panel:** Graph tab, sub-tab Dragging (Configure), toolbar with selection, zoom, and orientation tools.
- Right Panel:**
  - Context:** Nodes: 77, Edges: 254, Undirected Graph.
  - Filters:** Library (Attributes, Dynamic, Edges, Operator, Topology, Saved queries).
  - Queries:** Drag filter here.
- Bottom Bar:** Font style and size (A· Arial-BoldMT, 32), color palette, and a Filter button.

# Gephi Layout: Force Atlas

Screenshot of the Gephi software interface showing the Force Atlas layout.

The main window displays a network graph with a central red node and several clusters of green, blue, and purple nodes connected by edges.

Toolbar (Top): Overview, Data Laboratory, Preview.

Appearance Panel (Left): Nodes, Edges, Unique, Attribute, Color #c0c0c0, Apply button.

Layout Panel (Left): Force Atlas dropdown (highlighted with a red box), Run button, Force Atlas settings:

Inertia	0.1
Repulsion strength	200.0
Attraction strength	10.0
Maximum displacement	10.0
Auto stabilize function	<input checked="" type="checkbox"/>
Autostab Strength	80.0
Autostab sensitivity	0.2
Gravity	30.0

Graph Panel (Center): Dragging, Configure, Graph Type: Undirected Graph.

Context Panel (Right): Nodes: 77, Edges: 254, Undirected Graph.

Filters Panel (Right): Library (Attributes, Dynamic, Edges, Operator, Topology, Saved queries).

Queries Panel (Bottom Right): Drag filter here.

Bottom Navigation Bar: Presets..., Reset, Filter.

# Gephi Layout: Contraction

The screenshot shows the Gephi interface with the following components:

- Top Bar:** Overview, Data Laboratory, Preview.
- Left Sidebar:** Appearance (Nodes, Edges, Unique, Attribute, color #c0c0c0), Tools (selection, zoom, etc.), Layout (Contraction, Run button highlighted with a red box).
- Graph Area:** A network graph with a large red central node connected to various clusters of smaller nodes in blue, green, purple, and yellow. Nodes are semi-transparent.
- Right Sidebar:** Context (Nodes: 77, Edges: 254, Undirected Graph), Filters (Library: Attributes, Dynamic, Edges, Operator, Topology, Saved queries), Statistics, Queries (Drag filter here).
- Bottom Bar:** Presets..., Reset, and a toolbar with icons for selection, zoom, etc.

# Gephi Layout: Expansion

The screenshot shows the Gephi software interface with the following components:

- Top Bar:** Overview, Data Laboratory, Preview.
- Left Sidebar:** Appearance (Nodes, Edges, Unique, Attribute), color palette (#c0c0c0), and a Layout panel.
- Layout Panel (highlighted with a red dashed border):**
  - Expansion dropdown menu.
  - Run button (highlighted with a red box).
  - properties section with Scale factor set to 0.8.
- Graph Area:** A network graph with a central red node and several clusters of green, blue, and purple nodes connected by edges.
- Right Sidebar:**
  - Context panel showing Nodes: 77, Edges: 254, Undirected Graph.
  - Filters, Statistics, and Library panels (containing Attributes, Dynamic, Edges, Operator, Topology, and Saved queries).
  - Queries panel with a Drag filter here placeholder.
- Bottom Bar:** Presets..., Reset, and various tool icons.

# Gephi Layout: ForceAtlas 2

Screenshot of the Gephi software interface showing the ForceAtlas 2 layout configuration and visualization.

The main window displays a network graph with nodes colored by community (green, cyan, purple, red, blue, yellow, orange) and edges representing connections between nodes.

**Layout Panel (Left):**

- Selected layout: ForceAtlas 2
- Buttons: Stop (highlighted with a red box)
- Threads:
  - Threads number: 3
- Performance:
  - Tolerance (speed): 1.0
  - Approximate Repu (checkbox)
  - Approximation: 1.2
- Tuning:
  - Scaling: 10.0
  - Stronger Gravity (checkbox)
  - Gravity: 1.0

**Graph Panel (Center):**

Dragging (Configure)

**Context Panel (Right):**

- Nodes: 77
- Edges: 254
- Undirected Graph
- Filters, Statistics, Reset
- Library:
  - Attributes
  - Dynamic
  - Edges
  - Operator
  - Topology
  - Saved queries
- Queries: Drag filter here

**Bottom Navigation:**

- Presets..., Reset
- Lightbulb icon, T icon, Text input, Scale slider, Text input, Arial-BoldMT, 32
- Color palette, Size slider, Selection tool
- ForceAtlas 2 progress bar
- Filter button

# Gephi Layout: Fruchterman Reingold

Screenshot of the Gephi software interface showing the Fruchterman Reingold layout.

The main window displays a network graph with nodes of various sizes and colors (red, blue, green, purple, yellow) connected by edges of different colors (blue, green, red, purple, orange, pink, grey).

The left sidebar contains the **Appearance** panel with tabs for **Nodes** and **Edges**, and a color picker set to `#c0c0c0`. The **Layout** panel is highlighted with a red dashed border and shows the **Fruchterman Reingold** algorithm selected. It includes parameters: **Area** (10000.0), **Gravity** (10.0), and **Speed** (1.0). A **Stop** button is also present in this panel.

The right sidebar includes the **Context** panel showing **Nodes: 77**, **Edges: 254**, and **Undirected Graph**. It also features the **Library** section with categories like **Attributes**, **Dynamic**, **Edges**, **Operator**, **Topology**, and **Saved queries**. The **Queries** section allows users to drag filters onto the graph.

The bottom navigation bar includes icons for Overview, Data Laboratory, Preview, and workspace switching, along with a search bar and filter options.

# Gephi Layout: OpenOrd

Overview Data Laboratory Preview

Workspace 1

Appearance Graph

Nodes Edges Unique Attribute

#c0c0c0

Apply

Layout

OpenOrd

Run

Stages

Liquid (%)	25
Expansion (%)	25
Cooldown (%)	25
Crunch (%)	10
Simmer (%)	15

OpenOrd

Edge Cut	0.8
Num Threads	3
Num Iterations	750

Presets... Reset

Dragging (Configure)

Context

Nodes: 77  
Edges: 254  
Undirected Graph

Filters Statistics

Reset

Library

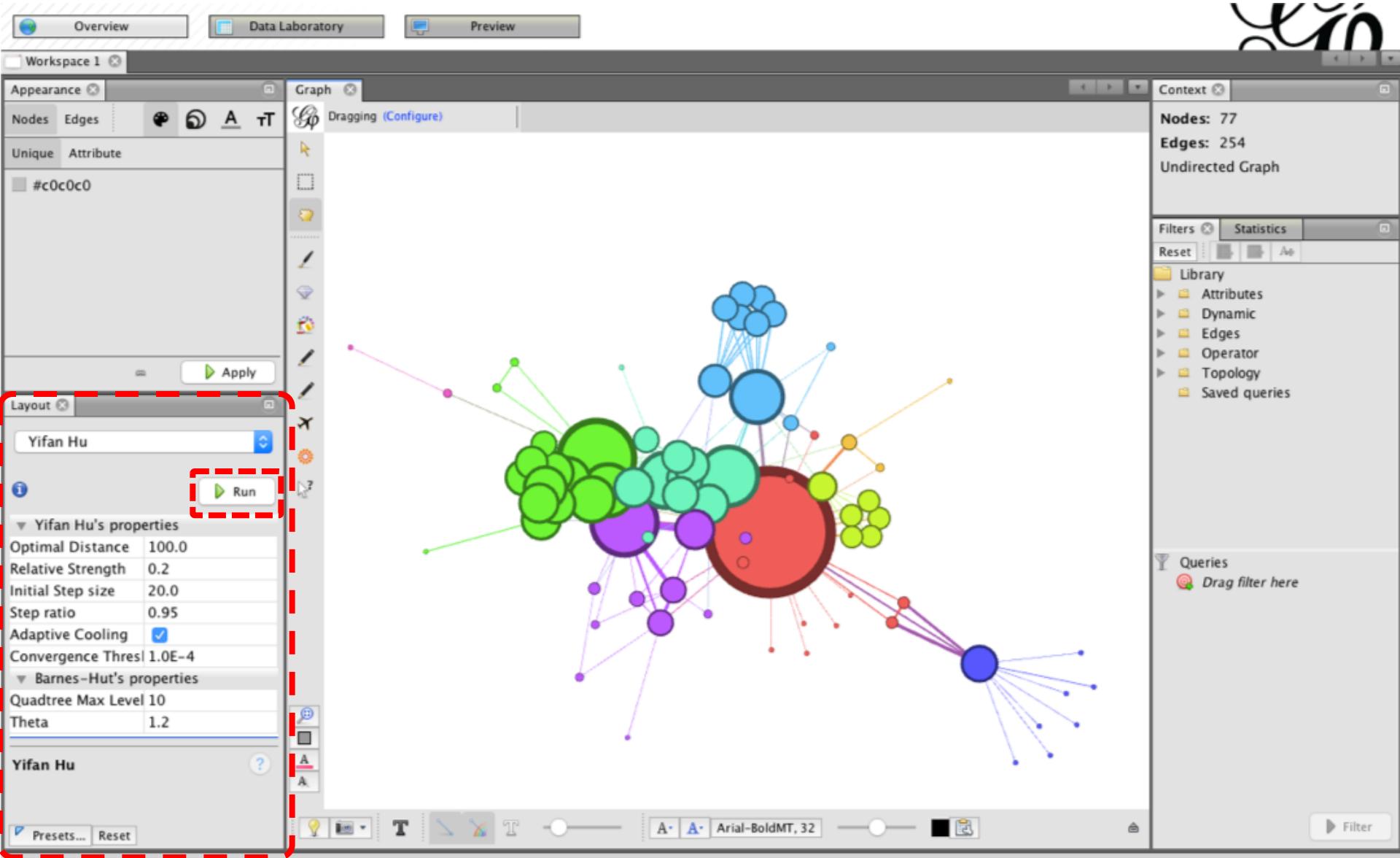
- Attributes
- Dynamic
- Edges
- Operator
- Topology
- Saved queries

