Tamkang University
淡江大學

Tamkang University

Social Computing and Big Data Analytics
社群運算與大數據分析

Social Network Analysis
(社會網絡分析)

1042SCBDA12
MIS MBA (M2226) (8628)
Wed, 8,9, (15:10-17:00) (B309)

Min-Yuh Day
戴敏育
Assistant Professor
專任助理教授
Dept. of Information Management, Tamkang University
淡江大學 資訊管理學系
http://mail. tku.edu.tw/myday/

2016-05-18

課程大綱 (Syllabus)

週次 (Week)	日期 (Date)	內容 (Subject/Topics)
1	2016/02/17	Course Orientation for Social Computing and Big Data Analytics (社群運算與大數據分析課程介紹)
2	2016/02/24	Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data (資料科學與大數據分析： 探索、分析、視覺化與呈現資料)
3	2016/03/02	Fundamental Big Data: MapReduce Paradigm, Hadoop and Spark Ecosystem (大數據基礎：MapReduce典範、 Hadoop與Spark生態系統)

課程大綱 (Syllabus)

週次 (Week)	日期 (Date)	內容 (Subject/Topics)
4	2016/03/09	Big Data Processing Platforms with SMACK: Spark, Mesos, Akka, Cassandra and Kafka (大數據處理平台SMACK：Spark, Mesos, Akka, Cassandra, Kafka)
5	2016/03/16	Big Data Analytics with Numpy in Python (Python Numpy 大數據分析)
6	2016/03/23	Finance Big Data Analytics with Pandas in Python (Python Pandas 財務大數據分析)
7	2016/03/30	Text Mining Techniques and Natural Language Processing (文字探勘分析技術與自然語言處理)
8	2016/04/06	Off-campus study (教學行政觀摩日)

課程大綱 (Syllabus)

週次 (Week)	日期 (Date)	內容 (Subject/Topics)
9	2016/04/13	Social Media Marketing Analytics (社群媒體行銷分析)
10	2016/04/20	期中報告 (Midterm Project Report)
11	2016/04/27	Deep Learning with Theano and Keras in Python (Python Theano 和 Keras 深度學習)
12	2016/05/04	Deep Learning with Google TensorFlow (Google TensorFlow 深度學習)
13	2016/05/11	Sentiment Analysis on Social Media with Deep Learning (深度學習社群媒體情感分析)

課程大綱 (Syllabus)

週次 (Week)	日期 (Date)	內容 (Subject/Topics)
14	2016/05/18	Social Network Analysis (社會網絡分析)
15	2016/05/25	Measurements of Social Network (社會網絡量測)
16	2016/06/01	Tools of Social Network Analysis (社會網絡分析工具)
17	2016/06/08	Final Project Presentation I (期末報告 I)
18	2016/06/15	Final Project Presentation II (期末報告 II)

Social Computing

Social Network Analysis

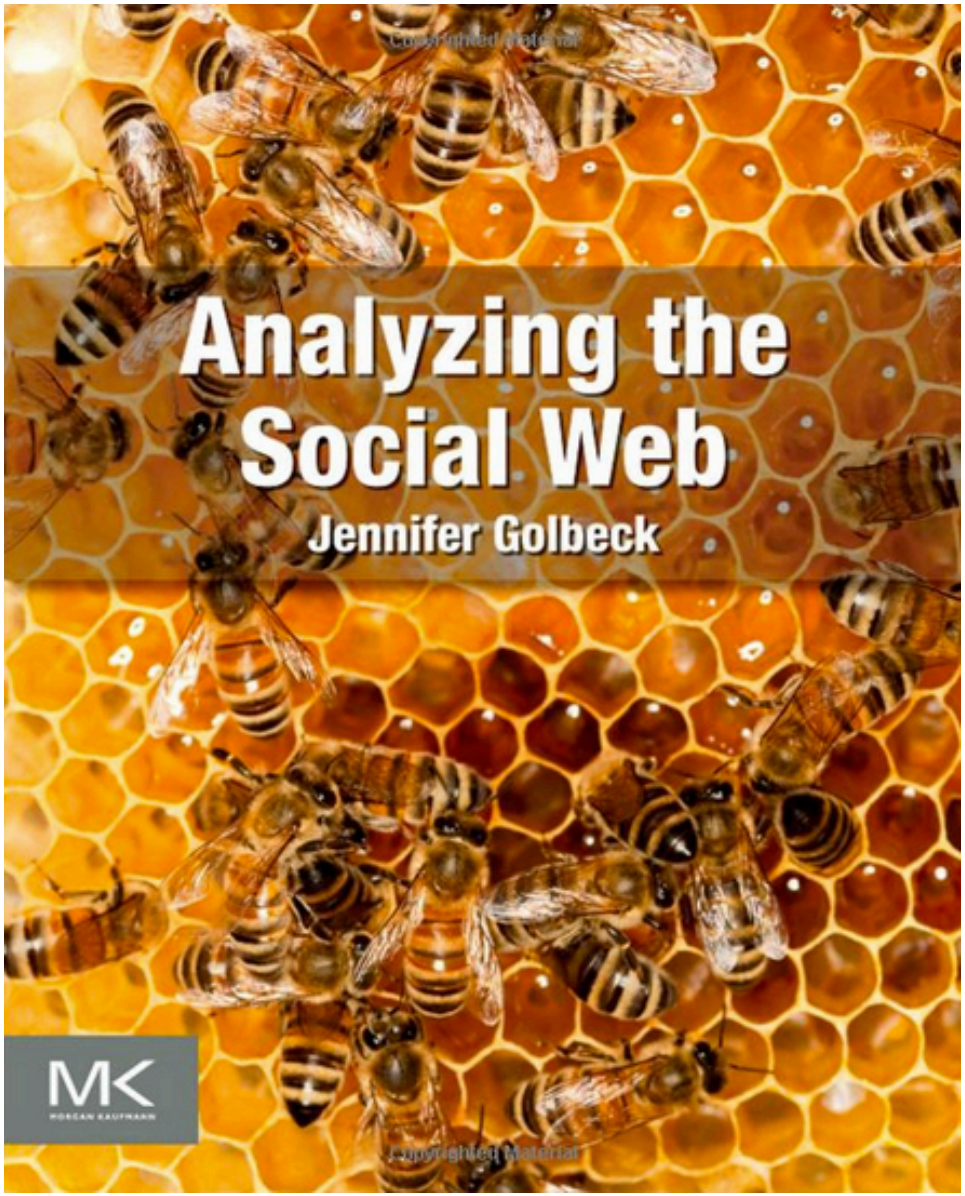
Social Computing

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

Business Insights with Social Analytics

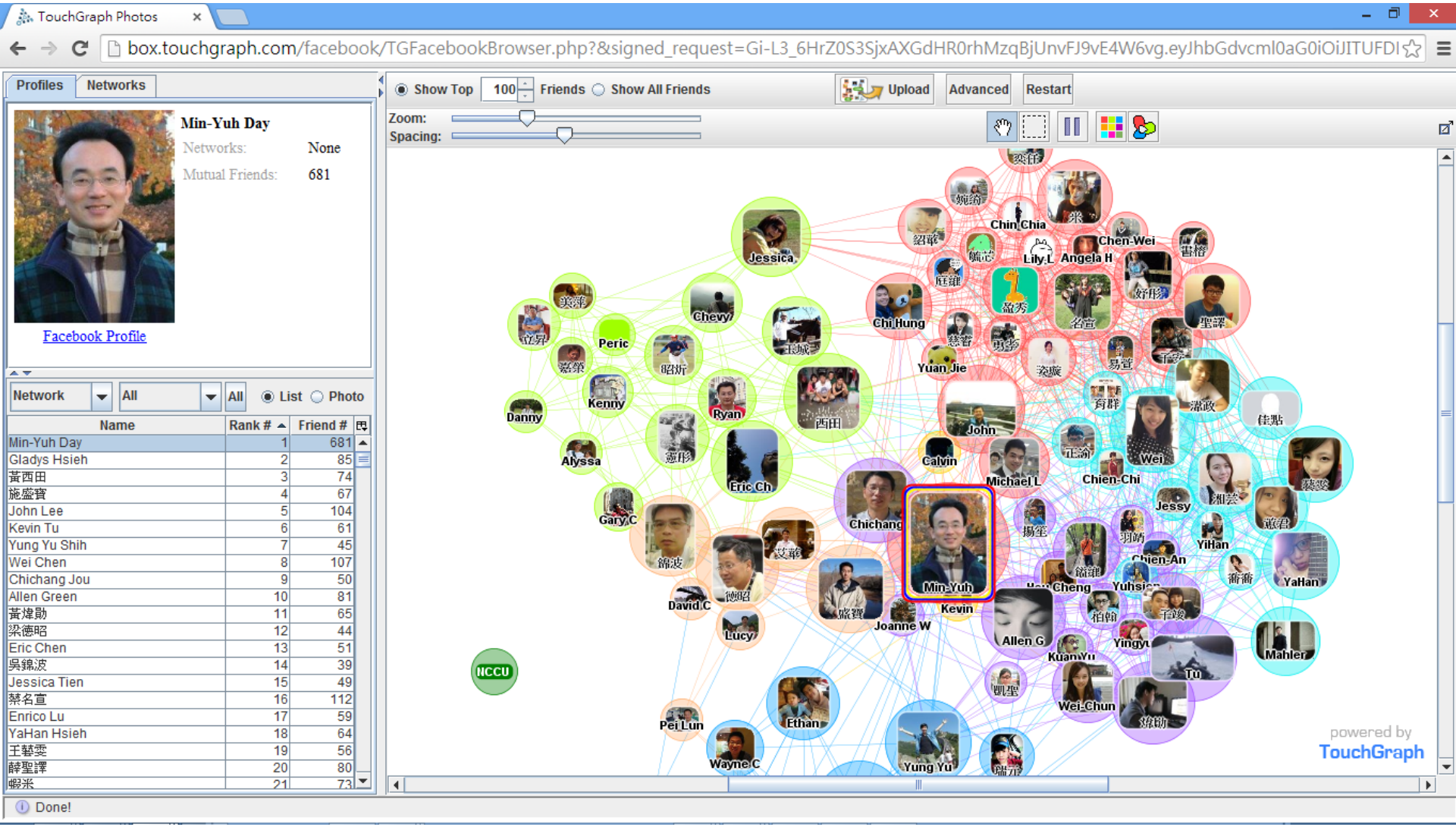
Analyzing the Social Web:
Social Network Analysis

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

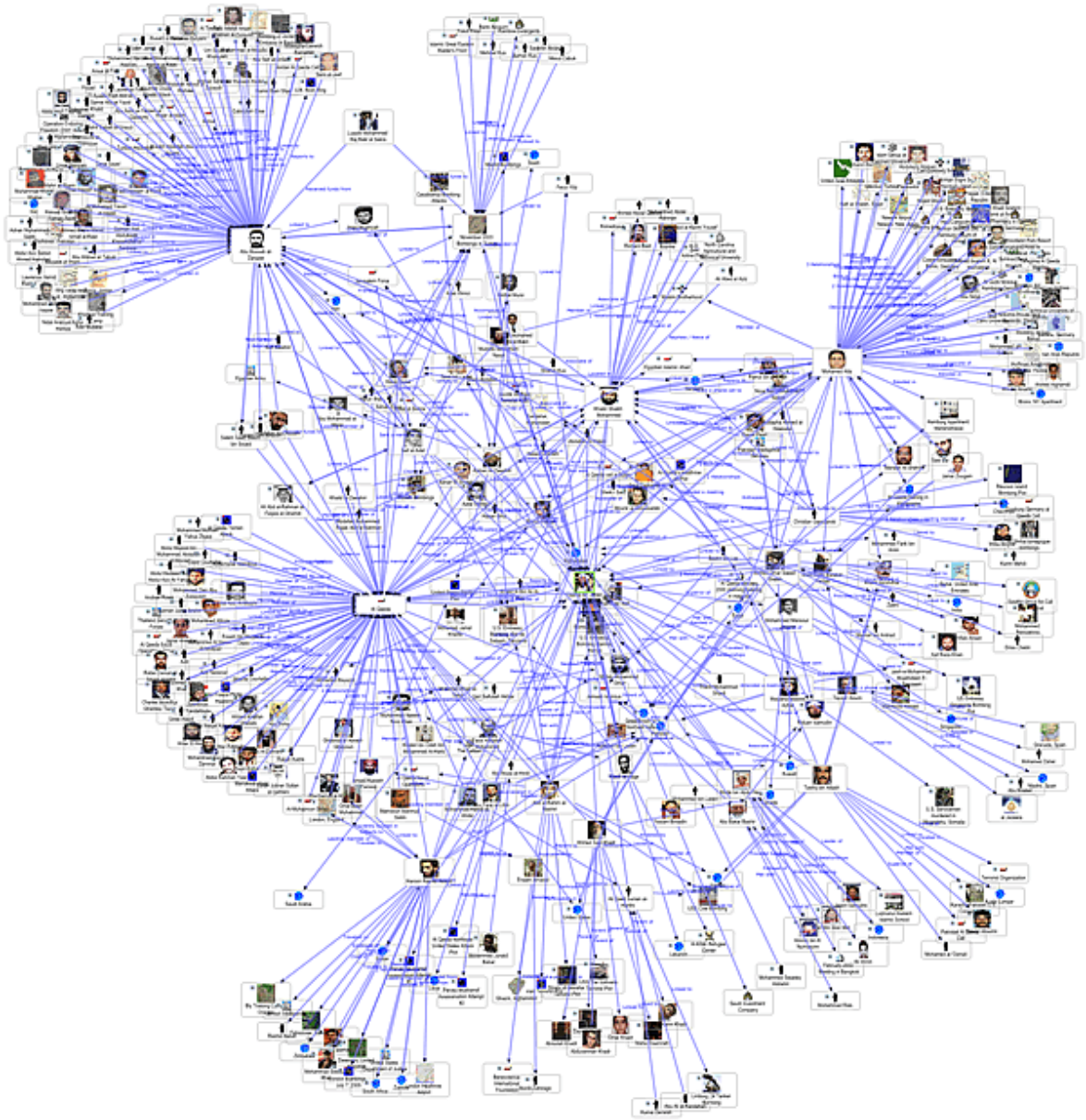


Source: http://www.amazon.com/Analyzing-Social-Web-Jennifer-Golbeck/dp/0124055311

