A comparative study of social network analysis tools

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Outline

- Context: social networks and analysis software
- Expected functionalities of network analysis software
- Benchmark
- Conclusion

Context

Definition (Wikipedia)

A social network is a social structure made up of individuals called "nodes," which are tied by one or more specific types of interdependency, such as friendship, common interest, etc.

Sociologic analysis

- Sociological works (Moreno 1934, Milgram 1967, Cartwright and Harary, 1977)
- Web 2.0 : Renewed interest from the Web based social networks websites development.

Context: Social network in business

- For the Gartner Institute:
  - **“By 2014, social networking services will replace e-mail as the primary vehicle for interpersonal communications for 20 percent of business users.”** (Gartner 2008)
  - Social network analysis is getting **mature.**
- Some applications in business:
  - Workflow study to adapt management to the real flow in a company;
  - Identify key actors, ie. for viral marketing.
- These applications need adapted software.

Context: social networks and analysis software

- Network analysis software
  - A previous statistical analysis oriented survey (Huisman & Van Duijn, 2003)
- Networks and needs are changing
  - Size
  - Complex graphs
  - Necessity to make a new benchmark

Context

Expected functionalities of network analysis software

Benchmark

Conclusion

Expected functionalities of network analysis software

1. **Representation**

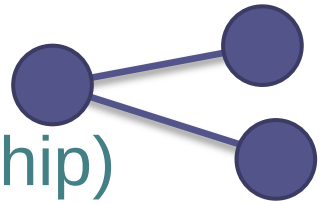
2. **Visualization**

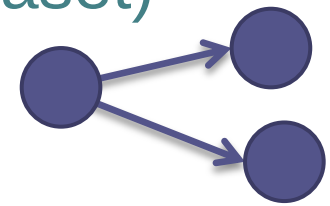
3. **Characterization by indicators**

4. **Community detection**

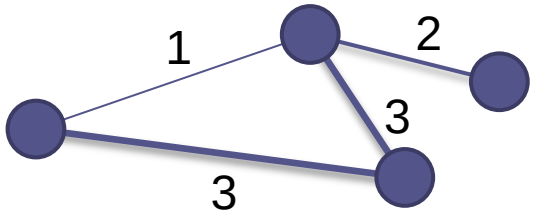
1. Network representation as graph (Cartwright and Harary, 1977)

- Link orientation
  - Undirected links (edges, ex: co-authorship)
  - Directed (arcs, ex: e-mails sent, Enron dataset)



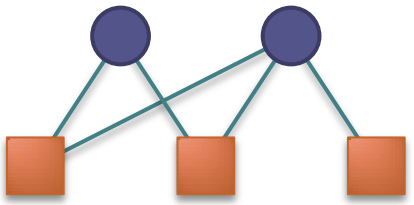


- Weight on edges



- With typed nodes

  (ex. bipartite network)



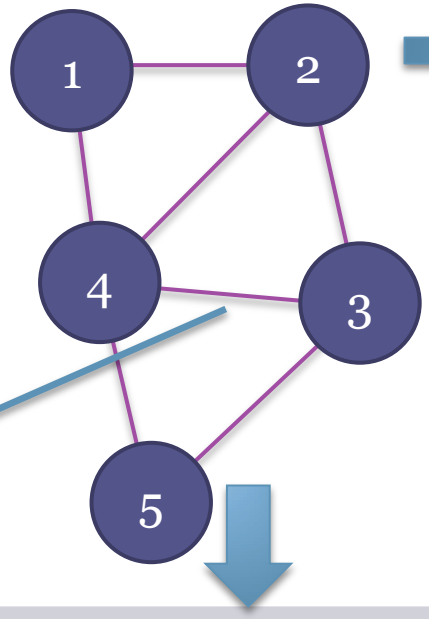
1. Network representation as graph

```
*Vertices 5
*Edges
1  2
1  4
2  3
2  4
3  4
3  5
4  5
```