Queries Drag filter here

Filter



# Gephi Layout: Yifan Hu



# Gephi Layout: Yifan Hu Proportional

Screenshot of the Gephi software interface showing the Yifan Hu Proportional layout.

The layout panel shows the following settings:

- Yifan Hu Proportional
- Run button (highlighted with a red box)
- Yifan Hu's properties:
  - Optimal Distance: 100.0
  - Relative Strength: 0.2
  - Initial Step size: 20.0
  - Step ratio: 0.95
  - Adaptive Cooling:
  - Convergence Thres: 1.0E-4
- Barnes–Hut's properties:
  - Quadtree Max Level: 10
  - Theta: 1.2

The main graph area displays a network of nodes and edges. A large central red node is surrounded by several green and cyan nodes. Other nodes are colored blue, purple, yellow, and orange. The edges connect these nodes in a complex web. The background features a faint watermark of a stylized figure.

Right-hand panels show:

- Context: Nodes: 77, Edges: 254, Undirected Graph
- Filters: Library (Attributes, Dynamic, Edges, Operator, Topology, Saved queries)
- Queries: Drag filter here

Bottom navigation bar includes: Presets..., Reset, Filter, and a font size selector set to Arial-BoldMT, 32.

# Gephi Data Laboratory: Nodes

Screenshot of the Gephi Data Laboratory interface showing the Nodes tab.

The top navigation bar includes tabs for Overview, Data Laboratory (highlighted with a red dashed box), and Preview.

The main area displays a Data Table with columns: Id, Label, Interval, and Modularity Class.

The data table contains the following rows:

Id	Label	Interval	Modularity Class
0	Myriel		0
1	Napoleon		0
10	Labarre		1
11	Valjean		1
12	Marguerite		1
13	MmeDeR		1
14	Isabeau		1
15	Gervais		1
16	Tholomyes		2
17	Listolier		2
18	Fameuil		2
19	Blacheville		2
2	MlleBaptistine		1
20	Favourite		2
21	Dahlia		2
22	Zephine		2
23	Fantine		2
24	MmeThenardier		7
25	Thenardier		7
26	Cosette		6
27	Javert		7
28	Fauchelevent		4
29	Bamatabois		3
3	MmeMagloire		1
30	Perpetue		2
31	Simplice		2
32	Scaufflaire		1
33	Woman1		1
34	Judge		3
35	Champmathieu		3

Below the table are several toolbar buttons:

- Add column
- Merge columns
- Delete column ▾
- Clear column ▾
- Copy data to other column ▾
- Fill column with a value ▾
- Duplicate column ▾
- Create a boolean column from regex match ▾
- Create column with list of regex matching groups ▾

# Gephi Data Laboratory: Edges

Screenshot of the Gephi Data Laboratory interface showing the Edges tab selected. The Data Laboratory tab is highlighted with a red dashed box.

The Data Table shows the following edge data:

Source	Target	Type	Id	Label	Interval	Weight
1	0	Undirected	0			1.0
2	0	Undirected	1			8.0
3	0	Undirected	2			10.0
3	2	Undirected	3			6.0
4	0	Undirected	4			1.0
5	0	Undirected	5			1.0
6	0	Undirected	6			1.0
7	0	Undirected	7			1.0
8	0	Undirected	8			2.0
9	0	Undirected	9			1.0
11	0	Undirected	13			5.0
11	2	Undirected	12			3.0
11	3	Undirected	11			3.0
11	10	Undirected	10			1.0
12	11	Undirected	14			1.0
13	11	Undirected	15			1.0
14	11	Undirected	16			1.0
15	11	Undirected	17			1.0
17	16	Undirected	18			4.0
18	16	Undirected	19			4.0
18	17	Undirected	20			4.0
19	16	Undirected	21			4.0
19	17	Undirected	22			4.0
19	18	Undirected	23			4.0
20	16	Undirected	24			3.0
20	17	Undirected	25			3.0
20	18	Undirected	26			3.0
20	19	Undirected	27			4.0
21	16	Undirected	28			3.0
21	17	Undirected	29			3.0

Bottom navigation bar:

- Add column
- Merge columns
- Delete column ▾
- Clear column ▾
- Copy data to other column ▾
- Fill column with a value ▾
- Duplicate column ▾
- Create a boolean column from regex match ▾
- Create column with list of regex matching groups ▾

# Gephi Data Laboratory:

## Export table to CSV file

The screenshot shows the Gephi Data Laboratory interface. At the top, there are three tabs: 'Overview', 'Data Laboratory' (which is selected and highlighted with a red dashed box), and 'Preview'. Below the tabs is a toolbar with buttons for 'Nodes', 'Edges', 'Configuration' (selected and highlighted with a red dashed box), 'Add node', 'Add edge', 'Search/Replace', 'Import Spreadsheet', 'Export table' (highlighted with a red dashed box), 'More actions', and a 'Filter' field. The main area is a 'Data Table' view showing a list of nodes with columns for 'Id', 'Label', 'Interval', and 'Modularity Class'. A modal dialog box is open, also highlighted with a red dashed box, titled 'Export table to CSV file'. It contains settings for 'Separator: Comma', 'Charset: UTF-8', and a 'Columns:' section with checkboxes for 'Id', 'Label', 'Interval', and 'Modularity Class', all of which are checked. At the bottom of the dialog are 'Cancel' and 'OK' buttons.

Id	Label	Interval	Modularity Class
0	Myriel		0
1	Napoleon		0
10	Labarre		1
11	Valjean		1
12	Marguerite		1
13	MmeDeR		1
14	Isabeau		1
15	Gervais		1
16	Tholomyes		2
17	Listolier		2
18	Fameuil		2
19	Blacheville		2
2	MlleBaptistine		1
20	Favourite		2
21	Dahlia		2
22	Zephine		2
23	Fantine		2
24	MmeThenardier		7
25	Thenardier		7
26	Cosette		6
27	Javert		7
28	Fauchelevent		4
29	Bamatabois		3
3	MmeMagloire		1
30	Perpetue		2
31	Simplice		2
32	Scaufflaire		1
33	Woman1		1
34	Judge		3
35	Champmathieu		3

Below the table are several utility buttons:

- Add column
- Merge columns
- Delete column
- Clear column
- Copy data to other column
- Fill column with a value
- Duplicate column
- Create a boolean column from regex match
- Create column with list of regex matching groups

