

Graph representations

V - number of vertices (nodes), E - number of edges

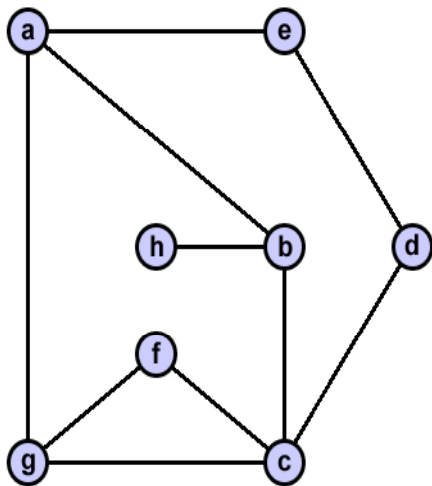
Edge array - size: E

Adjacency matrix - size: $V * V$

Adjacency lists - size: $V + E$

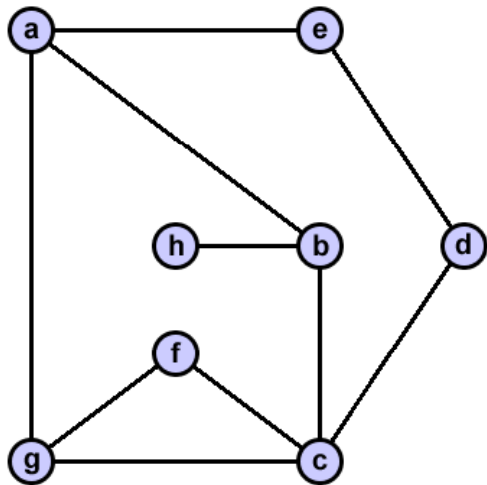
“pure” representations

Adjacency matrix



	a	b	c	d	e	f	g	h
a	0	1	0	0	1	0	1	0
b	1	0	1	0	0	0	0	1
c	0	1	0	1	0	1	1	0
d	0	0	1	0	1	0	0	0
e	1	0	0	1	0	0	0	0
f	0	0	1	0	0	0	1	0
g	1	0	1	0	0	0	0	0
h	0	1	0	0	0	0	0	0

Adjacency List



a: b e g

b: c h

c: b g

d: c e

e: a d

f: c g

g: a c f

h: b

Representation properties

V - number of vertices

E - number of edges

	matrix	list	edge array
space	V^2	$V+E$	E
find edge	1	V	E
insert edge	1	1	1
path v to w ?	V^2	$V+E$	$E \lg V$

Graph processing software tools

- GUI programs: Pajek, yED, UCINET
- Command line programs: graphviz, R, statnet
- Software Libraries: LEDA, networkx, igraph
- Input: user input (mouse-clicks) or files
- Most file formats are text, graph formats
- Output: images or data files
- Focus: visualization or graph algorithms

Graphviz

command line graph visualizer – the language itself is called **dot**



About

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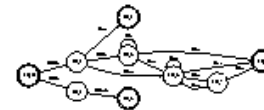
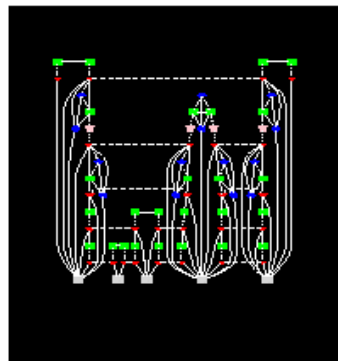
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Graphviz - Graph Visualization Software



Graph Visualization

Graph visualization is a way of representing structural information as diagrams of abstract graphs and networks. Automatic graph drawing has many important applications in software engineering, database and web design, networking, and in visual interfaces for many other domains.

Graphviz is open source graph visualization software. It has several main graph layout programs. See the [gallery](#) for some sample layouts. It also has web and interactive graphical interfaces, and auxiliary tools, libraries, and language bindings.

The [Mac OS X edition of Graphviz](#), by Glen Low, won two 2004 Apple Design Awards.