Social Network Analysis (SNA)
Facebook TouchGraph



Social Network Analysis



Source: http://www.fmsasg.com/SocialNetworkAnalysis/

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

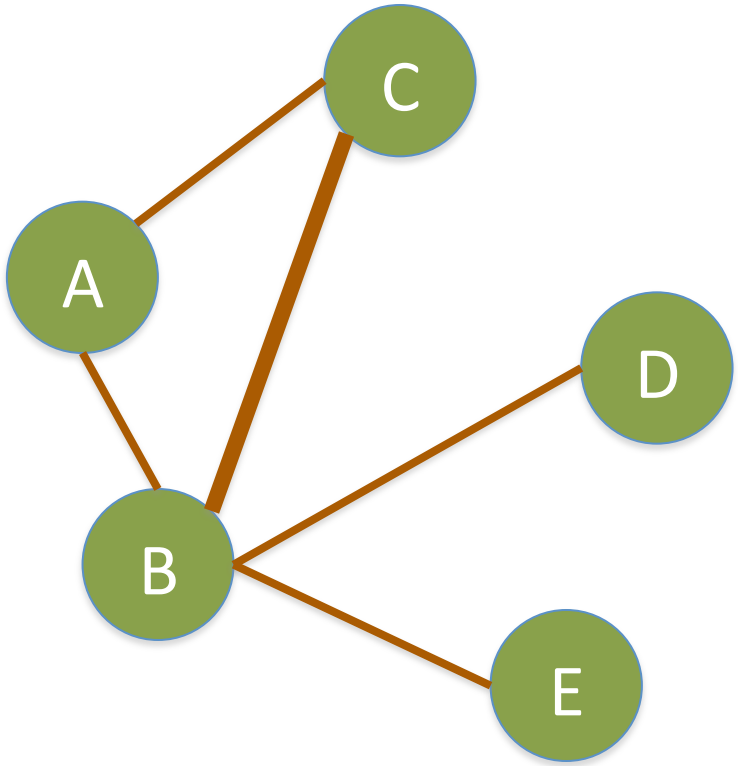
Social Network Analysis (SNA)

Centrality

Prestige

Graph Theory

Graph



Graph

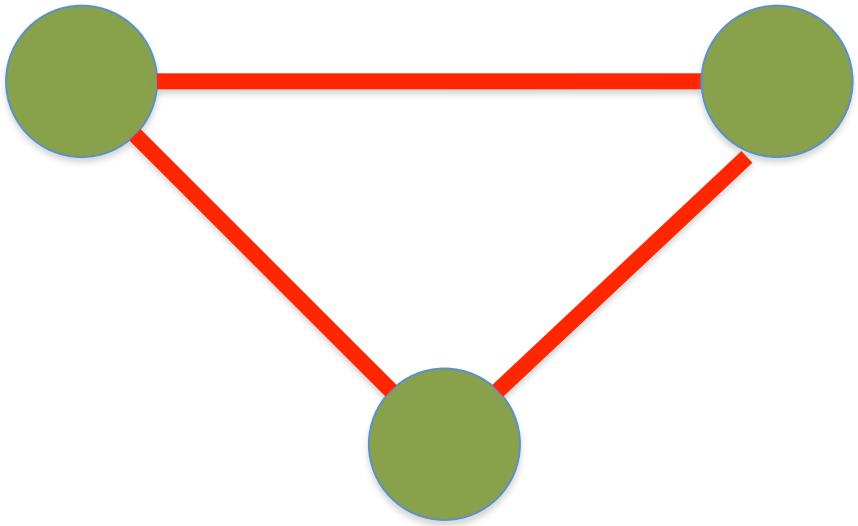
g = (V, E)

Vertex (Node)

Vertices (Nodes)

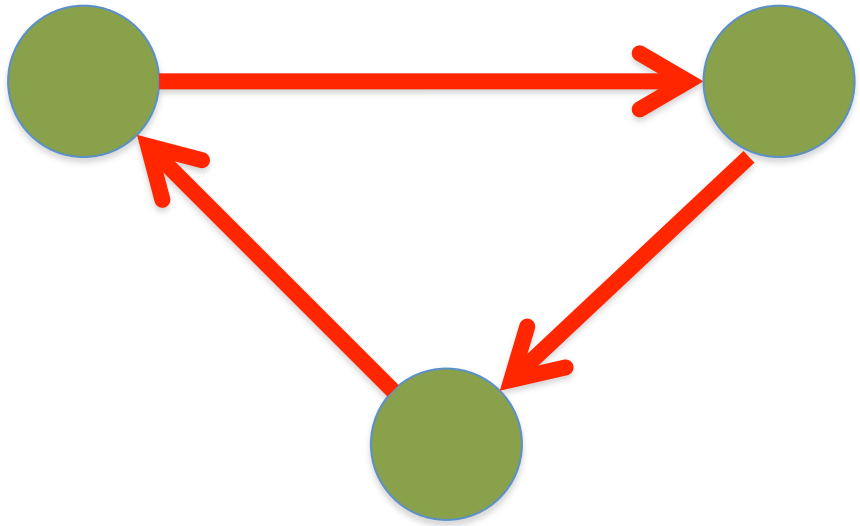
Edge

Edges

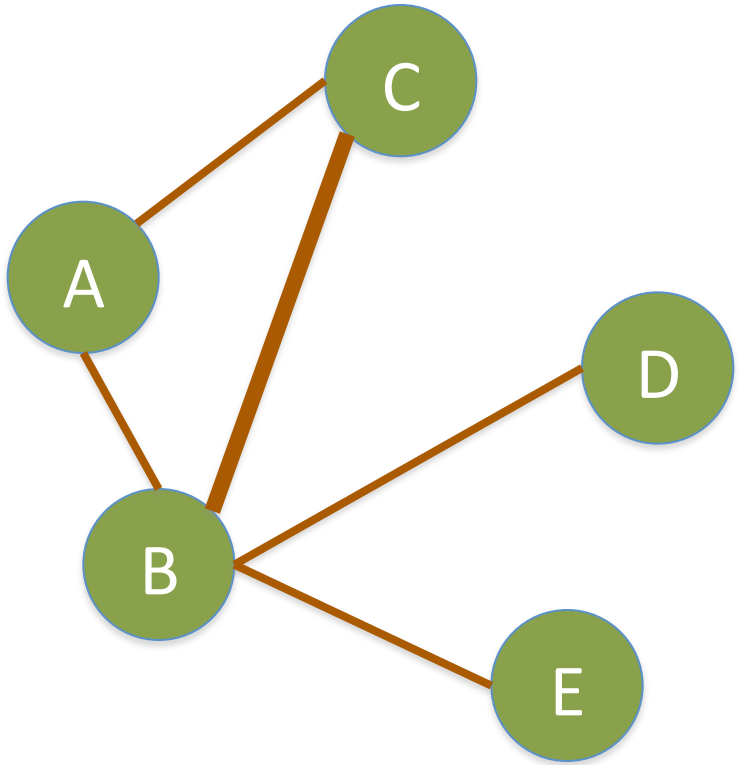


Arc

Arcs

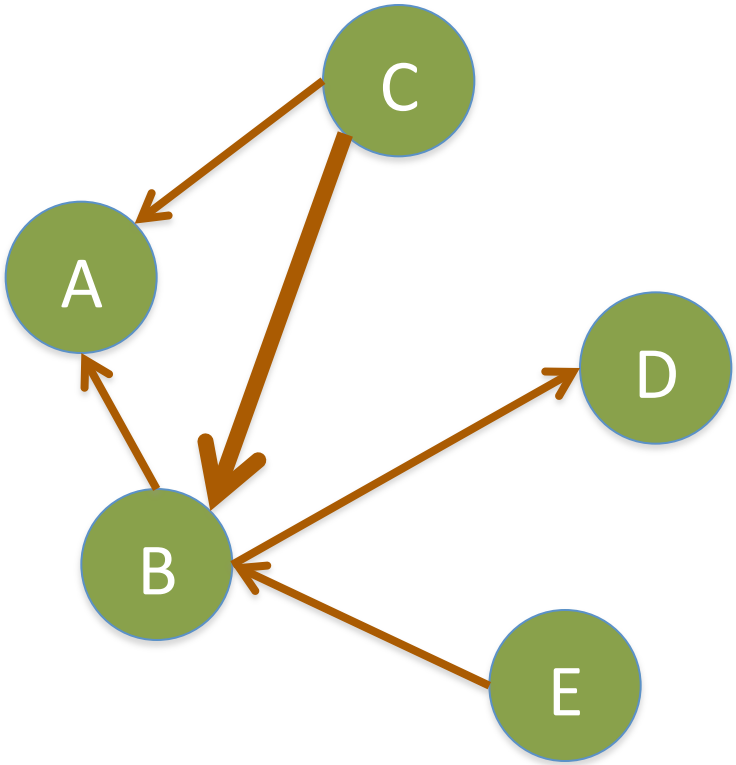


Undirected Graph



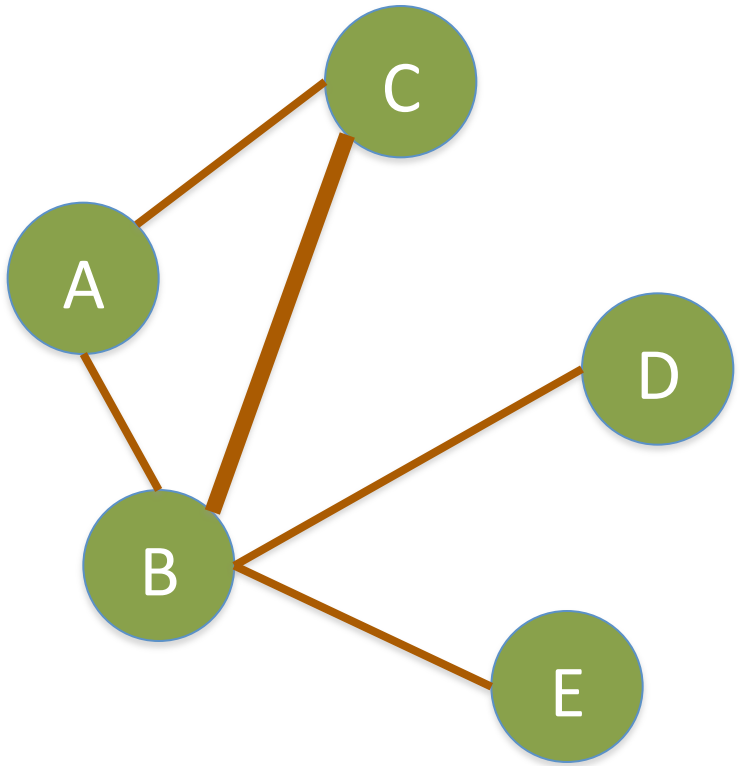
Source: https://www.youtube.com/watch?v=89mxOdwPfxA

Directed Graph



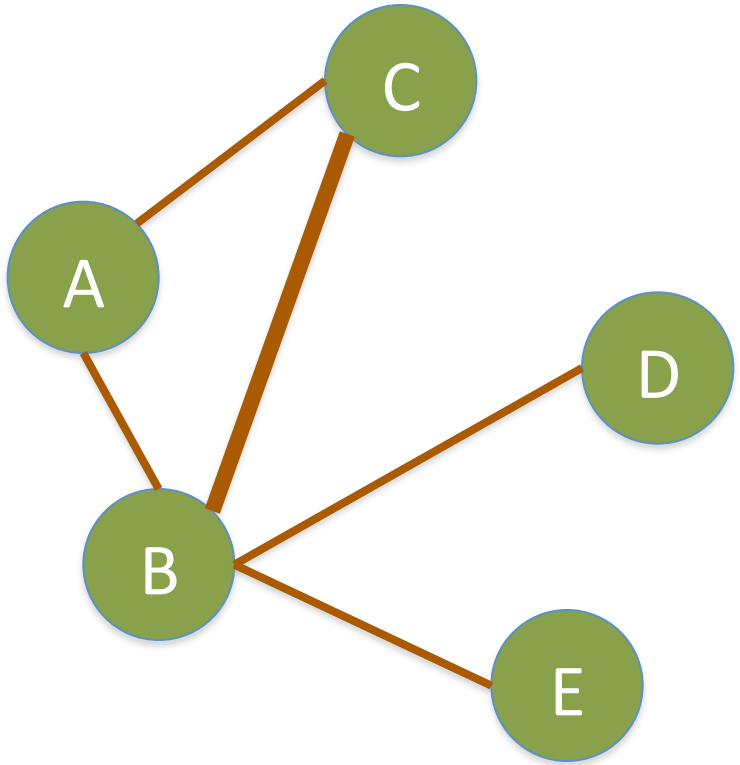
Source: https://www.youtube.com/watch?v=89mxOdwPfxA