Connections

(.net file format)

Edge list



1 → 2, 4
2 → 1, 2, 4
3 → 2, 4, 5
4 → 2, 3, 5
5 → 3, 4

Adjacency list

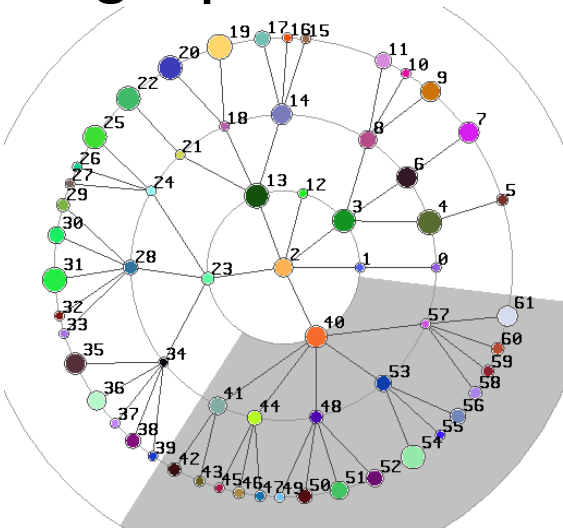
	1	2	3	4	5
1	0	1	0	1	0
2	1	0	1	1	0
3	0	1	0	1	1
4	1	1	1	0	1
5	0	0	1	1	0

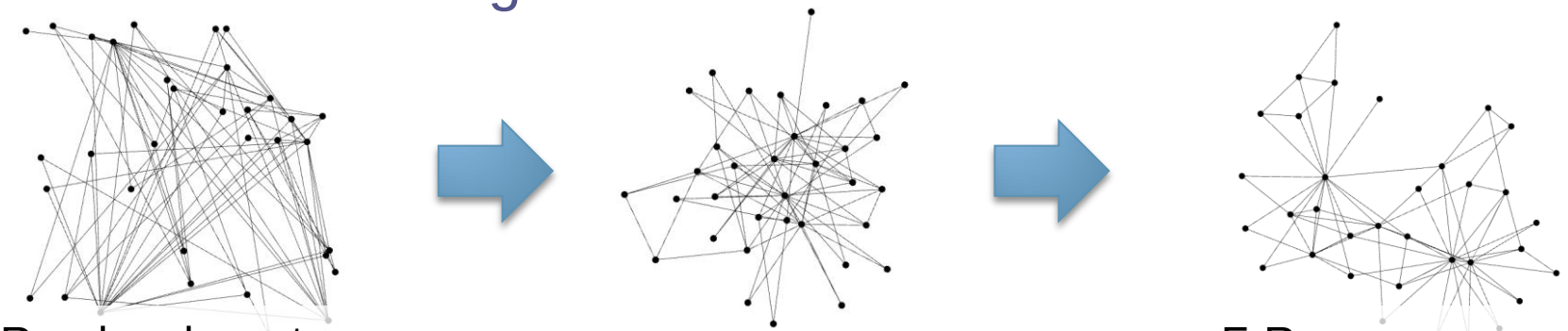
Adjacency matrix

2. Visualization

Aim: give a visual representation of the graph, with different approaches:

- Fish eye
  - Centered on an actor
- Force driven visualization layouts
  - Fruchterman Reingold (1984)
    - Iterative algorithm





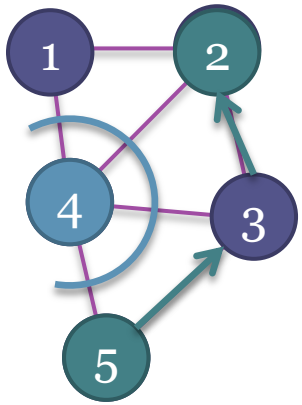
Random layout

F-R convergence

3. Characterization by indicators

- Global indicators at network level by:
  - Number of nodes
  - Number of edges
  - Diameter
  - …