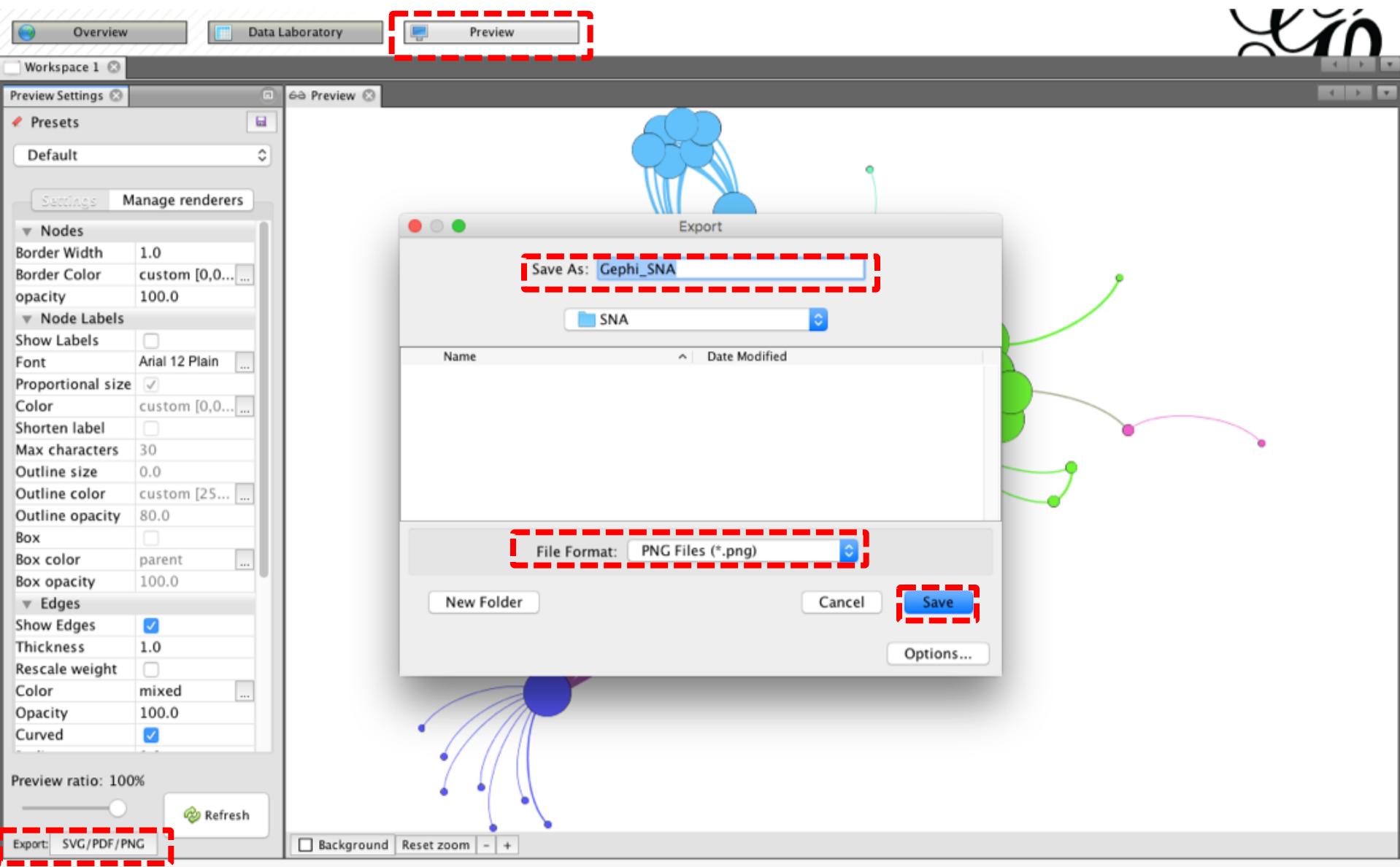
# Gephi Preview

Screenshot of the Gephi software interface showing a network graph preview.

The interface includes the following components:

- Top Bar:** Overview, Data Laboratory, Preview (highlighted with a red dashed box).
- Left Sidebar:** Workspace 1, Preview Settings (Presets: Default), Settings (selected), Manage renderers.
- Nodes Settings:**
  - Border Width: 1.0
  - Border Color: custom [0,0,...]
  - opacity: 100.0
- Node Labels Settings:**
  - Show Labels:
  - Font: Arial 12 Plain
  - Proportional size:
  - Color: custom [0,0,...]
  - Shorten label:
  - Max characters: 30
  - Outline size: 0.0
  - Outline color: custom [25...
  - Outline opacity: 80.0
  - Box:
  - Box color: parent
  - Box opacity: 100.0
- Edges Settings:**
  - Show Edges:
  - Thickness: 1.0
  - Rescale weight:
  - Color: mixed
  - Opacity: 100.0
  - Curved:
- Preview Area:** A complex network graph with nodes of various sizes and colors (red, blue, green, purple, yellow) connected by edges of different colors and thicknesses.
- Bottom Tools:**
  - Preview ratio: 100% (with a slider)
  - Refresh button (highlighted with a red dashed box)
  - Export: SVG/PDF/PNG
  - Background checkbox, Reset zoom button, Zoom controls (- +)

# Gephi Preview: Export SVG/PDF/PNG

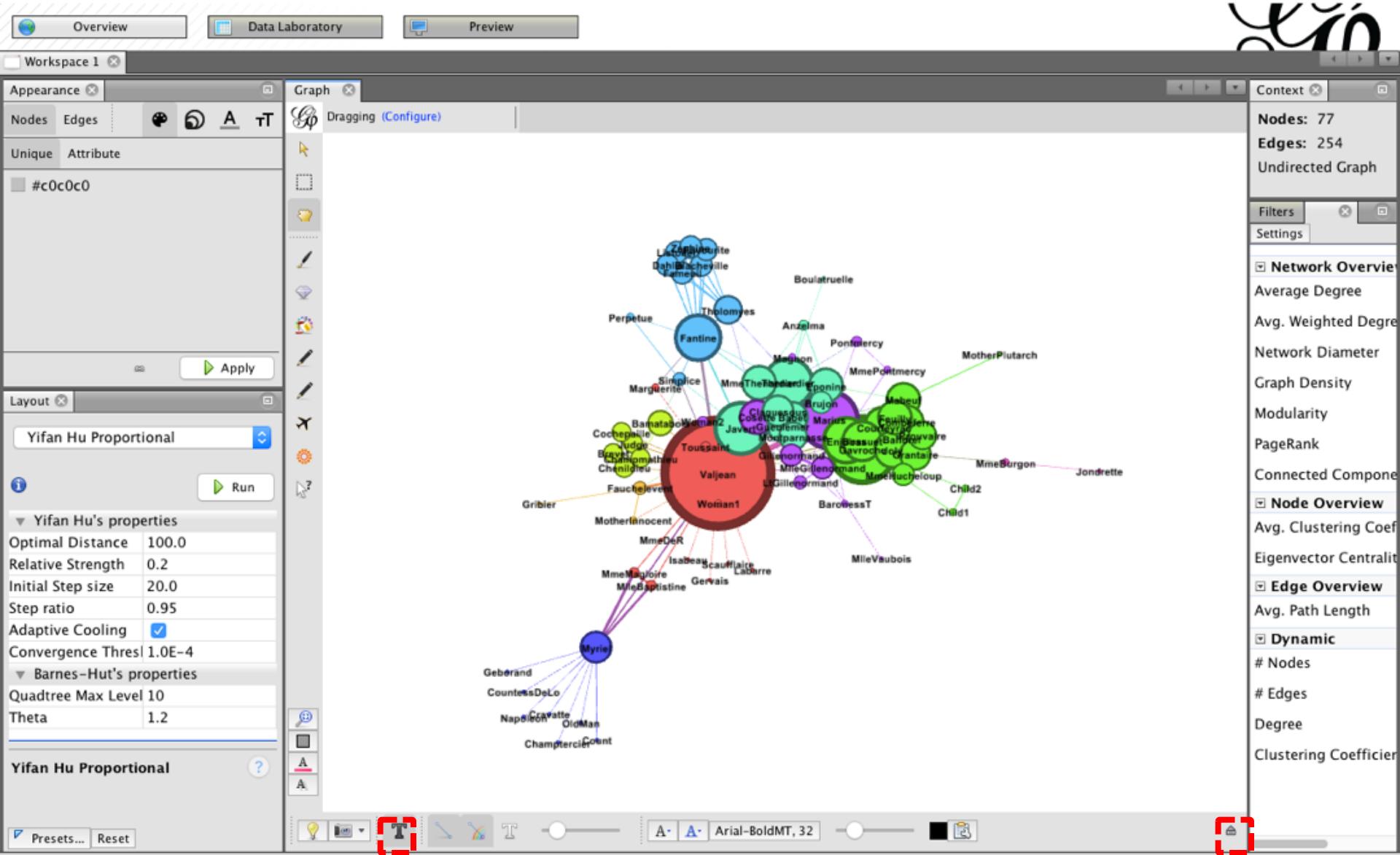


# Gephi Overview: Text Labels

The screenshot shows the Gephi interface with the following components:

- Top Bar:** Overview, Data Laboratory, Preview.
- Left Panel (Appearance):**
  - Nodes Edges
  - Unique Attribute
  - Color: #c0c0c0
  - Apply button
- Left Panel (Layout):**
  - Yifan Hu Proportional
  - Run button
  - Properties:
    - Optimal Distance: 100.0
    - Relative Strength: 0.2
    - Initial Step size: 20.0
    - Step ratio: 0.95
    - Adaptive Cooling (checkbox checked)
    - Convergence Thresh: 1.0E-4
  - Barnes-Hut's properties:
    - Quadtree Max Level: 10
    - Theta: 1.2
- Graph Area:** A network graph with nodes labeled with names like "Veljan", "Todor", "Margareta", "Mihailo", etc., and edges connecting them.
- Bottom Panel (Text Labels):**
  - Font: Arial-BoldMT, 32
  - Color: black
  - Size: Scaled
  - Color: Text
  - Hide non-selected (checkbox)
- Right Panel (Context):**
  - Nodes: 77
  - Edges: 254
  - Undirected Graph
  - Filters, Settings
  - Network Overview, Average Degree, Avg. Weighted Degree, Network Diameter, Graph Density, Modularity, PageRank, Connected Components, Node Overview, Avg. Clustering Coef, Eigenvector Centralit, Edge Overview, Avg. Path Length, Dynamic, # Nodes, # Edges, Degree, Clustering Coefficient