Degree



Source: https://www.youtube.com/watch?v=89mxOdwPfxA

Degree



A: 2

B: 4

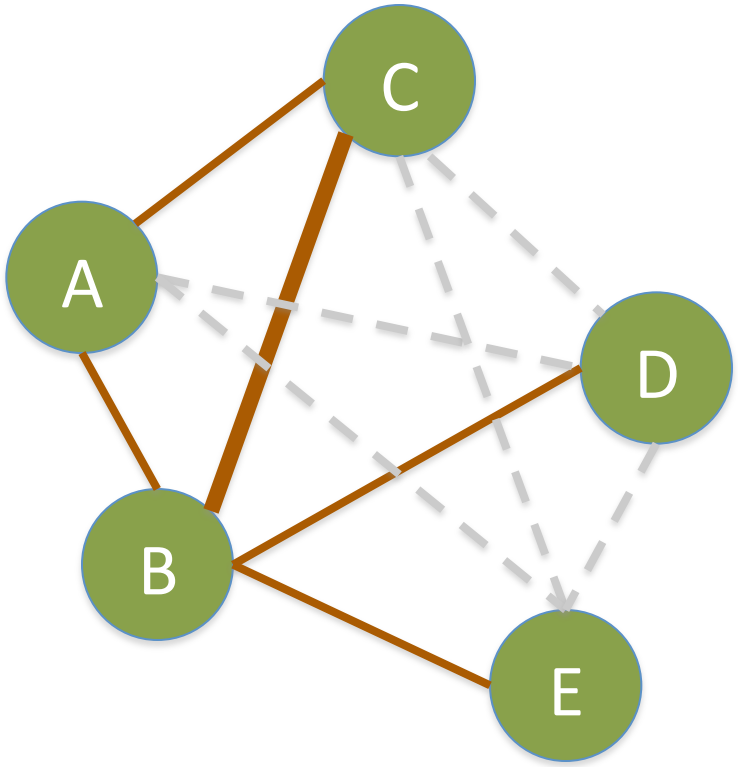
C: 2

D:1

E: 1

Source: https://www.youtube.com/watch?v=89mxOdwPfxA

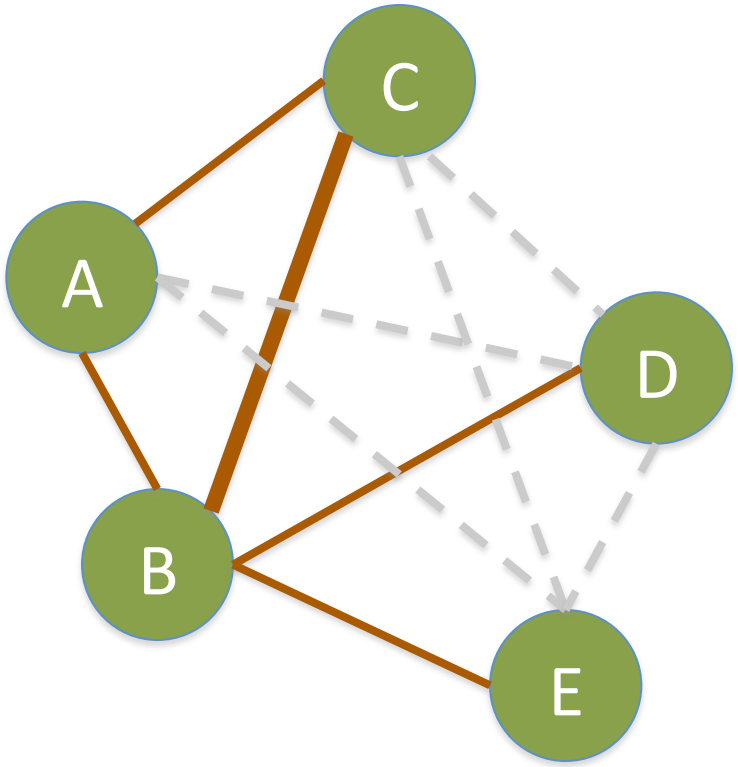
Density



Source: https://www.youtube.com/watch?v=89mxOdwPfxA

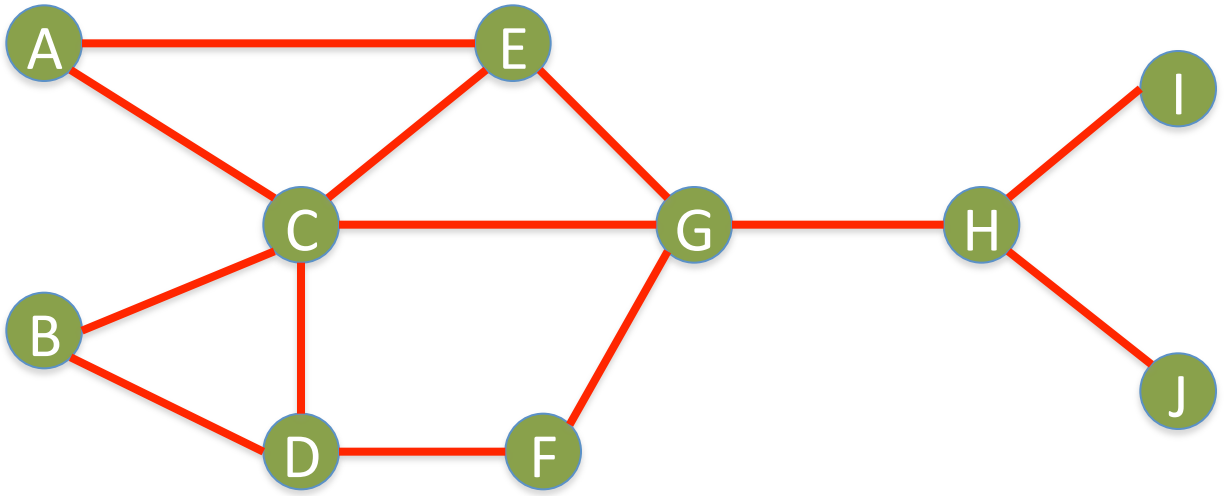
Density

Edges (Links): 5
Total Possible Edges: 10
Density: 5/10 = 0.5



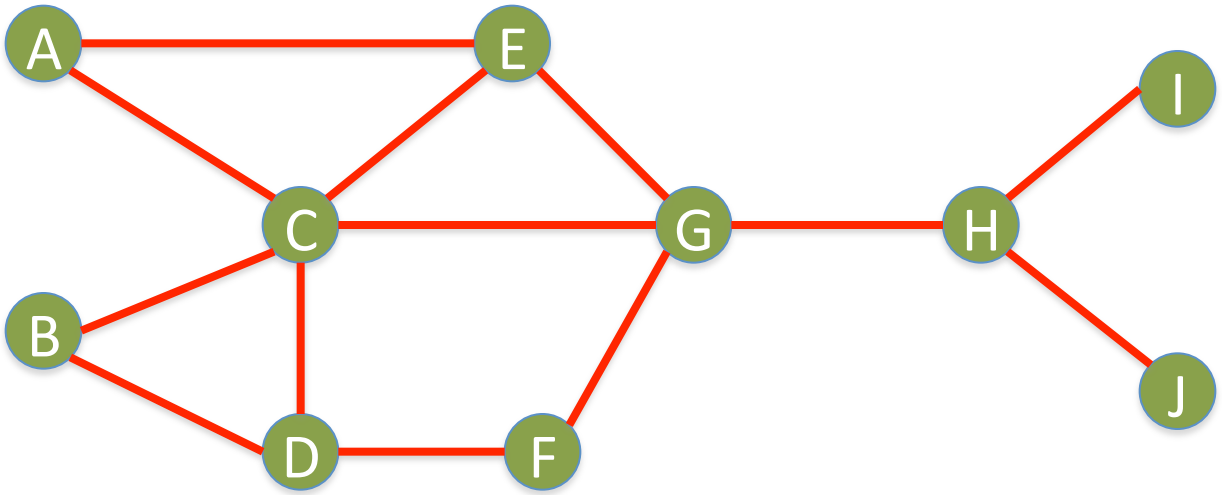
Source: https://www.youtube.com/watch?v=89mxOdwPfxA

Density



Nodes (n): 10
Edges (Links): 13
Total Possible Edges: (n * (n-1)) / 2 = (10 * 9) / 2 = 45
Density: 13/45 = 0.29

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.

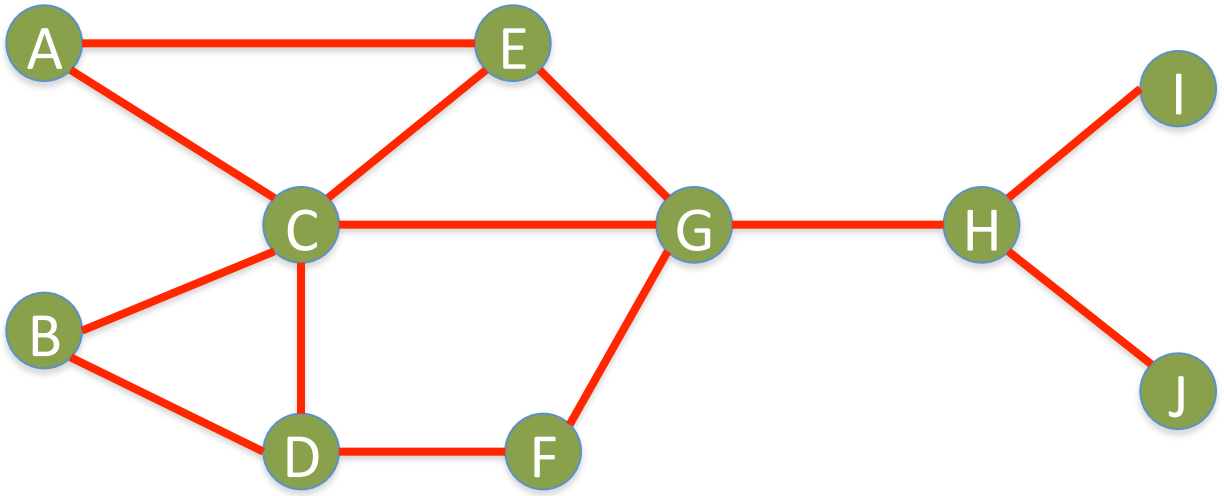
Source: Bing Liu (2011) , "Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data"

Social Network Analysis (SNA)

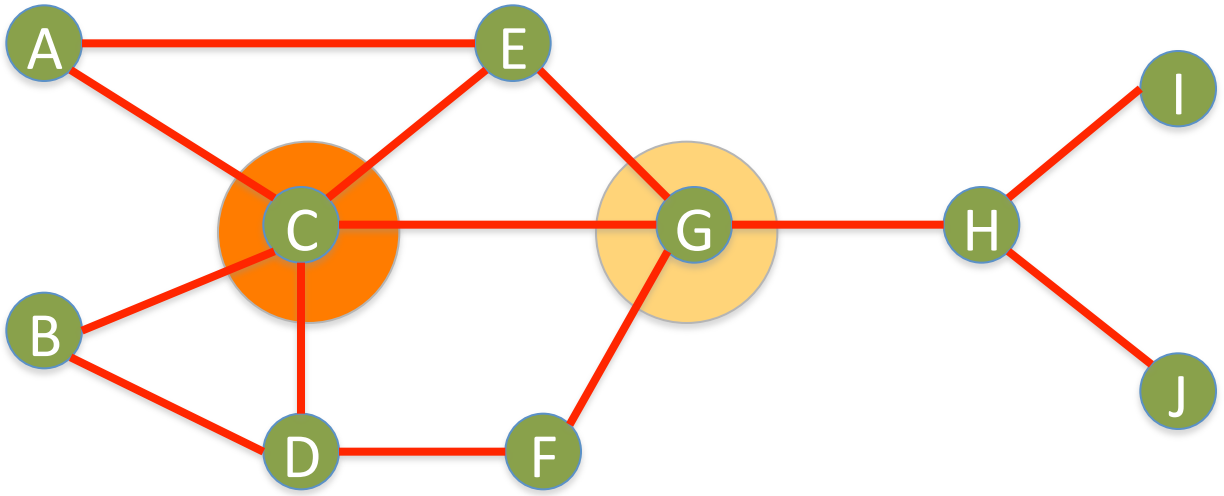
- Degree Centrality
- Betweenness Centrality
- Closeness Centrality

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	**5**	**5/10 = 0.5**
D	3	3/10 = 0.3
E	3	3/10 = 0.3
F	2	2/10 = 0.2
G	**4**	**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.