} Density

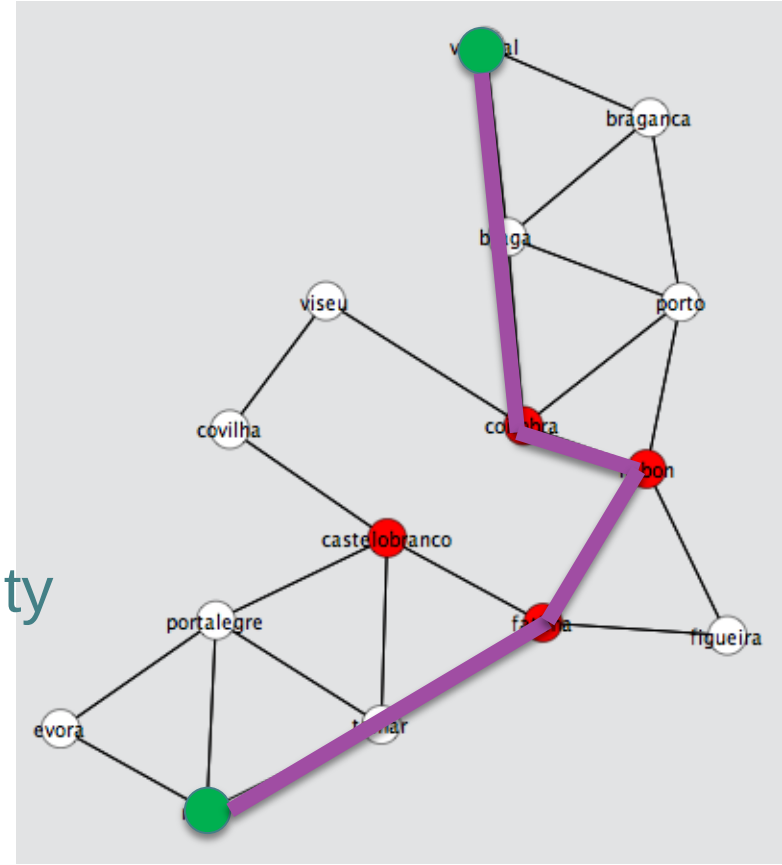


- Local indicators at node level:
  - Number of neighboors → degree
  - …

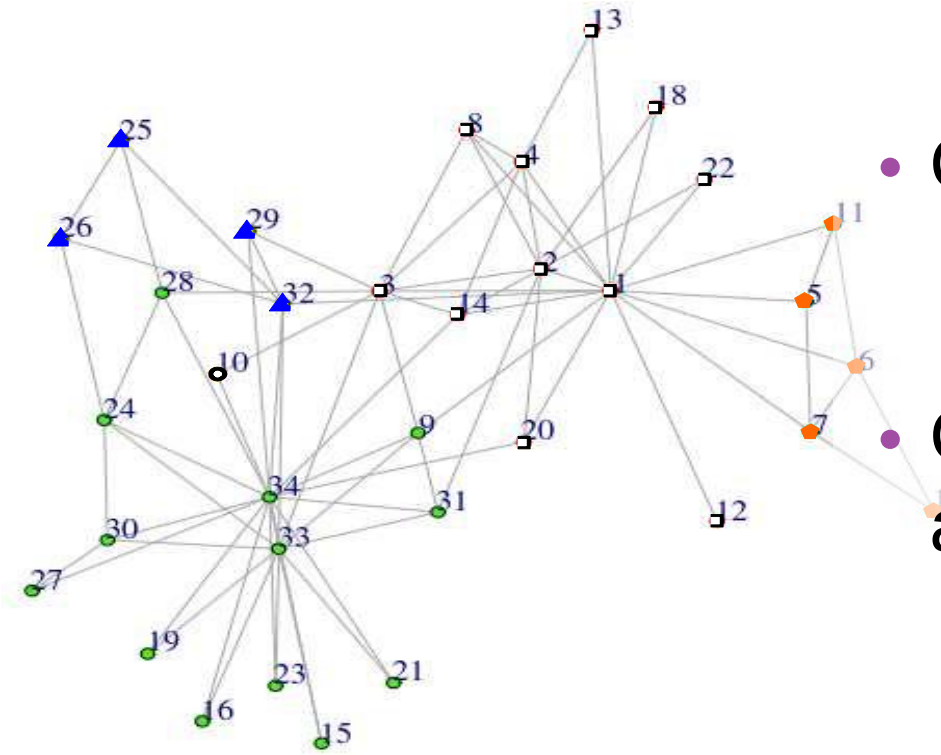
- Distance
  - Length of the shortest path