# Gephi Overview: Text Labels



# Comparison of Social Network Analysis (SNA) Tools

# General Comparison of SNA Tools

Software	NETWORKX	IGRAPH	GEPHI	PAJEK
TYPE	LIBRARY	LIBRARY	STAND ALONE	STAND ALONE
PLATFORM	PYTHON	PYTHON\R\C LIBRARY	WINDOWS	WINDOWS
COMPUTATIONAL TIME	FAST	FAST	FAST	MEDIUM
NO. OF NODES	1 MILLION	1 MILLION	0.15 MILLION	1 MILLION

Naheed Akhtar (2014)

# Network Types Supported by SNA Tools

Graph type	Networkx	IGraph	Gephi	Pajek
1-Mode network	Yes	Yes	Yes	Yes
2-Mode network Graph	Yes	Yes	Yes	Yes
Multirelational network Graph	No	No	No	Yes
Temporarily network Graph	Yes	No	No	Yes

Naheed Akhtar (2014)

# Graph Layout Supported by SNA Tools

Layout	Networkx	IGraph	Pajek	Gephi
Circular layout	Yes	Yes	Yes	Yes
Random layout	Yes	Yes	Yes	No
Spectral layout	Yes	No	No	No
Spring layout	Yes	Yes	Yes	Yes
Graphviz layout	Yes	No	No	No
Kamada kawai	No	Yes	Yes	No
Fruchterman reingold	No	Yes	Yes	No
Force Atlas layout	No	No	Yes	No

Naheed Akhtar (2014)

# Execution Time for SNA Features

SNA Features	Networkx	IGraph	Gephi	Pajek
Load time	54.67 sec.	3.707 sec	29 sec	3 sec
Degree centrality	58.57 sec	6.199 sec	4 sec	2 sec
Graph degree	60.87 sec	6.22 sec	4 sec	2 sec
Page rank	120.78 sec	9.81 sec	10 sec	No
Hits	57.23 sec	15.43	8 sec	No
Cliques	66.98 sec	9.35 sec	Na	No
Density	58.94 sec	3.302 sec	4 sec	No
Modularity	81 .4 sec	9 sec	30 sec	6 sec
Network diameter	35 sec	3.51 sec	120 sec	No
Core	65.84 sec	6.532 sec	No	1 sec
Cohesion	No	8.943 sec	No	No
Clustering coefficient	3303.99 sec	1800 sec	1200 sec	108 sec
Hub	76.57	5.831 sec	3 sec	No
Authority	Array is to big	6.783 sec	3 sec	No

Naheed Akhtar (2014)

# Comparative analysis of Social Networking Analysis tools

Software	Pajek	Gephi	Social Network Visualizer	Netlytic	Graphviz
Version	1.26	0.7 alpha	1.56 Beta	Tier 1,2,3	2.38.0
Type	Stand-alone software	Stand-alone software	Stand-alone software	Stand-alone software	Stand-alone software
Platform	Windows	Java	Windows	Windows	Windows
License	Free	GNU GPL	Free	Tier 1,2 (Free) Tier 3 (CS)	Free
Expectable Computing Time	Fast(C)	Medium(JAVA)	Fast(C)	Medium(JAVA)	Fast(C)
Tractable number of nodes	500000 nodes	150000 nodes	100000 nodes	300000 nodes	1400000 nodes
Time to load $10^5$ nodes and $10^6$ edges	24 seconds	40 seconds	46 seconds	50 seconds	34 seconds
<b>File formats</b>					
GML	No	Yes	Yes	Yes	No
Pajek(.net)	No	Important Only	No	No	No
GraphML	Export only	Yes	Yes	Yes	No
DL	Yes	Yes	Yes	Yes	No
GEXF	No	Yes	Yes	Yes	No
<b>Graph types</b>					
Two-mode graphs	Yes	No	No	No	Yes
Multi-relational graphs	Yes	No	No	Yes	Yes
Temporality	Yes	No	No	Yes	Yes
<b>Visualization layouts</b>					
FruchtermanReingold	Yes	Yes	Yes	Yes	No
Kamada Kawai	Yes	Yes	No	No	Yes
Other spring layouts	No	Yes	Yes	No	Yes
<b>Indicators</b>					
Degree centrality	Yes	Yes	Yes	Yes	Yes
Betweenness centrality	Yes	Yes	Yes	Yes	Yes
Closeness centrality	Yes	Yes	Yes	Yes	Yes
Dyad census	No	No	No	No	No
Triad census	Yes	No	No	No	No
HITS	No	Yes	Yes	No	No
Page Rank	No	Yes	Yes	Yes	No
<b>Clustering Algorithms</b>					
Edge Betweenness	No	No	No	Yes	No
Walktrap	No	No	No	Yes	No
Spinglass	No	No	No	Yes	No
Dendogram Display	Yes	Yes	Yes	Yes	Yes

# Comparative analysis of Social Networking Analysis tools

Software	Pajek	Gephi
Version	1.26	0.7 alpha
Type	Stand-alone software	Stand-alone software
Platform	Windows	Java
License	Free	GNU GPL
Expectable Computing Time	Fast(C)	Medium(JAVA)
Tractable number of nodes	500000 nodes	150000 nodes
Time to load $10^5$ nodes and $10^6$ edges	24 seconds	40 seconds

## File formats

GML	No	Yes
Pajek(.net)	No	Important Only
GraphML	Export only	Yes
DL	Yes	Yes
GEXF	No	Yes

## Graph types

Two-mode graphs	Yes	No
Multi-relational graphs	Yes	No
Temporality	Yes	No

# Comparative analysis of Social Networking Analysis tools

Software	Pajek	Gephi
<b>Visualization layouts</b>		
FruchtermanReingold	Yes	Yes
Kamada Kawai	Yes	Yes
Other spring layouts	No	Yes
<b>Indicators</b>		
Degree centrality	Yes	Yes
Betweenness centrality	Yes	Yes
Closeness centrality	Yes	Yes
Dyad census	No	No
Triad census	Yes	No
HITS	No	Yes
Page Rank	No	Yes
<b>Clustering Algorithms</b>		
Edge Betweenness	No	No
Walktrap	No	No
Spinglass	No	No
<b>Dendogram Display</b>	Yes	Yes

# A Survey of Tools for Community Detection and Mining in Social Networks

(Maivizhi et al., 2016)

Tools	Pajek	Gephi	igraph
Version	4.1	0.9.1	1.0.1
Website	<a href="http://vlado.fmf.uni-lj.si/pub/networks/pajek/">vlado.fmf.uni-lj.si/pub/networks/pajek/</a>	<a href="http://gephi.org">gephi.org</a>	<a href="http://igraph.org">igraph.org</a>
Type	Software	Software	Library
Platform	Windows	Windows, Mac OS X, Linux	R, Python, C/C++
License	Free and Commercial	Open source and free	Open source and free
Number of nodes	1 Billion	0.6 Million	>1 Million
Computing Time	Medium	Fast	Fast

# A Survey of Tools for Community Detection and Mining in Social Networks

(Maivizhi et al., 2016)

Network Type	Pajek	Gephi	igraph
1-mode network	Yes	Yes	Yes
2-mode network	Yes	Yes	Yes
Multi-relational network	Yes	No	No
Temporal (dynamic) network	Yes	No	No

# A Survey of Tools for Community Detection and Mining in Social Networks

(Maivizhi et al., 2016)