Graphviz example

```

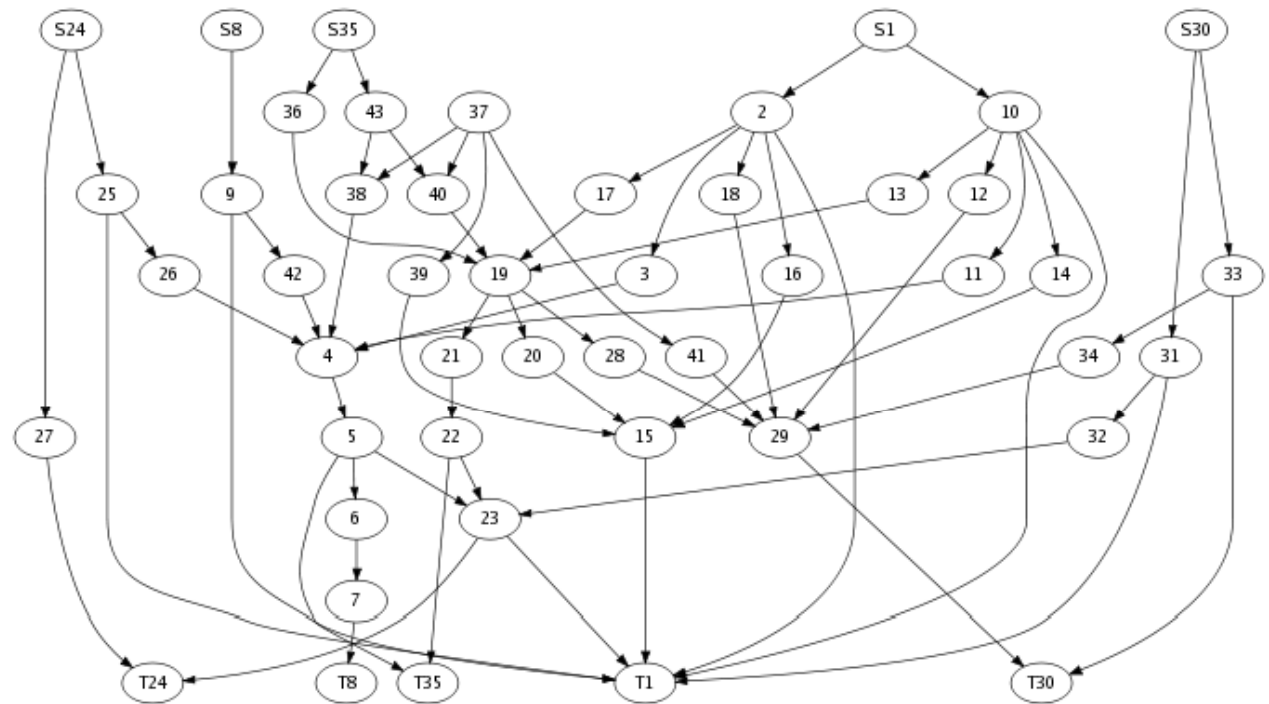
digraph world {
size="7,7";
    {rank=same; S8 S24 S1 S35 S30;}
    {rank=same; T8 T24 T1 T35 T30;}
    {rank=same; 43 37 36 10 2;}
    {rank=same; 25 9 38 40 13 17 12 18;}
    {rank=same; 26 42 11 3 33 19 39 14 16;}
    {rank=same; 4 31 34 21 41 28 20;}
    {rank=same; 27 5 22 32 29 15;}
    {rank=same; 6 23;}
    {rank=same; 7;}