3. Characterization by indicators : how to decide if an actor is « central »?

- Many ways to determine central actors.
- Ex: Betweenness centrality
  - Which node is the most likely to be an **intermediary for a random communication**?
  - →**higher betweenness** centrality
- Selection depends on what they are needed for.



4. Community detection



- Community:
  - A set of actors having strong connexions.
- Community detection algorithms
  - Newman–Girvan (Newman and Girvan, 2002)
  - Walktrap (Latapy & Pons, 2005)

Context
Expected functionalities of network analysis software

Benchmark

Conclusion

Benchmark methodology

- Required points:
  - **A social network analysis point of view**
  - **Scalability**
  - **Free for educational purposes**

- A balance between **well established software** and newer ones, based on **recent development standards** (ergonomics, modularity and data portability).

- Datasets: *Zachary*'s karate-club, DBLP

Software comparison criteria


Input/output formats


Custom attribute handling


Bipartite graphs specific functions


Longitudinal analysis


Visualization


Indicators


Community detection

Studied software

- Gephi is an “interactive **visualization** and **exploration** platform”.
- GUESS is dedicated to **visualization** purposes, with several layouts.
- Tulip can handle over 1 million vertices and 4 millions edges. It has **visualization**, **clustering** and extension by **plug-ins** capabilities.
- GraphViz is mainly for graph **visualization**.