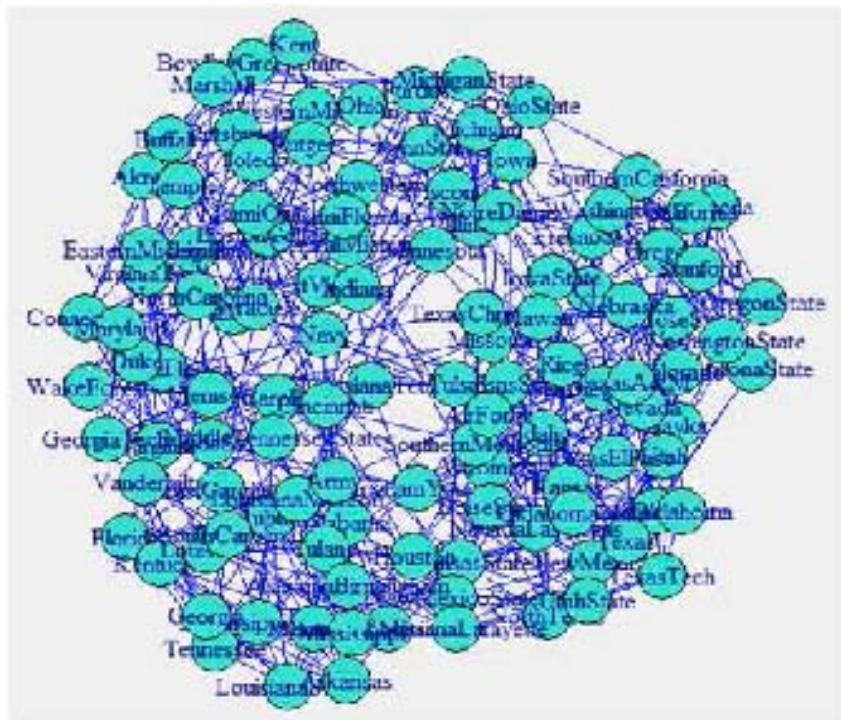
File Format	Pajek	Gephi	igraph
.net	Yes	Yes	No
.gml	No	Yes	Yes
.graphml	No	Yes	Yes
.txt	No	No	Yes
.csv	No	Yes	Yes
.pajek	Yes	Import only	Yes
.dl	No	Yes	Import only
.graphdb	No	No	Yes
.dot	No	Yes	Export only

# A Survey of Tools for Community Detection and Mining in Social Networks

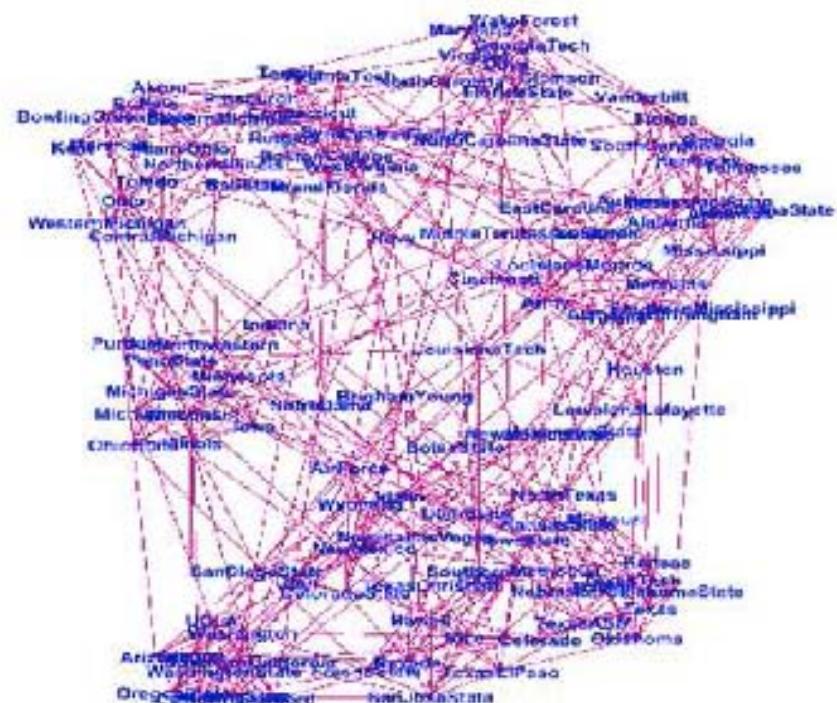
(Maivizhi et al., 2016)

Visualization Layout	Pajek	Gephi	igraph
Kamada-kawai	Yes	No	Yes
Fruchterman-Reingold	Yes	Yes	Yes
Other spring layout	Yes	No	Yes
Circular layout	Yes	No	Yes
Random layout	Yes	Yes	Yes
Force atlas layout	Yes	Yes	Yes
Spectral layout	No	No	No
Tree layout	No	No	Yes

# Visualization using igraph and Gephi



Visualization of American College Football using **igraph** with **kamada-kawai** layout.



Visualization of American College Football using **Gephi** with **force-directed** layout.

# A Survey of Tools for Community Detection and Mining in Social Networks

(Maivizhi et al., 2016)

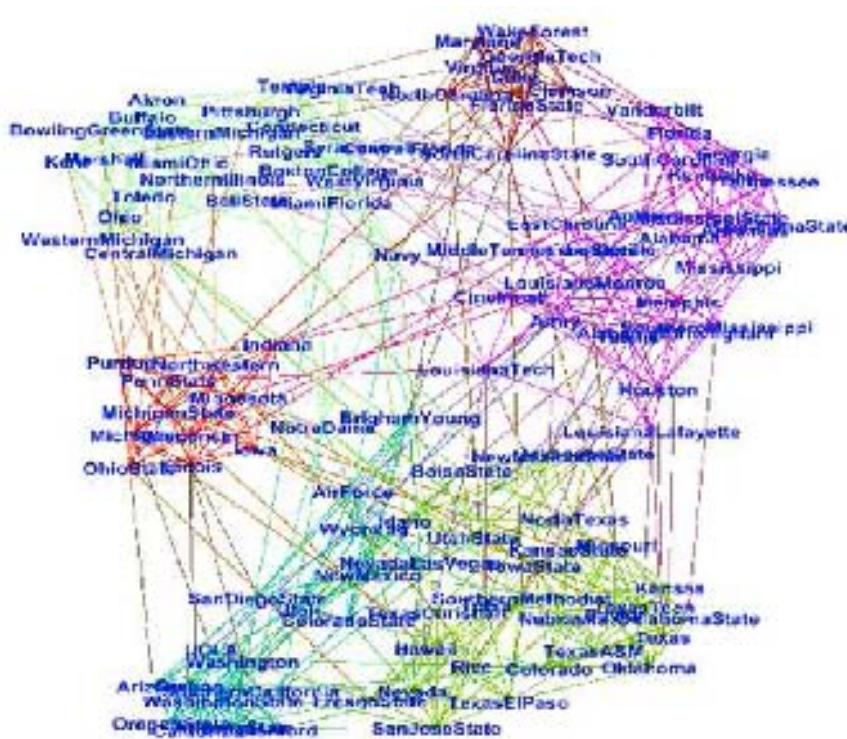
Network Metrics	Pajek	Gephi	igraph
Degree Centrality	Yes	Yes	Yes
Betweenness Centrality	Yes	Yes	Yes
Closeness Centrality	Yes	Yes	Yes
Network Diameter	Yes	Yes	Yes
Dyad Census	No	No	Yes
Triad Census	Yes	No	Yes
HITS	No	No	Yes
Page Rank	No	Yes	Yes

# A Survey of Tools for Community Detection and Mining in Social Networks

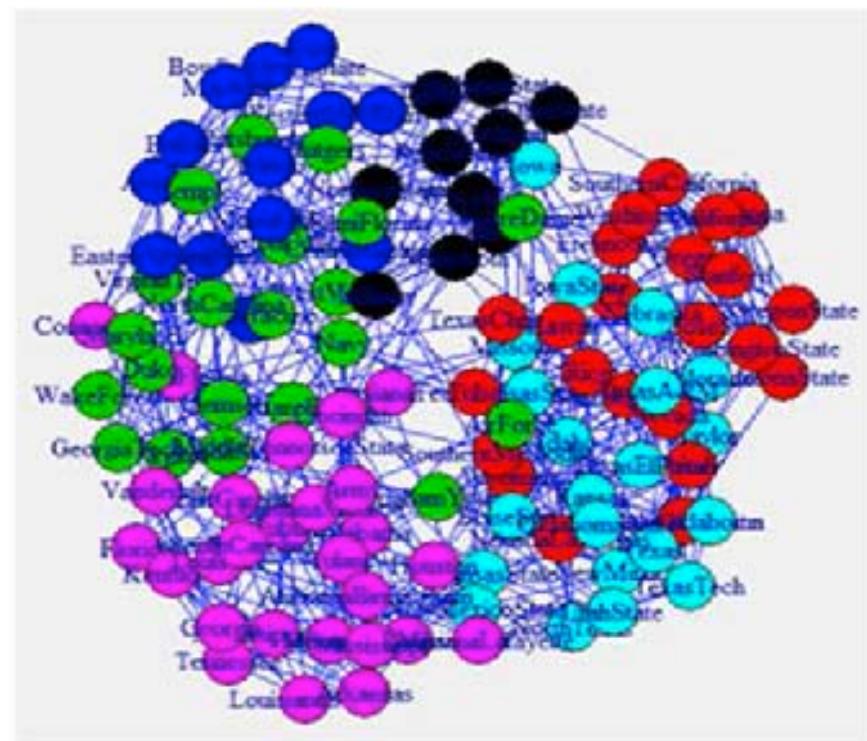
(Maivizhi et al., 2016)

Community Algorithms	Pajek	Gephi	igraph
Louvain Method	Yes	Yes	Yes
Edge Betweenness	No	No	Yes
Greedy Method	No	No	Yes
Modularity Method	No	No	No
Clique Percolation Method	No	No	No
Label Propagation	No	No	Yes
Eigen Vector	No	No	Yes
Random Walk	No	No	Yes
Statistical Method	No	No	Yes

# Community Detection using Gephi and igraph



Community detection using **Gephi**  
with **Louvain method**.