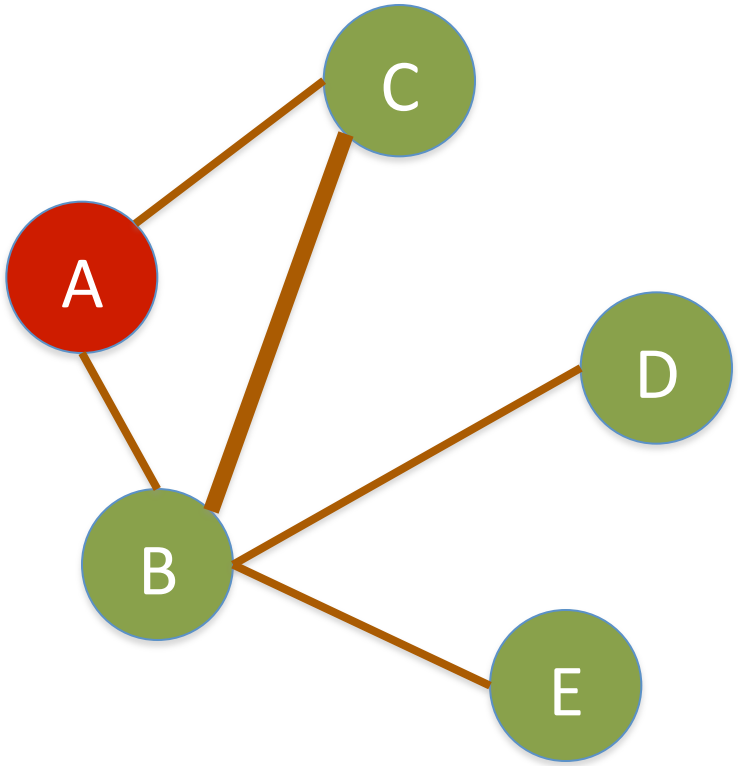
Normalized Betweenness Centrality

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

Number of pairs of vertices excluding the vertex itself

Source: https://www.youtube.com/watch?v=RXohUeNCJiU

Betweenness Centrality

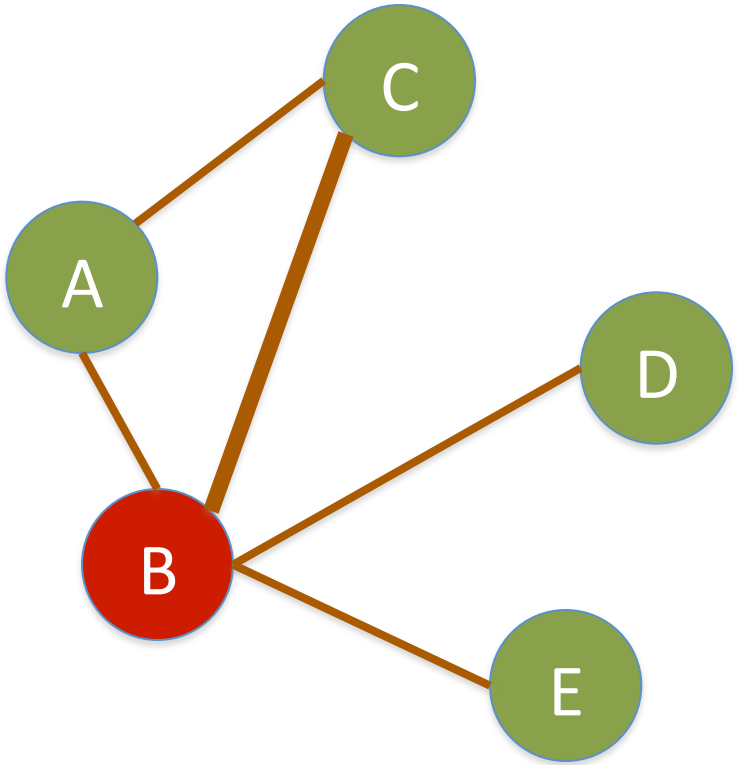


A:
B→C: 0/1 = 0
B→D: 0/1 = 0
B→E: 0/1 = 0
C→D: 0/1 = 0
C→E: 0/1 = 0
D→E: 0/1 = 0

Total: 0

A: Betweenness Centrality = 0

Betweenness Centrality

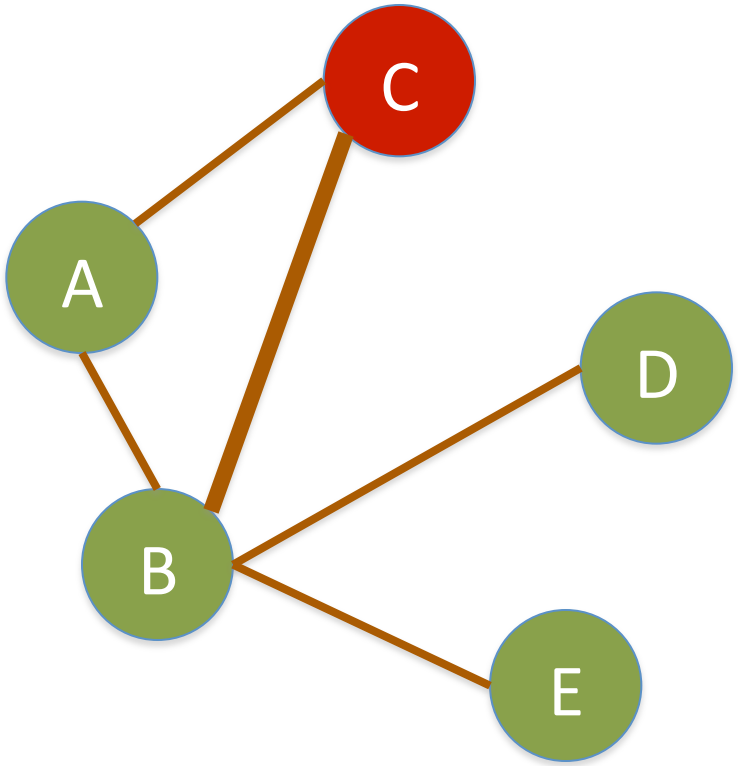


B:
A→C: 0/1 = 0
A→D: 1/1 = 1
A→E: 1/1 = 1
C→D: 1/1 = 1
C→E: 1/1 = 1
D→E: 1/1 = 1

Total: 5

B: Betweenness Centrality = 5

Betweenness Centrality

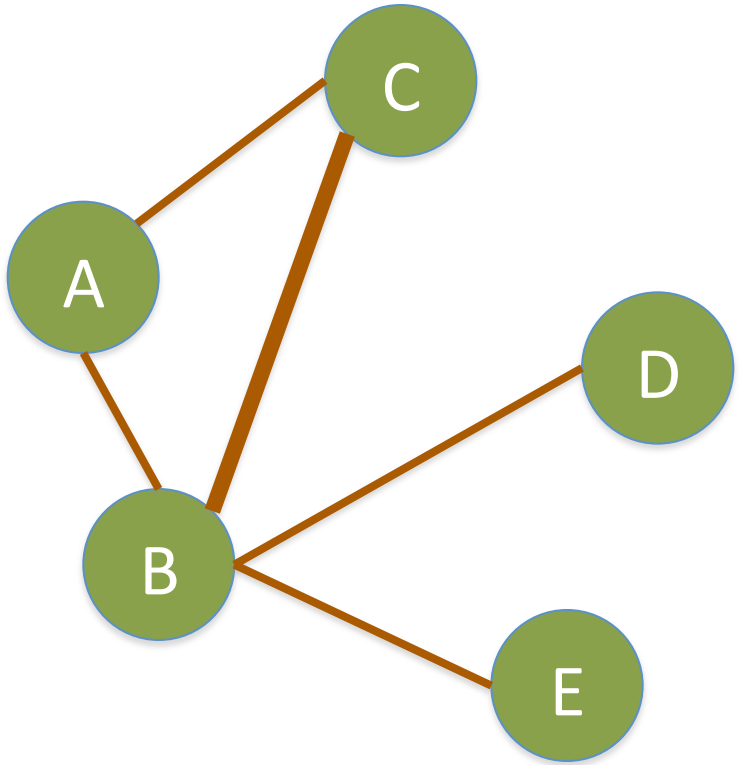


C:
A→B: 0/1 = 0
A→D: 0/1 = 0
A→E: 0/1 = 0
B→D: 0/1 = 0
B→E: 0/1 = 0
D→E: 0/1 = 0

Total: 0

C: Betweenness Centrality = 0

Betweenness Centrality



A: 0

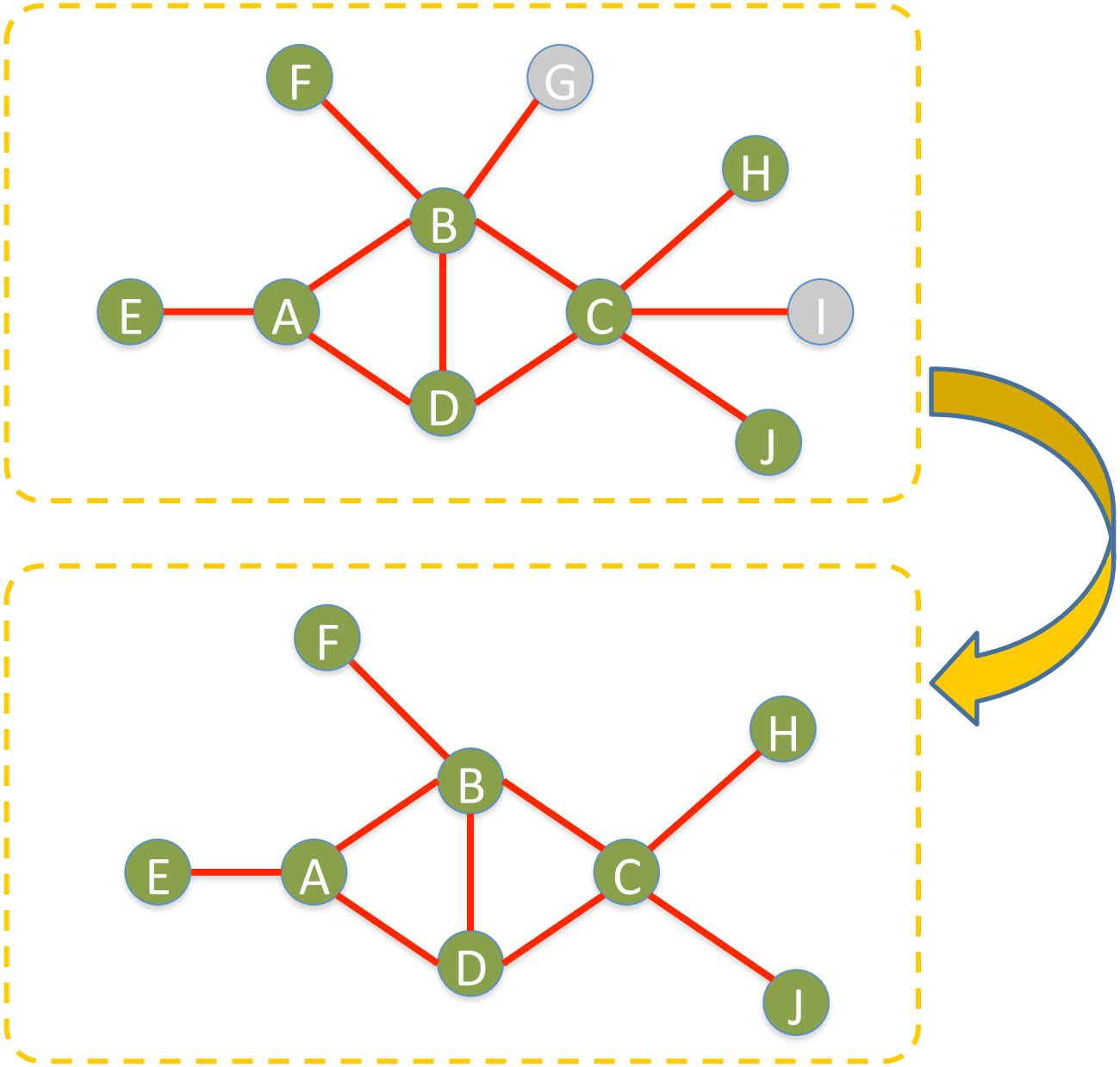
B: 5

C: 0

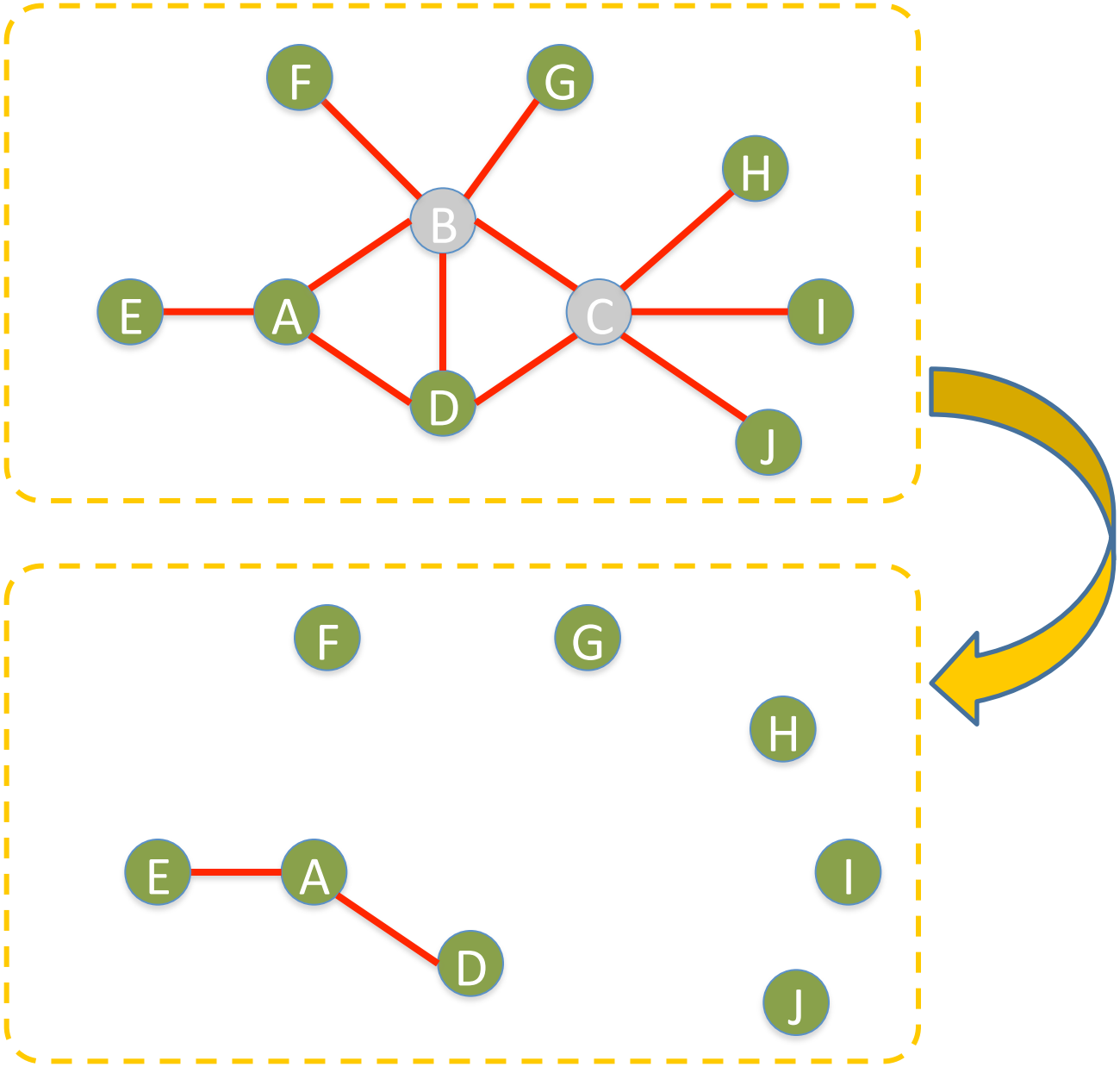
D: 0

E: 0

Which Node is Most Important?

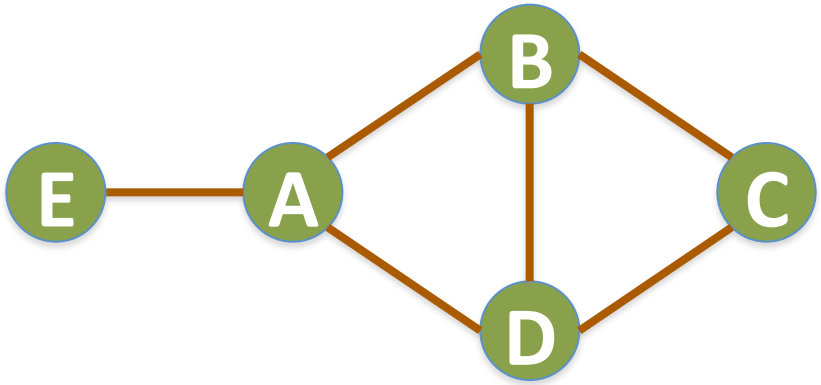


Which Node is Most Important?