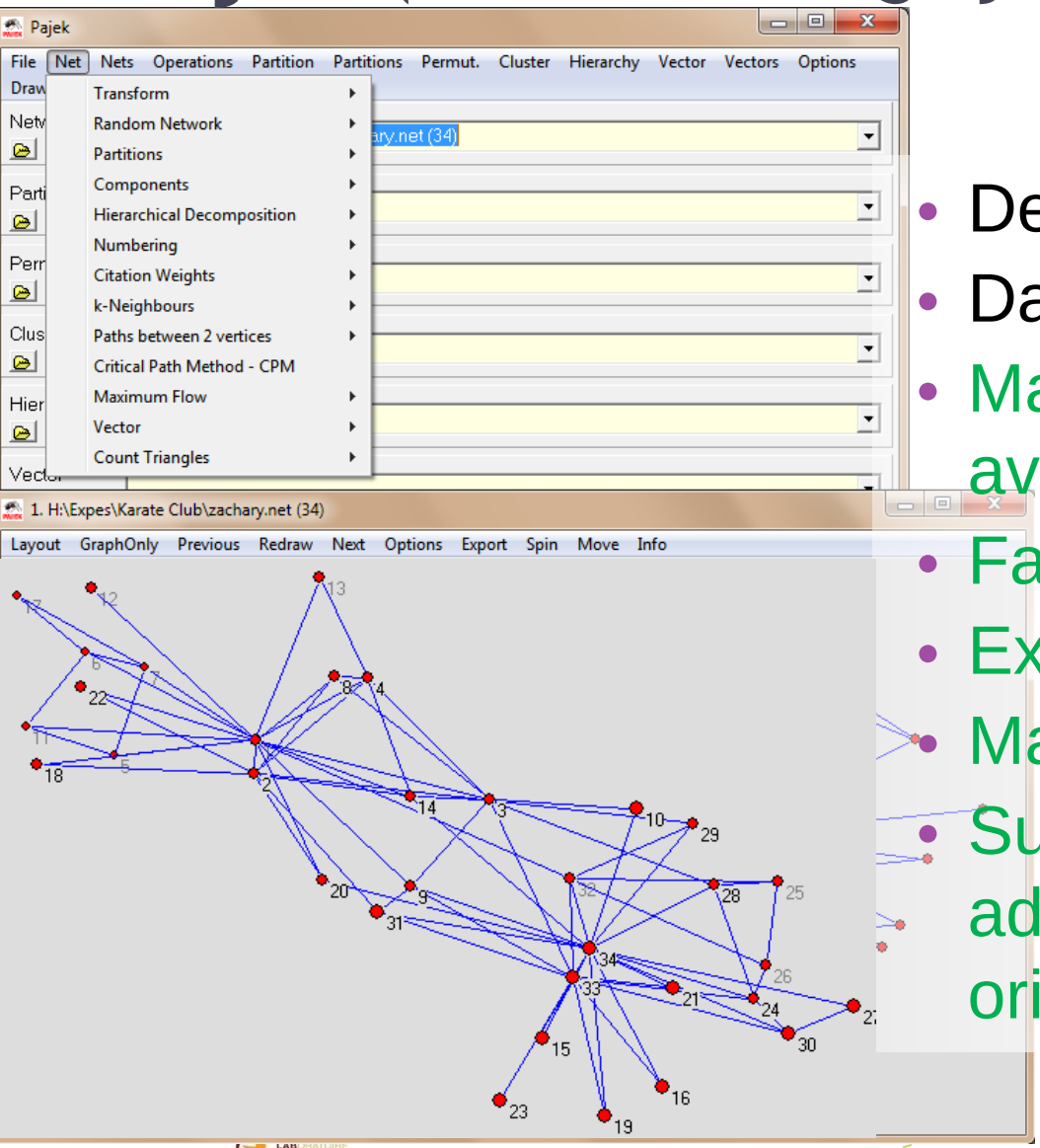
- UCInet is not free. It uses Pajek and Netdraw for **visualization**. It is specialized in **statistical and matricial analysis**. It calculates **indicators** (such as triad census, Freeman betweenness) and performs **hierarchical clustering**.
- Pajek is a Windows program for **analysis** and **visualization** of large networks. It is freely available, for noncommercial use.

- igraph is a free software package for creating and **manipulating** graphs. It also implements algorithms for some recent network analysis methods.
- NetworkX is a package for the creation, **manipulation**, and **study** of the structure, **dynamics**, and functions of **complex** networks.
- JUNG, for Java Universal Network/Graph Framework, is mainly developed for creating **interactive** graphs in Java GUIs, JUNG has been extended with some SNA **metrics**.

Selected software

- Stand-alone software
  - Pajek http://pajek.imfm.si/doku.php
  - Gephi http://gephi.org/
- Libraries
  - igraph http://igraph.sourceforge.net/
  - NetworkX http://networkx.lanl.gov/