Community detection using **igraph**  
with **Fast Greedy Algorithm**.

# **Application of SNA**

# **Social Network Analysis**

## **of**

## **Research Collaboration**

## **in**

## **Information Reuse and Integration**

# Example of SNA Data Source



home | browse | search | about



## IRI 2010: Las Vegas, NV, USA

- □ ⬇ 🔍 **Proceedings of the IEEE International Conference on Information Reuse and Integration, IRI 2010, 4-6 August 2010, Las Vegas, Nevada, USA.**  
IEEE Systems, Man, and Cybernetics Society 2010
- 📄 ⬇ 🔍 Reda Alhajj, James B. D. Joshi, Mei-Ling Shyu: **Message from Program Co-Chairs.** 1
- 📄 ⬇ 🔍 Stuart Harvey Rubin, Shu-Ching Chen: **Forward.** 1
- 📄 ⬇ 🔍 Lotfi A. Zadeh: **Precision of meaning - toward computation with natural language.** 1-4
- 📄 ⬇ 🔍 Reda Alhajj, Shu-Ching Chen, Gongzhu Hu, James B. D. Joshi, Gordon K. Lee, Stuart Harvey Rubin, Mei-Ling Shyu, Lotfi A. Zadeh: **Panel title: Critical need for funding of basic and applied research in large-scale computing.** 1

### Automation, Integration and Reuse across Various Apps

- 📄 ⬇ 🔍 László István Etesi, André Csillaghy, Lin-Ching Chang: **A message-based interoperability framework with application to astrophysics.** 1-6
- 📄 ⬇ 🔍 Awny Alnusair, Tian Zhao, Eric Bodden: **Effective API navigation and reuse.** 7-12
- 📄 ⬇ 🔍 Manabu Ohta, Ryohei Inoue, Atsuhiro Takasu: **Empirical evaluation of active sampling for CRF-based analysis of pages.** 13-18
- 📄 ⬇ 🔍 Qunzhi Zhou, Viktor K. Prasanna: **Workflow management of simulation based computation processes in transportation domain.** 19-24

# Research Question

- RQ1: What are the scientific **collaboration patterns** in the IRI research community?
- RQ2: Who are the **prominent researchers** in the IRI community?

# Methodology

- Developed a simple **web focused crawler** program to download literature information about all IRI papers published between **2003 and 2010** from **IEEE Xplore** and **DBLP**.
  - **767** paper
  - **1599** distinct author
- Developed a program to convert the list of coauthors into the **format of a network file** which can be readable by social network analysis software.
- **UCINet** and **Pajek** were used in this study for the social network analysis.

# Top10 prolific authors (IRI 2003-2010)

1. Stuart Harvey Rubin
2. Taghi M. Khoshgoftaar
3. Shu-Ching Chen
4. Mei-Ling Shyu
5. Mohamed E. Fayad
6. Reda Alhajj
7. Du Zhang
8. Wen-Lian Hsu
9. Jason Van Hulse
10. Min-Yuh Day

# Data Analysis and Discussion

- **Closeness Centrality**
  - Collaborated widely
- **Betweenness Centrality**
  - Collaborated diversely
- **Degree Centrality**
  - Collaborated frequently
- **Visualization of Social Network Analysis**
  - Insight into the structural characteristics of research collaboration networks

# Top 20 authors with the highest **closeness** scores

Rank	ID	Closeness	Author
1	3	0.024675	Shu-Ching Chen
2	1	0.022830	Stuart Harvey Rubin
3	4	0.022207	Mei-Ling Shyu
4	6	0.020013	Reda Alhajj
5	61	0.019700	Na Zhao
6	260	0.018936	Min Chen
7	151	0.018230	Gordon K. Lee
8	19	0.017962	Chengcui Zhang
9	1043	0.017962	Isai Michel Lombera
10	1027	0.017962	Michael Armella
11	443	0.017448	James B. Law
12	157	0.017082	Keqi Zhang
13	253	0.016731	Shahid Hamid
14	1038	0.016618	Walter Z. Tang
15	959	0.016285	Chengjun Zhan
16	957	0.016285	Lin Luo
17	956	0.016285	Guo Chen
18	955	0.016285	Xin Huang
19	943	0.016285	Sneh Gulati
20	960	0.016071	Sheng-Tun Li

Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),  
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

# Top 20 authors with the highest **betweenness** scores

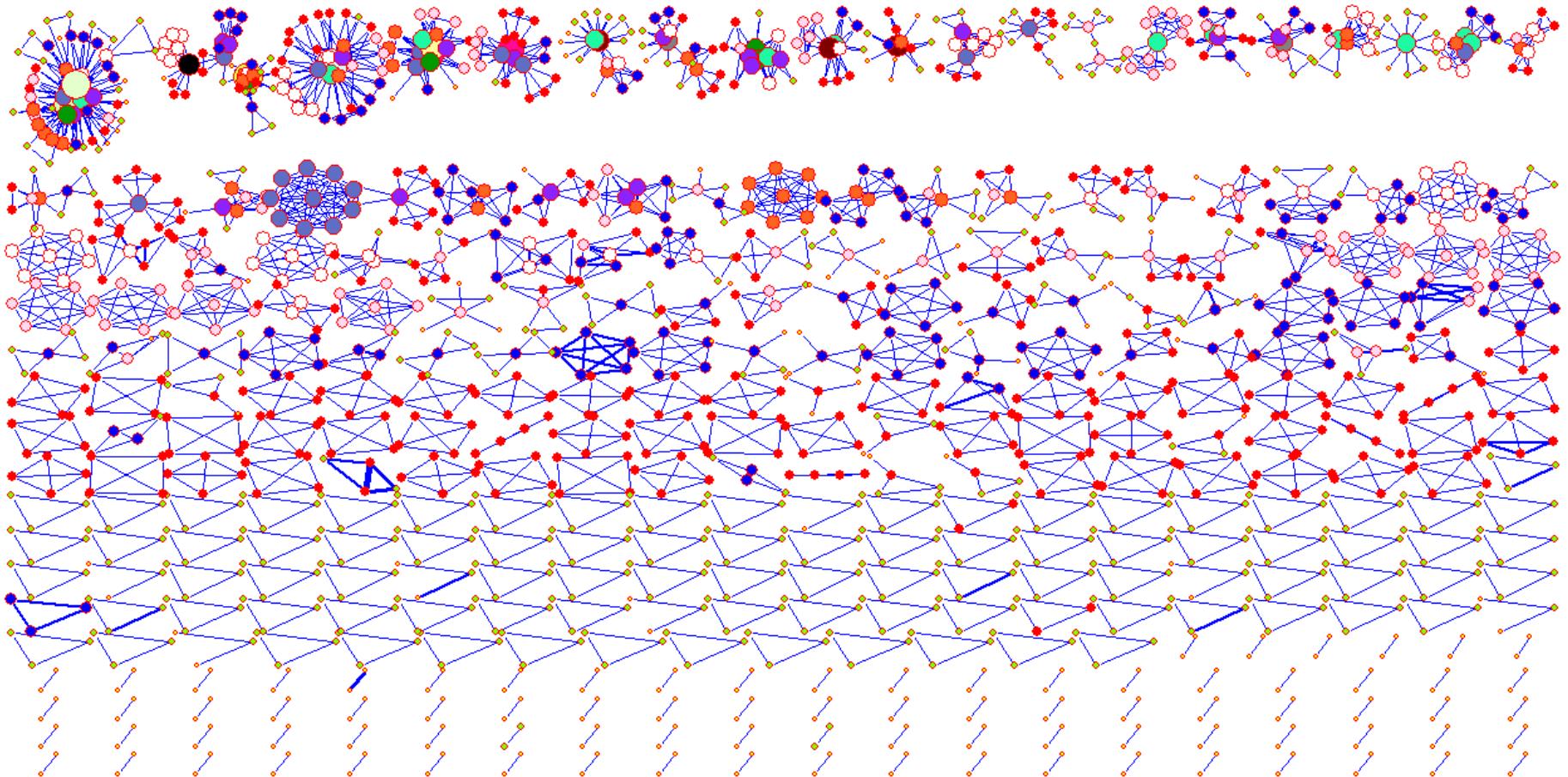
Rank	ID	Betweenness	Author
1	1	0.000752	Stuart Harvey Rubin
2	3	0.000741	Shu-Ching Chen
3	2	0.000406	Taghi M. Khoshgoftaar
4	66	0.000385	Xingquan Zhu
5	4	0.000376	Mei-Ling Shyu
6	6	0.000296	Reda Alhajj
7	65	0.000256	Xindong Wu
8	19	0.000194	Chengcui Zhang
9	39	0.000185	Wei Dai
10	15	0.000107	Narayan C. Debnath
11	31	0.000094	Qianhui Althea Liang
12	151	0.000094	Gordon K. Lee
13	7	0.000085	Du Zhang
14	30	0.000072	Baowen Xu
15	41	0.000067	Hongji Yang
16	270	0.000060	Zhiwei Xu
17	5	0.000043	Mohamed E. Fayad
18	110	0.000042	Abhijit S. Pandya
19	106	0.000042	Sam Hsu
20	8	0.000042	Wen-Lian Hsu

Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),  
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

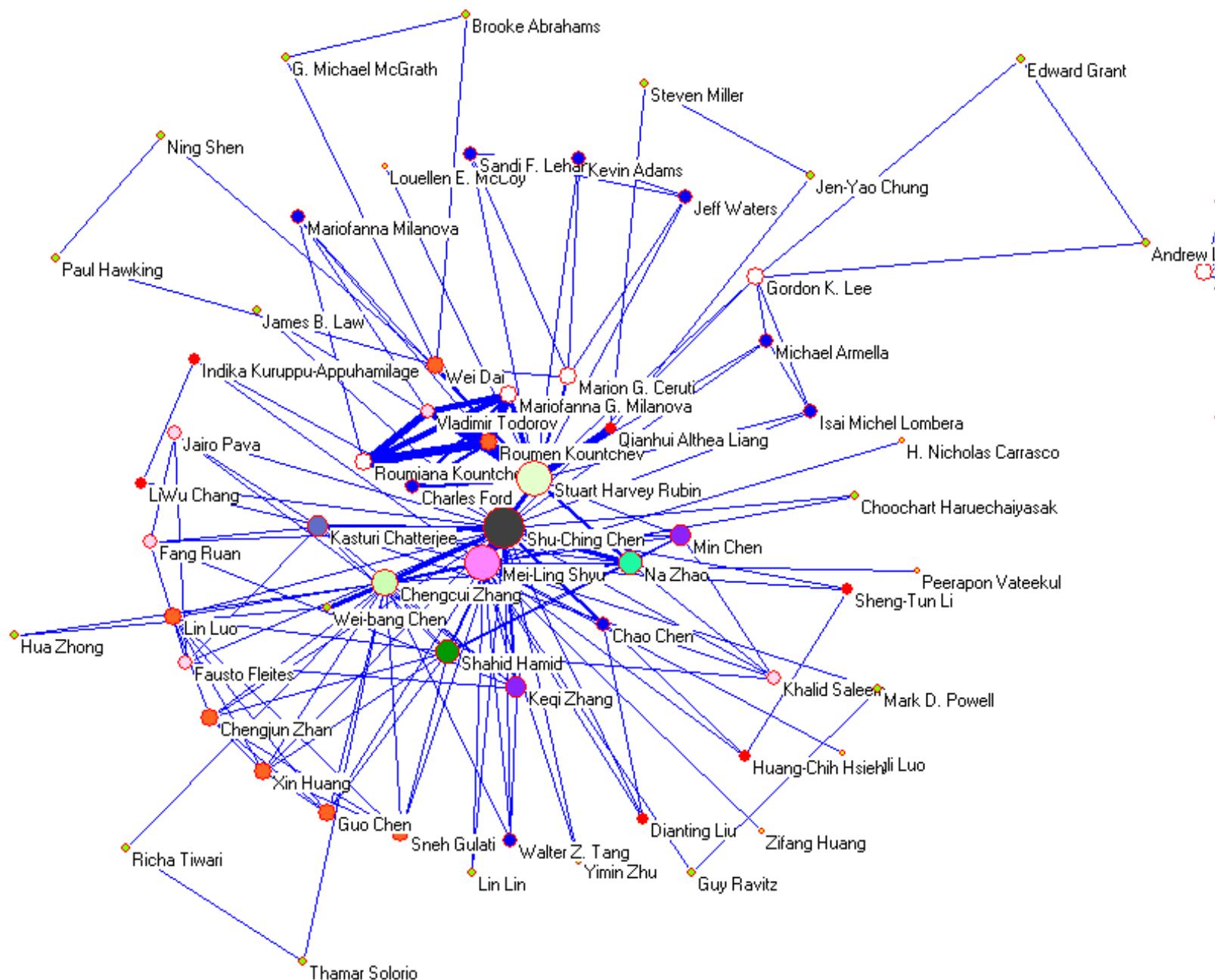
# Top 20 authors with the highest degree scores

Rank	ID	Degree	Author
1	3	0.035044	Shu-Ching Chen
2	1	0.034418	Stuart Harvey Rubin
3	2	0.030663	Taghi M. Khoshgoftaar
4	6	0.028786	Reda Alhajj
5	8	0.028786	Wen-Lian Hsu
6	10	0.024406	Min-Yuh Day
7	4	0.022528	Mei-Ling Shyu
8	17	0.021277	Richard Tzong-Han Tsai
9	14	0.017522	Eduardo Santana de Almeida
10	16	0.017522	Roumen Kountchev
11	40	0.016896	Hong-Jie Dai
12	15	0.015645	Narayan C. Debnath
13	9	0.015019	Jason Van Hulse
14	25	0.013767	Roumiana Kountcheva
15	28	0.013141	Silvio Romero de Lemos Meira
16	24	0.013141	Vladimir Todorov
17	23	0.013141	Mariofanna G. Milanova
18	5	0.013141	Mohamed E. Fayad
19	19	0.012516	Chengcui Zhang
20	18	0.011890	Waleed W. Smari

# Visualization of IRI (IEEE IRI 2003-2010) co-authorship network (global view)

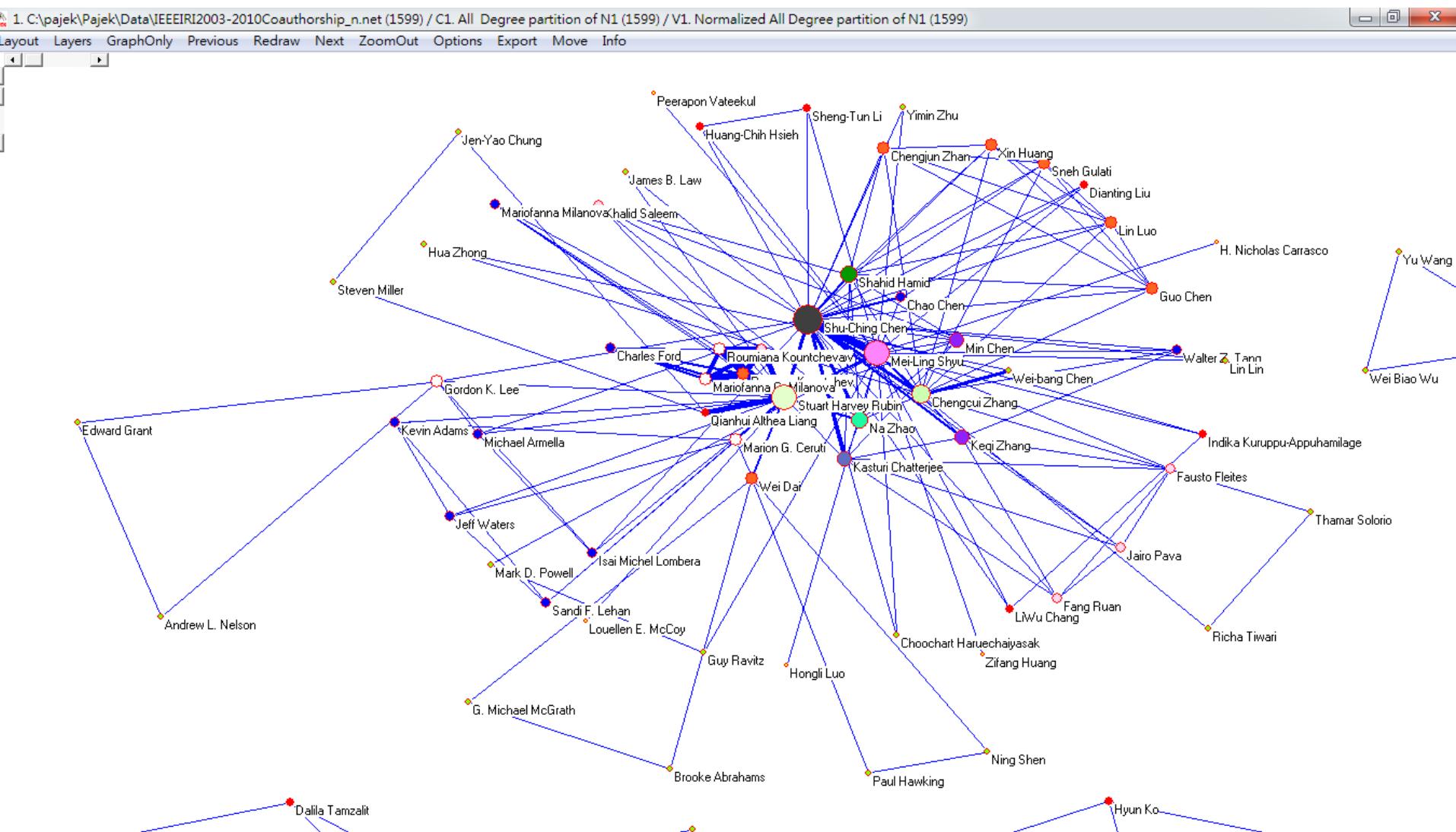


Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),  
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"