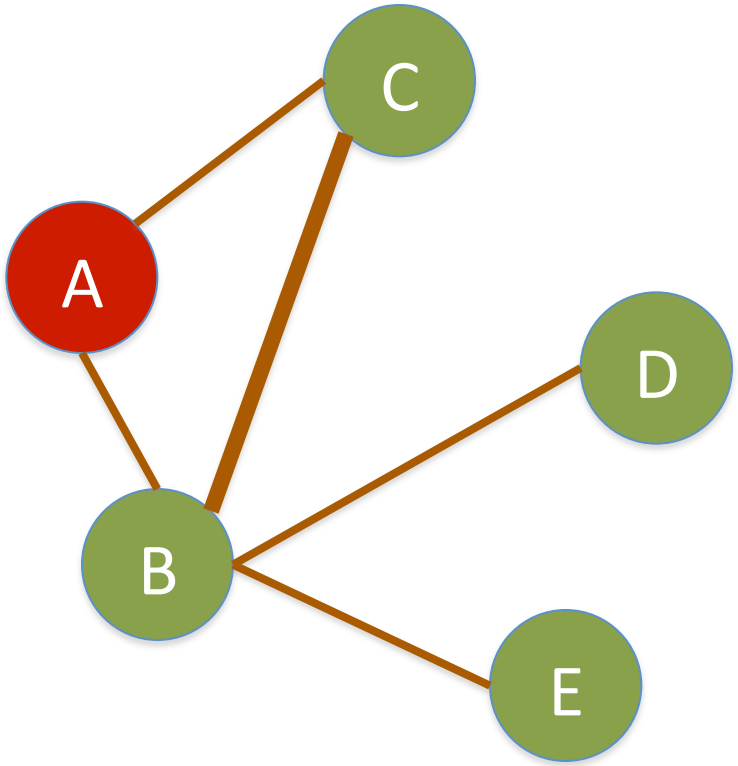


Betweenness Centrality

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



Betweenness Centrality



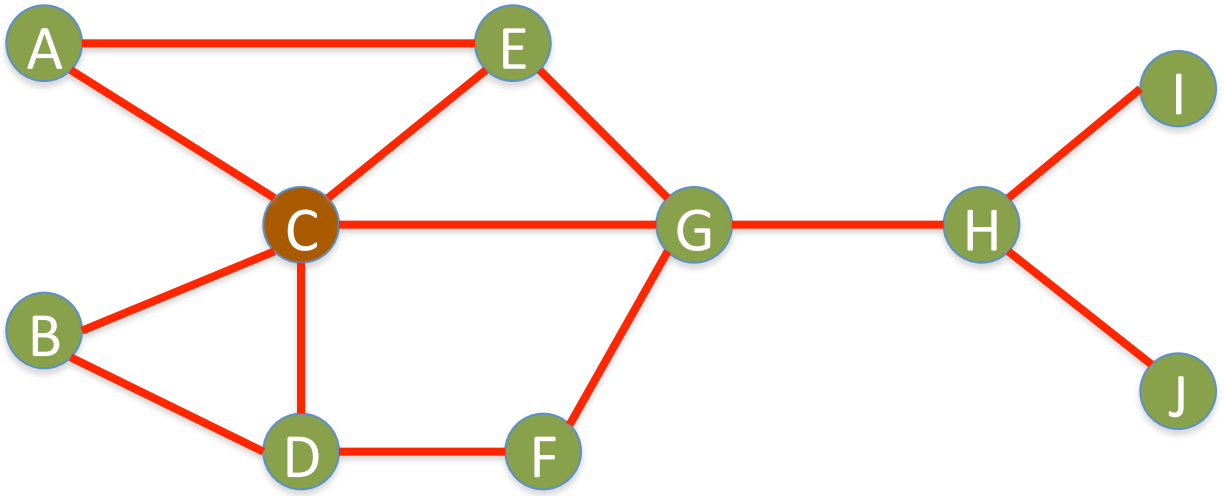
A:
B→C: 0/1 = 0
B→D: 0/1 = 0
B→E: 0/1 = 0
C→D: 0/1 = 0
C→E: 0/1 = 0
D→E: 0/1 = 0

Total: 0

A: Betweenness Centrality = 0

Closeness Centrality

Social Network Analysis: Closeness Centrality

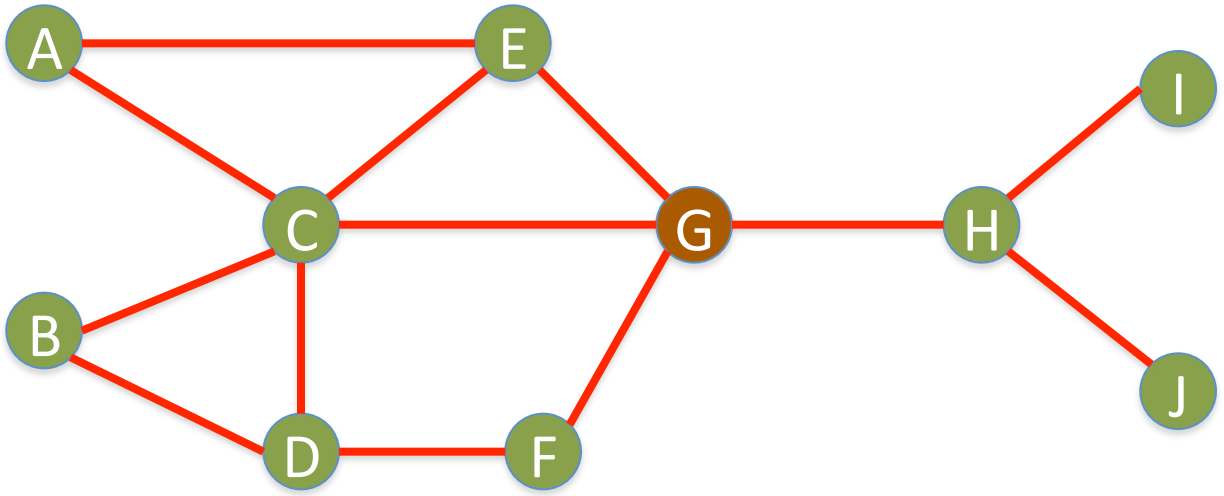


C→A: 1
C→B: 1
C→D: 1
C→E: 1
C→F: 2
C→G: 1
C→H: 2
C→I: 3
C→J: 3

Total=15

C: Closeness Centrality = 15/9 = 1.67

Social Network Analysis: Closeness Centrality

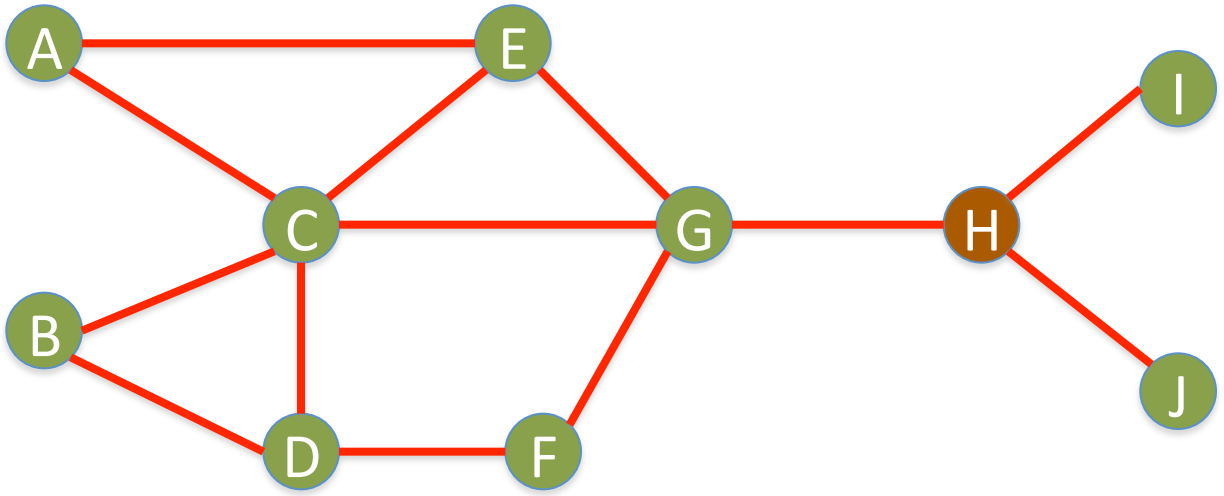


G→A: 2
G→B: 2
G→C: 1
G→D: 2
G→E: 1
G→F: 1
G→H: 1
G→I: 2
G→J: 2

Total=14

G: Closeness Centrality = 14/9 = 1.56

Social Network Analysis: Closeness Centrality

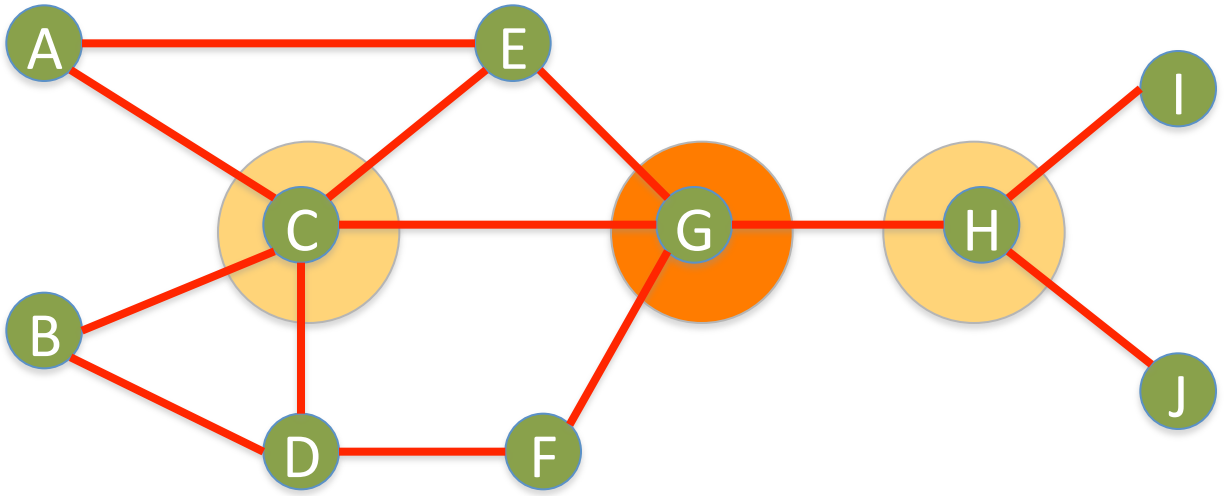


H→A: 3
H→B: 3
H→C: 2
H→D: 2
H→E: 2
H→F: 2
H→G: 1
H→I: 1
H→J: 1

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

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.

Source: Abbasi, A., Hossain, L., & Leydesdorff, L. (2012). Betweenness centrality as a driver of preferential attachment in the evolution of research collaboration networks. *Journal of Informetrics*, *6*(3), 403-412.

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

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

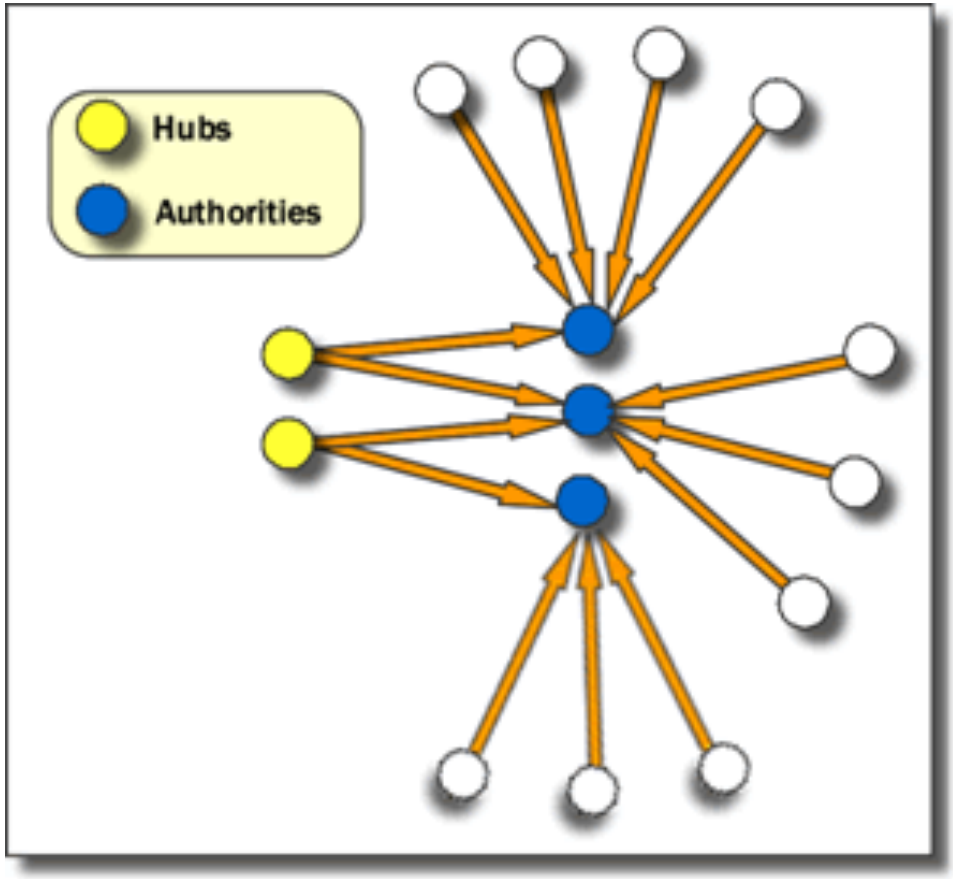
Social Networks, 1 (1978/79) 215–239

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.

Source: http://www.fmsasg.com/SocialNetworkAnalysis/

Application of SNA

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"

Example of SNA Data Source

dblp
computer science bibliography

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: **Precisiation 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

Source: http://www.informatik.uni-trier.de/~ley/db/conf/iri/iri2010.html

Research Question

- RQ1: What are the scientific collaboration patterns in the IRI research community?

- RQ2: Who are the prominent researchers in the IRI community?

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

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.