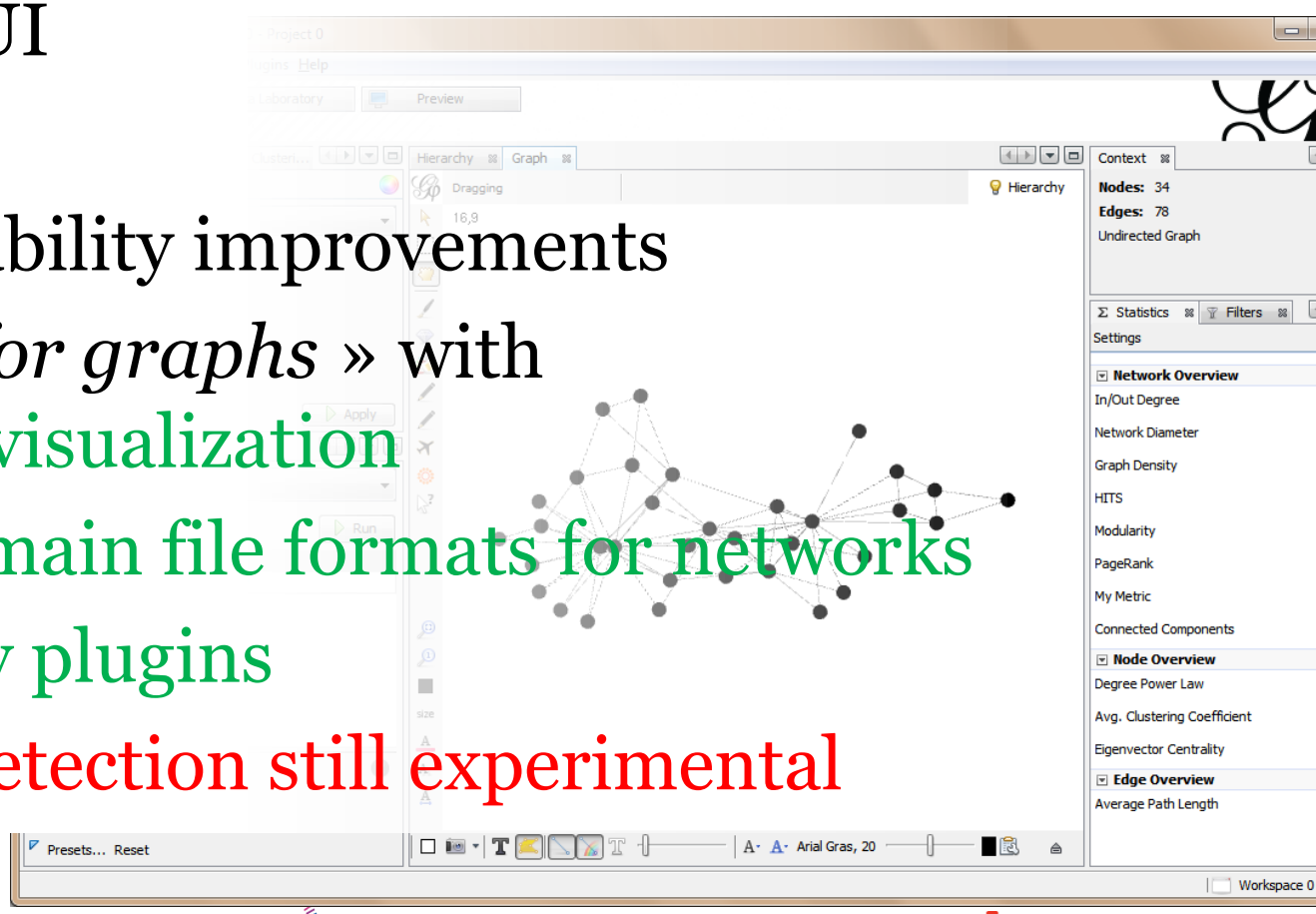
Pajek (Vladimir Batagelj and Andrej Mrvar)



- Development started in 1996
- Data mining oriented
- Many graph operators available
- Fast
- Exports 3D visualization
- Macro
- Supports matrices, adjacency lists and arcs lists oriented input files

Gephi (Bastian M., Heymann S., Jacomy M.)

- Development started in 2008
- Interactive GUI
- Uses Java
- Recent scriptability improvements
- « *Photoshop for graphs* » with customizable visualization
- Supports the main file formats for networks
- Improvable by plugins
- Community detection still experimental