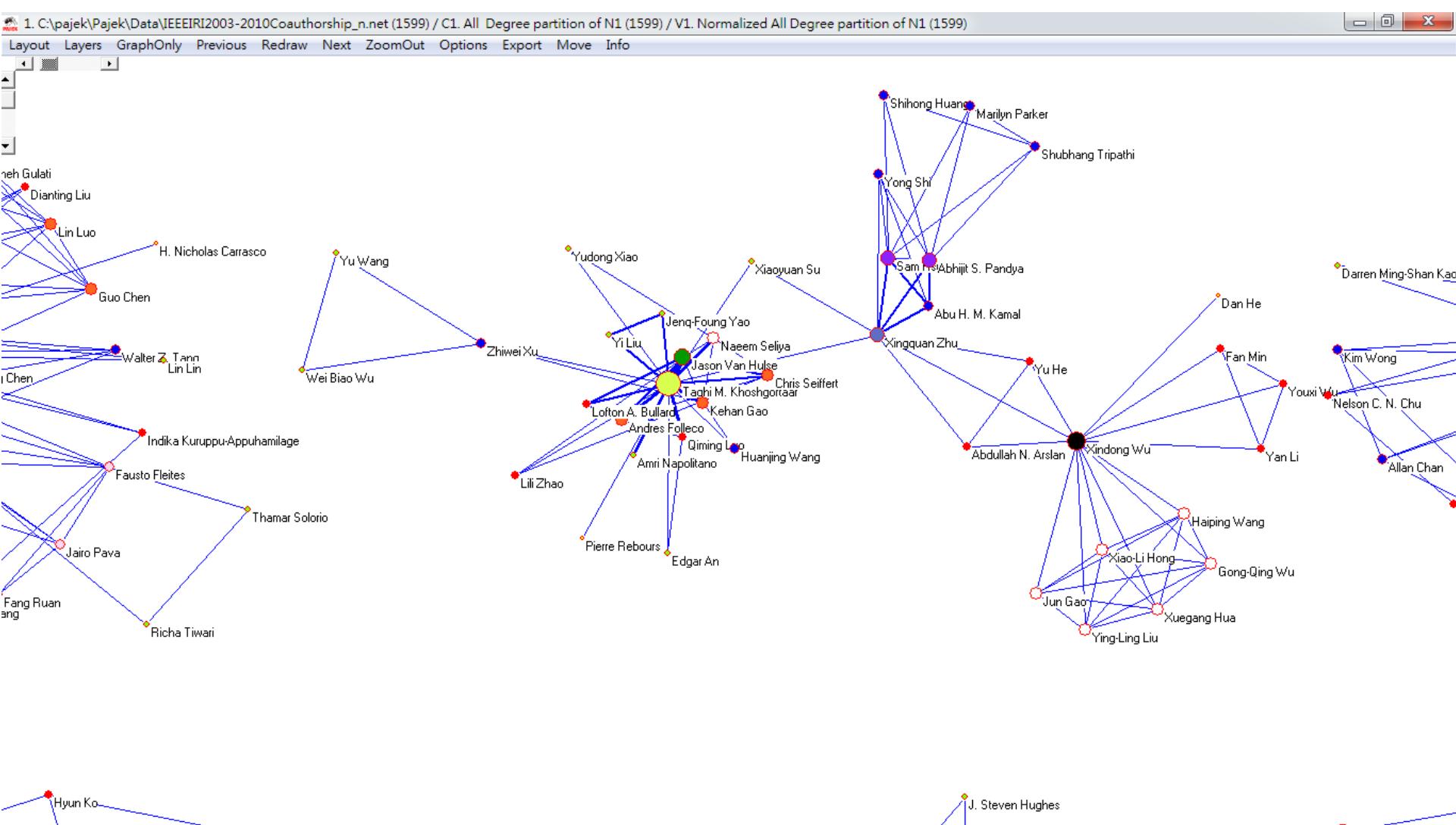
Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),  
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

# Visualization of Social Network Analysis



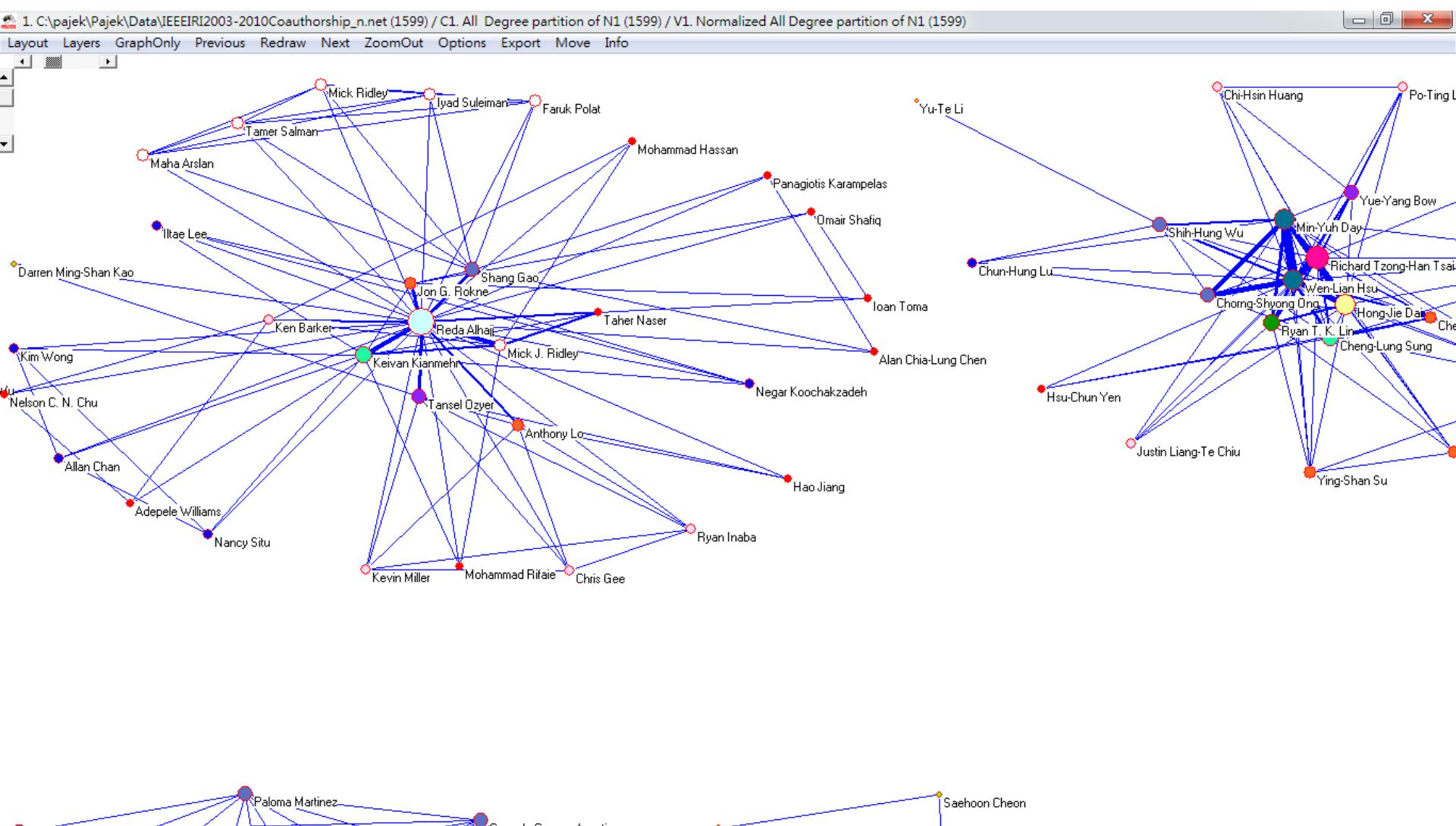
Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),  
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

# Visualization of Social Network Analysis



Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),  
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

# Visualization of Social Network Analysis



Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),  
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

# Summary

- Social Computing and Social Network Analysis (SNA)
- Social Network Analysis with Gephi
- Applications of SNA

# References

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