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

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

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

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

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 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 betweeness 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

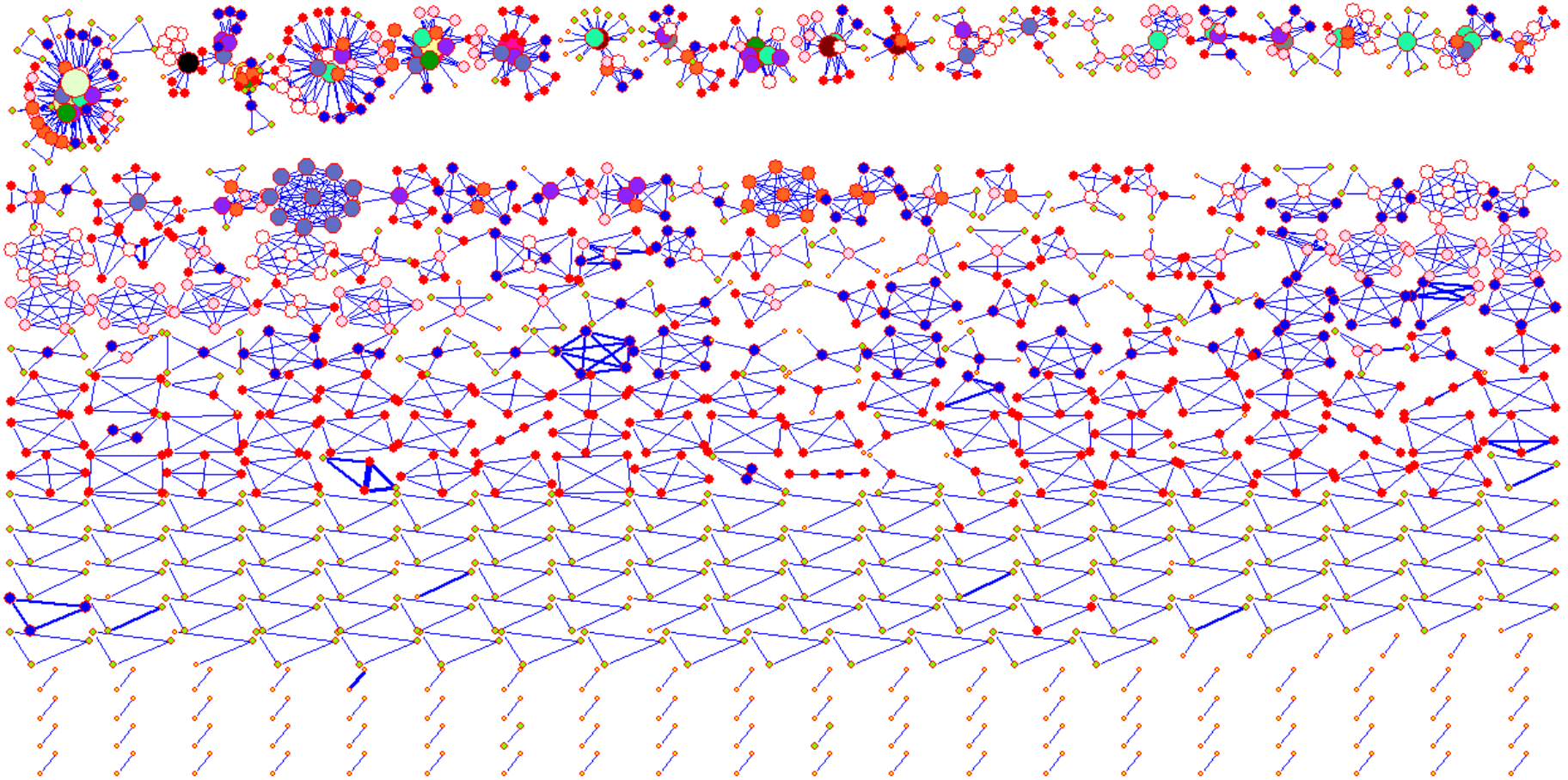
Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

Top 20 authors with the highest degree scores

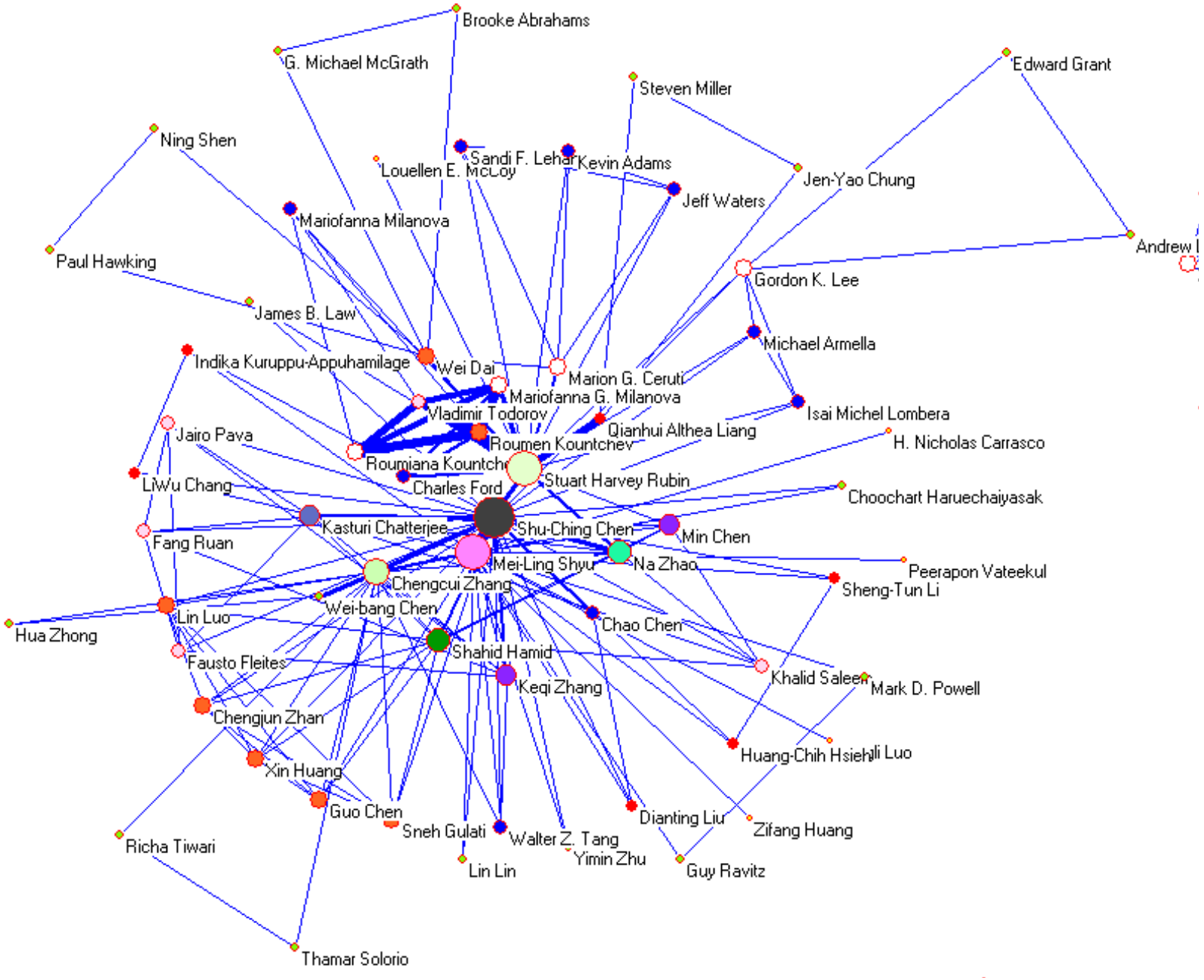
Rank	ID	Degree	Author
1	3	0.035044	Shu-Ching Chen
2	1	0.034418	Stuart Harvey Rubin
3	2	0.030663	Taghi M. Khoshgoftaar
4	6	0.028786	Reda Alhajj
5	8	0.028786	Wen-Lian Hsu
6	10	0.024406	Min-Yuh Day
7	4	0.022528	Mei-Ling Shyu
8	17	0.021277	Richard Tzong-Han Tsai
9	14	0.017522	Eduardo Santana de Almeida
10	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

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

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

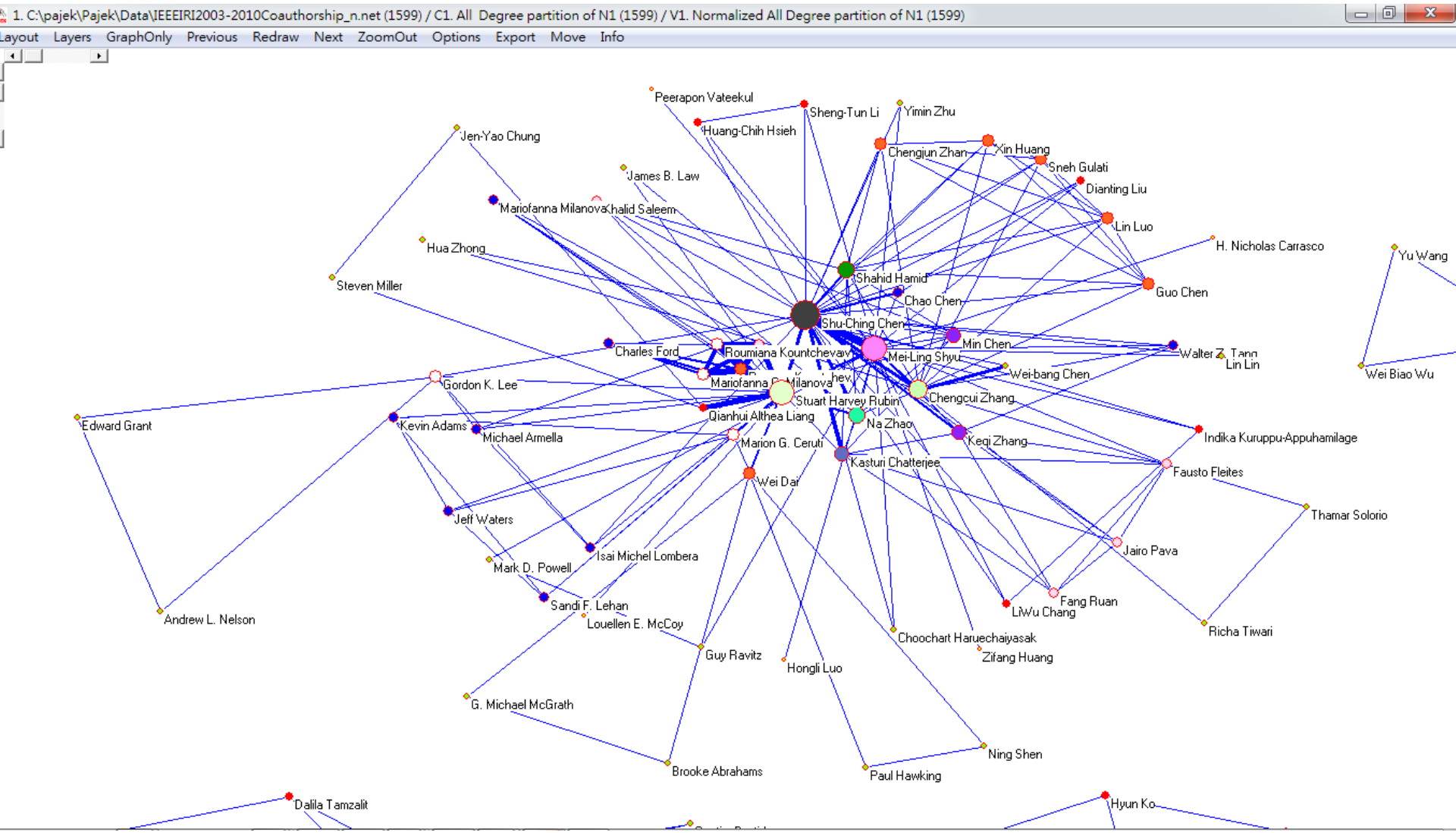


Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"



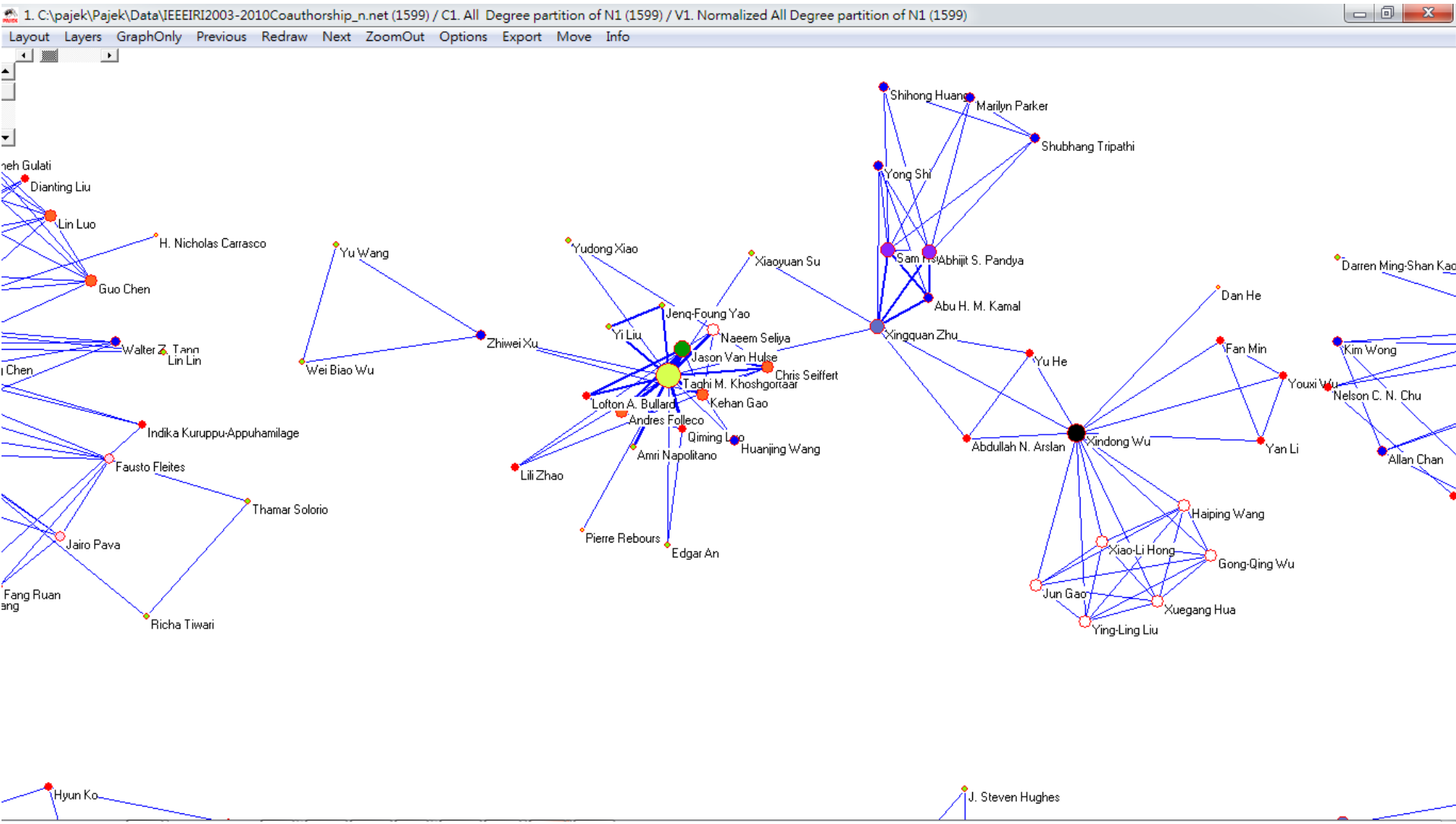
Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