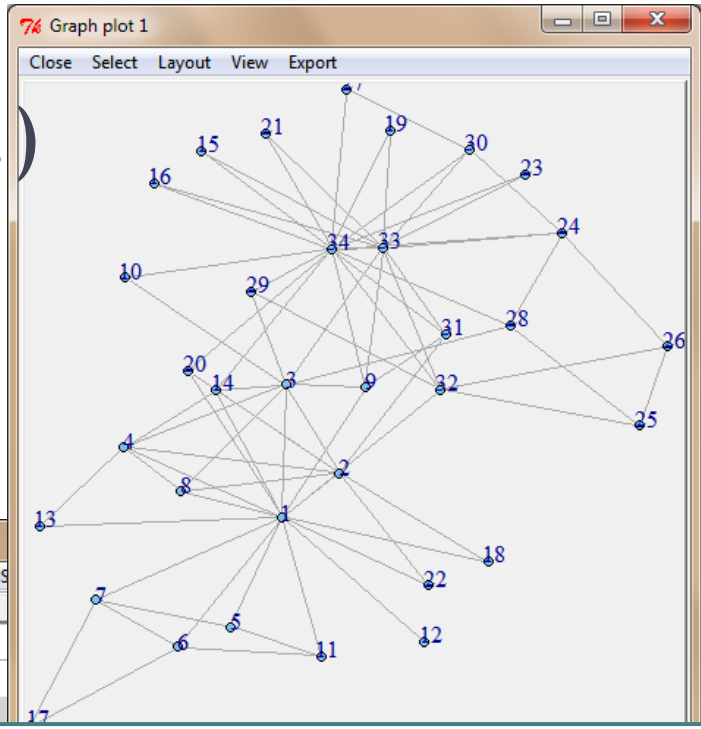
NetworkX (Brandes U., Erlebach T.)

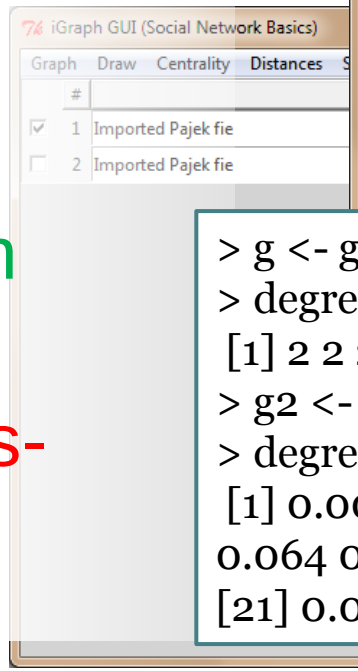
- Python
- Bipartite graphs ready
- Attribute-friendly
- 1,000,000 nodes wide networks can be handled.
- Lacks in community detection algorithms
- Relies on other software for visualization

```
>>> import networkx as nx
>>> G=nx.Graph()
>>> G.add_node("spam")
>>> G.add_edge(1,2)
>>> print(G.nodes())
[1, 2, 'spam']
>>> print(G.edges())
 [(1, 2)]
>>> G.degree(1)
1
```

Igraph (Csárdi G., Nepusz T.)

- For R (a statistical environment) and Python. The low level routines are written in C.
- GUI available for R.
- Community detection ready.
- Not custom attributes-friendly






```
> g <- graph.ring(10)
> degree(g)
 [1] 2 2 2 2 2 2 2 2 2 2
> g2 <- erdos.renyi.game(1000, 10/1000)
> degree.distribution(g2)
 [1] 0.000 0.000 0.002 0.009 0.020 0.039
0.064 0.107 0.111 0.115 0.118...
[21] 0.003 0.001
```