Visualization of Social Network Analysis



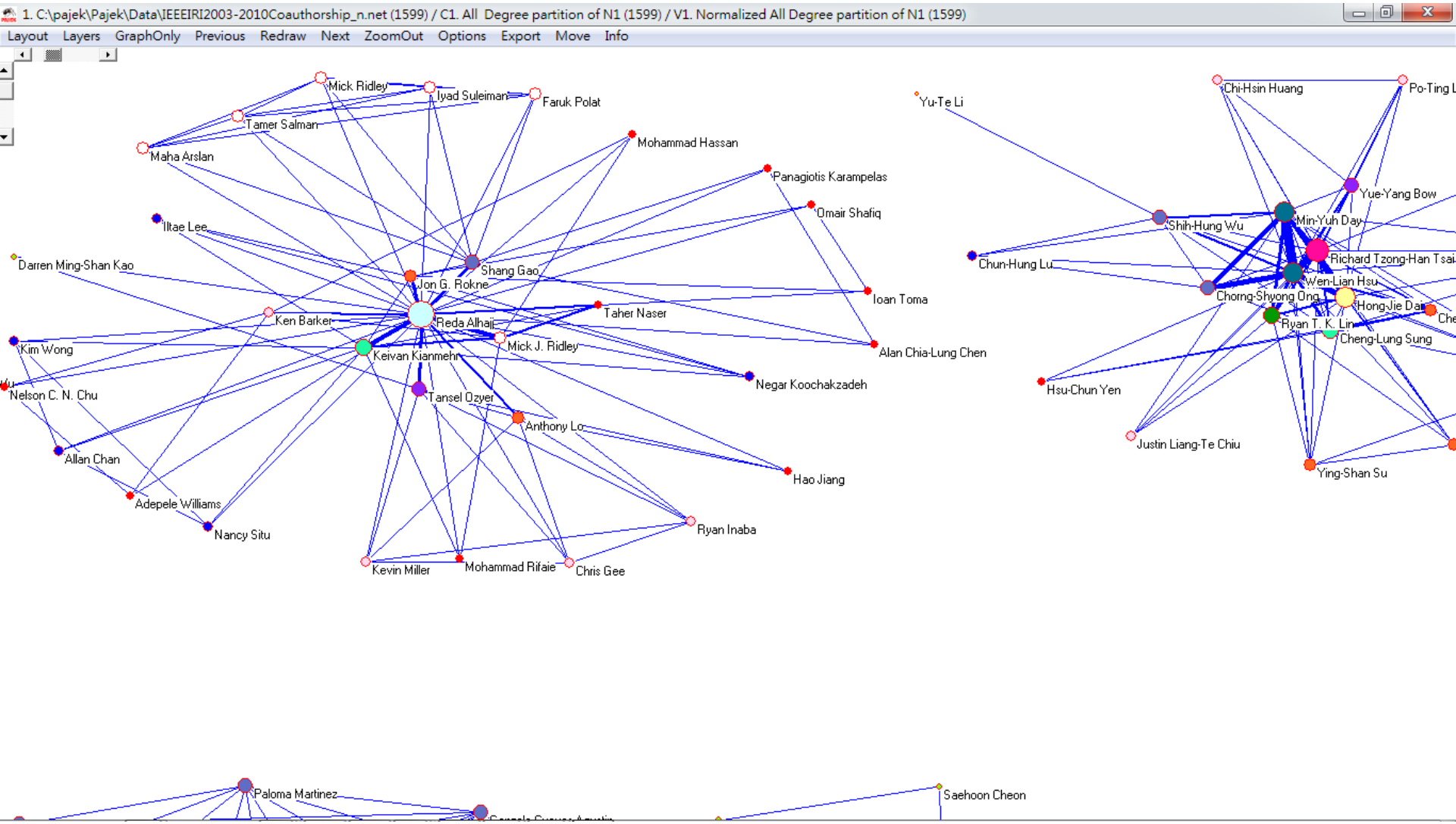
Source: Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011),
"Social Network Analysis of Research Collaboration in Information Reuse and Integration"

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"

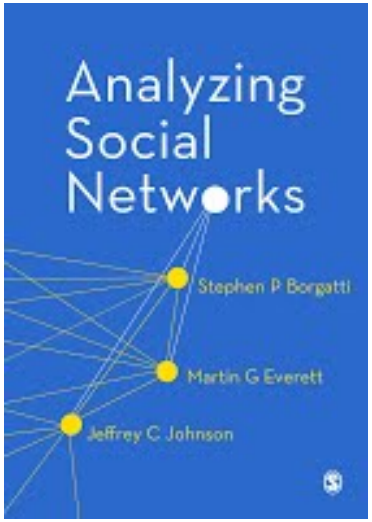
Visualization of Social Network Analysis



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

Social Network Analysis (SNA) Tools

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



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%

Contact

Mailing list
Issue tracker

https://networkx.github.io/

igraph

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

Recent news

R/igraph 1.0.0

June 24, 2015

Release Notes

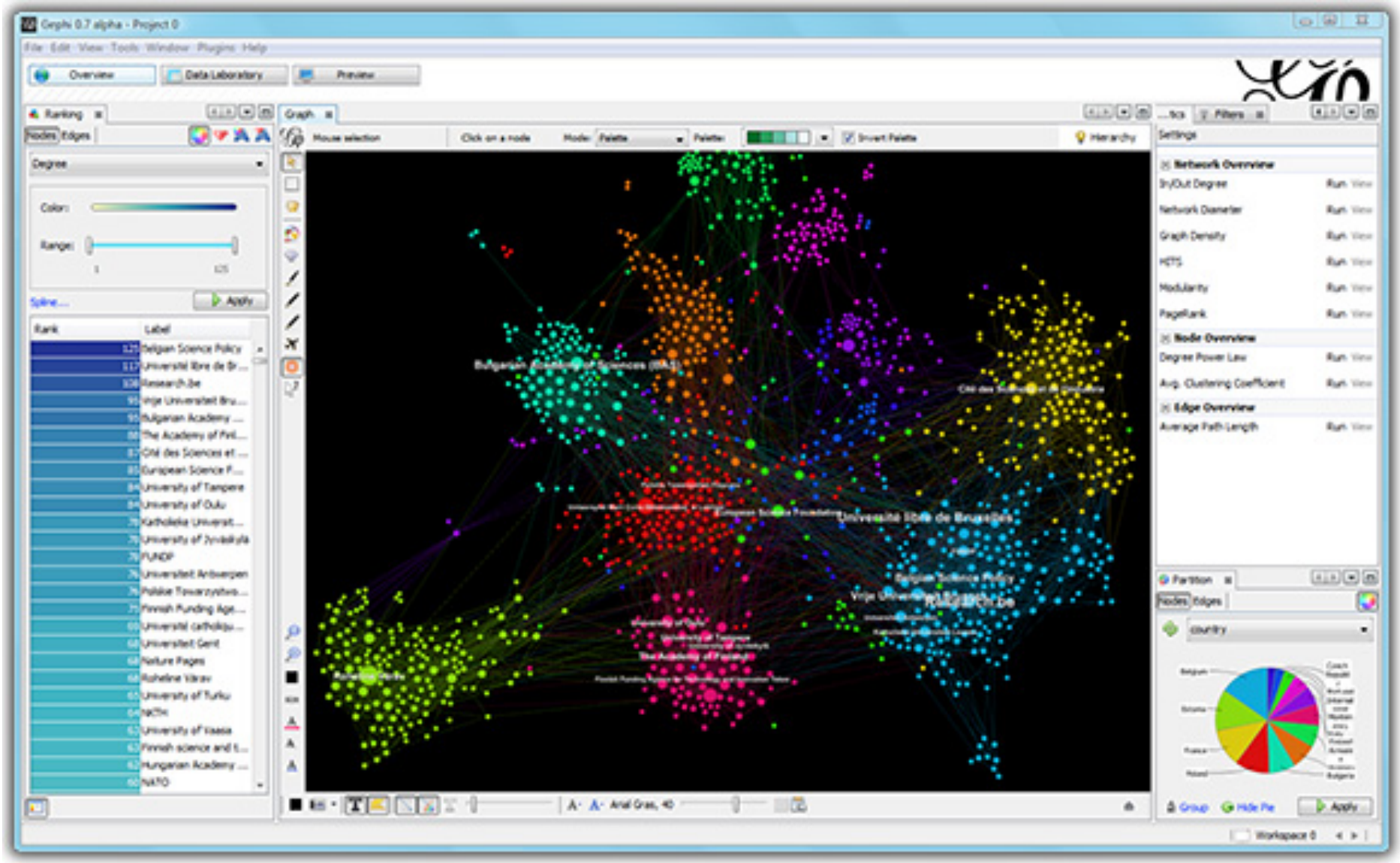
This is a new major release, with a lot of UI changes. We tried to make it easier to

http://igraph.org/

Gephi
makes graphs handy

Gephi

The Open Graph Viz Platform



Source: https://gephi.org/

SNA Tool: UCINet

https://sites.google.com/site/ucinetsoftware/home

UCINET Software

Search this site

Home | Download | Versions | FAQs & Tips | Buy!

Navigation

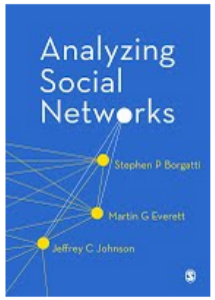
- Home
- Datasets
- Download
- History
- How to Use
  - QuickStart guide
  - Users group
  - FAQs & Tips
  - Tutorials
  - Spanish Resources
  - Workshops
  - More ...
- Purchasing
  - Info
  - Buy now
  - Trial Version
- Versions
  - Recent
  - Jan 2012 only
  - 2011 and before
  - Fix List

Links

- Analytic Technologies
  - NetDraw
  - E-Net
- LINKS Center

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.**

For customer support (e.g., ordering info, billing etc) contact roberta@analytictech.com. For tech support join the users group or contact support@analytictech.com. We prefer you try the users group first since the answer to your question may benefit others.

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

Problem with NetDraw The current UCINET installation package includes NetDraw version 2.141. Unfortunately, this version of NetDraw has a problem reading UCINET system files, and we are temporarily unable to update the ...
Posted Dec 12, 2014, 1:22 PM by Steve Borgatti

Showing posts **1** - **1** of **7**.
View more »

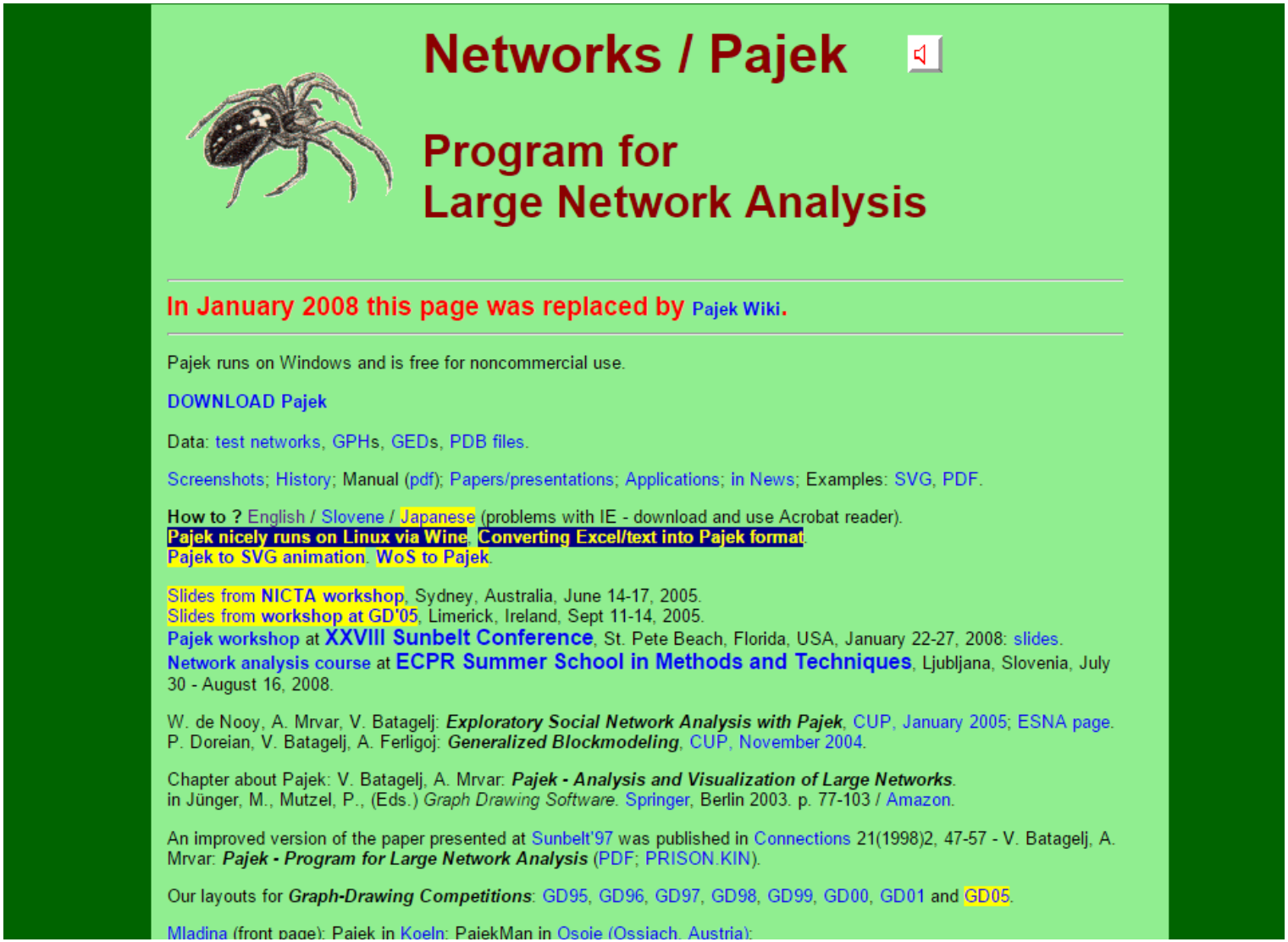
Current Version

Version 6.538 | 12 Dec 2014 This version replaces the old "spreadsheet editor" with a new "matrix editor",

/sites.google.com/site/ucinetsoftware/

SNA Tool: Pajek

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

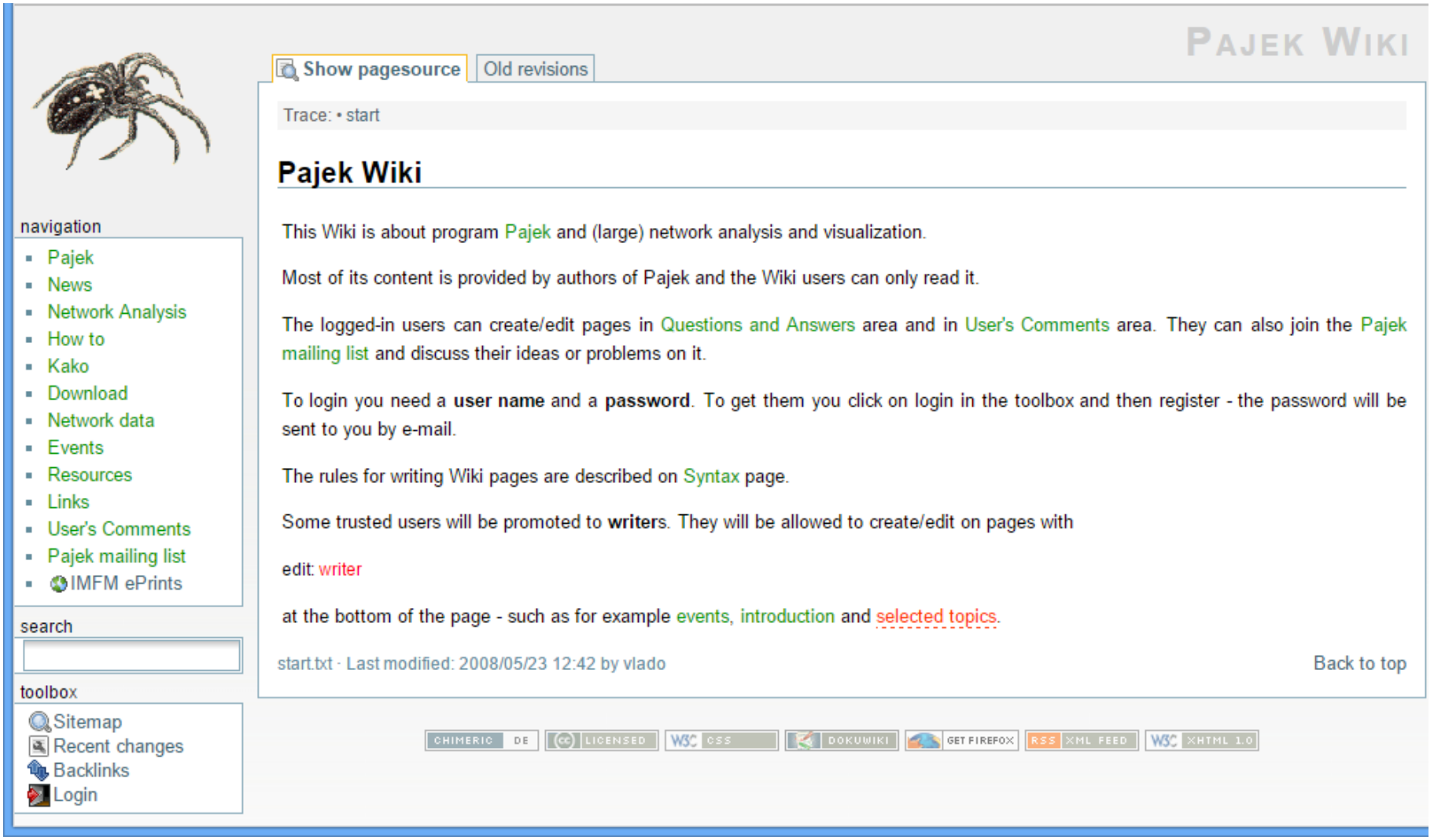
An improved version of the paper presented at Sunbelt'97 was published in Connections 21(1998)2, 47-57 - V. Batagelj, A. Mrvar: ***Pajek - Program for Large Network Analysis*** (PDF; PRISON.KIN).

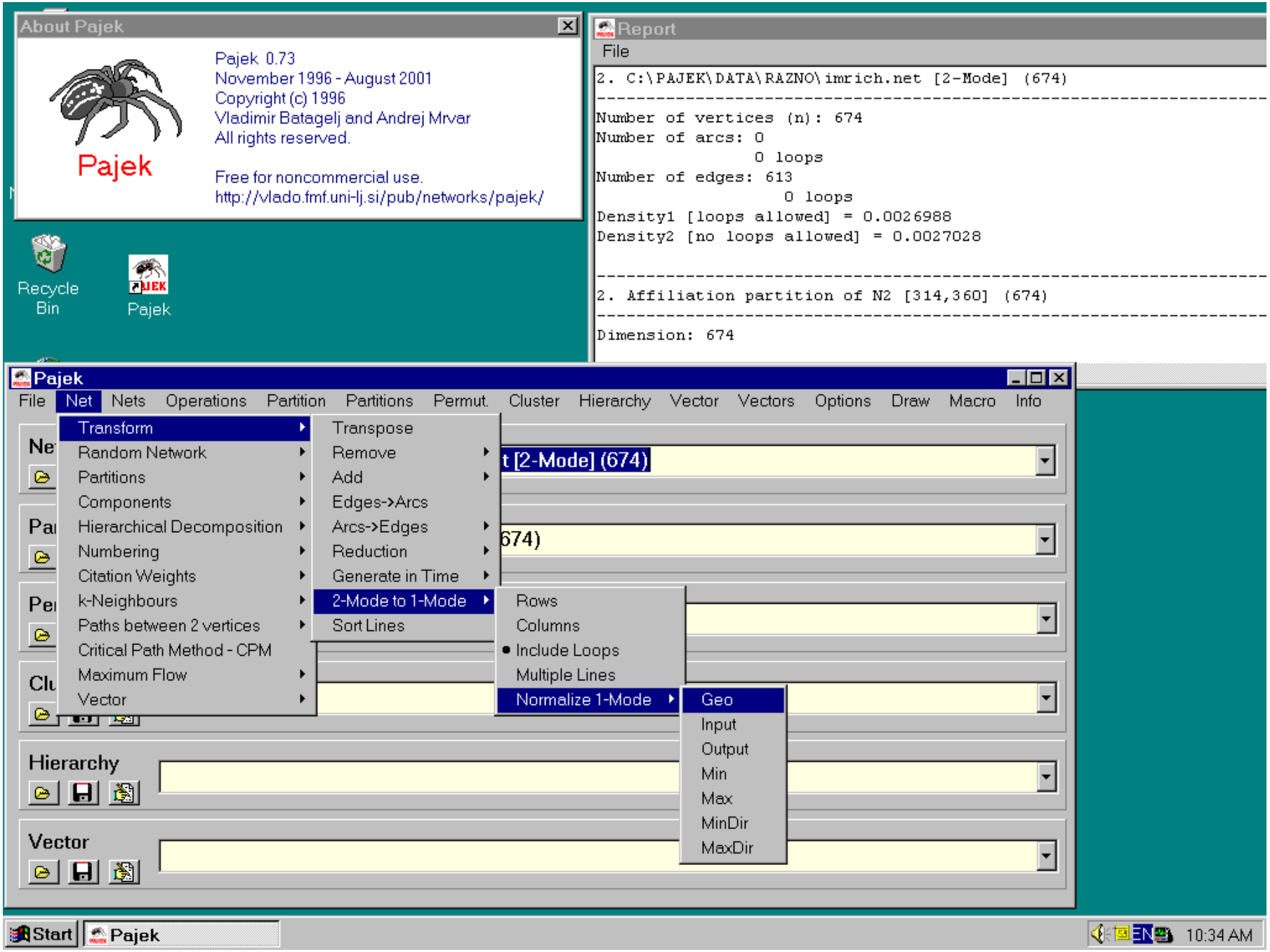
Our layouts for ***Graph-Drawing Competitions***: GD95, GD96, GD97, GD98, GD99, GD00, GD01 and GD05.

Mladina (front page): Pajek in Koeln; PajekMan in Osoje (Ossiach, Austria):

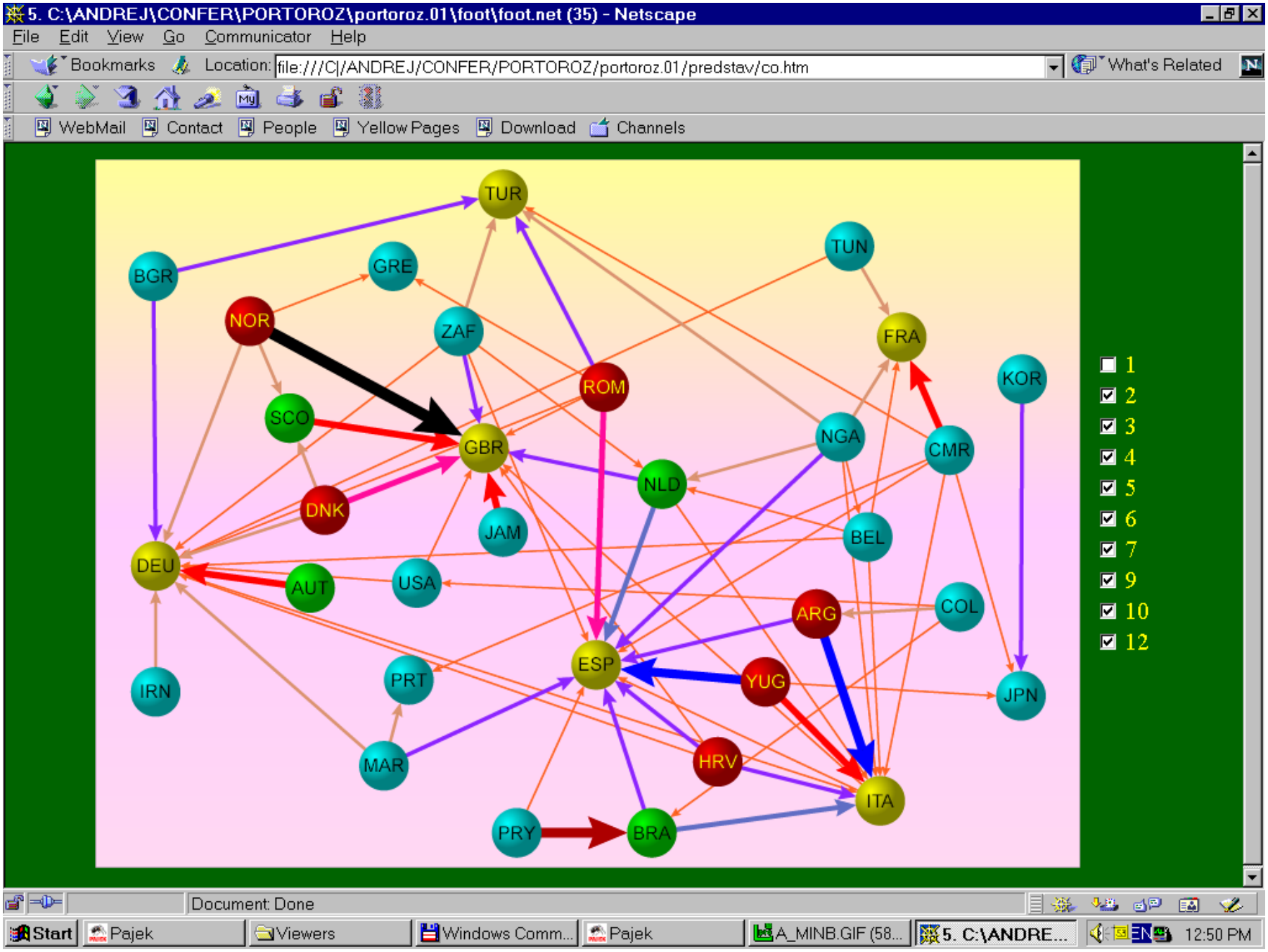
SNA Tool: Pajek

http://pajek.imfm.si/doku.php





Source: http://vlado.fmf.uni-lj.si/pub/networks/doc/gd.01/Pajek9.png



Source: http://vlado.fmf.uni-lj.si/pub/networks/doc/gd.01/Pajek6.png

References

- Bing Liu (2011) , “Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data,” 2nd Edition, Springer. http://www.cs.uic.edu/~liub/WebMiningBook.html
- Jennifer Golbeck (2013), Analyzing the Social Web, Morgan Kaufmann. http://analyzingthesocialweb.com/course-materials.shtml
- Sentinel Visualizer, http://www.fmsasg.com/SocialNetworkAnalysis/
- Min-Yuh Day, Sheng-Pao Shih, Weide Chang (2011), "Social Network Analysis of Research Collaboration in Information Reuse and Integration," The First International Workshop on Issues and Challenges in Social Computing (WICSOC 2011), August 2, 2011, in Proceedings of the IEEE International Conference on Information Reuse and Integration (IEEE IRI 2011), Las Vegas, Nevada, USA, August 3-5, 2011, pp. 551-556.