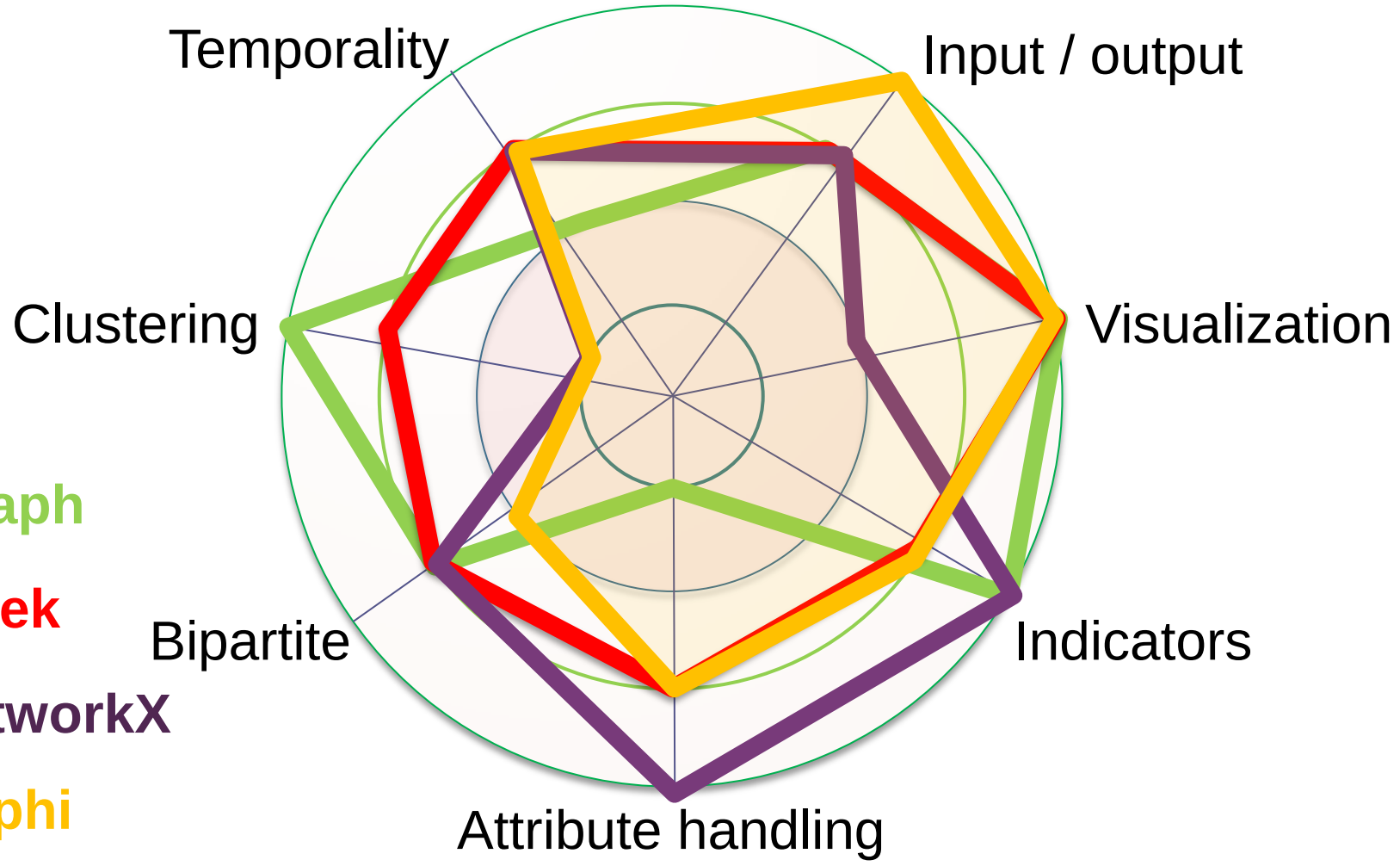
How to choose the right tool?

	Pajek	Gephi	NetworkX	igraph
Input/output	+	++	+	+
Attribute handling	+	+	++	- -
Bipartite graphs	+	-	+	+
Temporality	+	+	+	-
Visualization	++	++	-	++
Indicators	+	+	++	++
Clustering	+	- -	- -	++

++ Mature functionality

- - Not available or weak

Feature comparison



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- Many domains, many approaches, many software (sociology, computer science, mathematics and physics).
- Functionalities to develop in the future (e.g. for decision support):
  - Temporality awareness
  - Links and nodes attributes analysis
  - Hierarchical graphs

Thank you for your attention.

Any questions ?

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