```

```

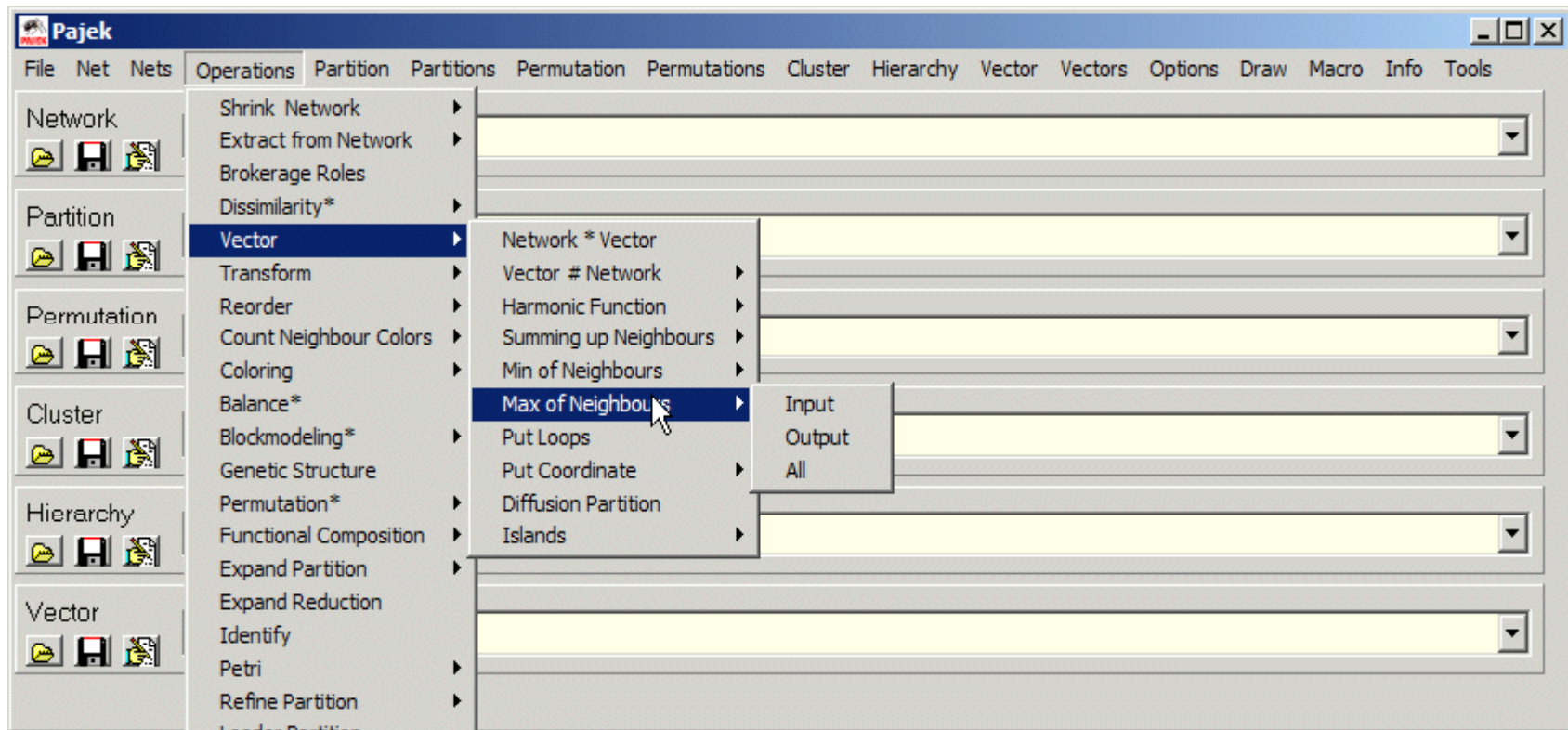
S8 -> 9;
S24 -> 25;
S24 -> 27;
S1 -> 2;
S1 -> 10;
S35 -> 43;
S35 -> 36;
S30 -> 31;
S30 -> 33;
9 -> 42;
9 -> T1;
25 -> T1;
25 -> 26;
27 -> T24;
2 -> { 3 ; 16 ; 17 ; T1 ; 18 }
10 -> { 11 ; 14 ; T1 ; 13 ; 12 ; }
31 -> T1;
31 -> 32;
33 -> T30;
33 -> 34;
42 -> 4;
26 -> 4;
3 -> 4;
16 -> 15;
17 -> 19;
18 -> 29;
11 -> 4;
14 -> 15;
37 -> { 39 ; 41 ; 38 ; 40 ; }
13 -> 19;
12 -> 29;

```



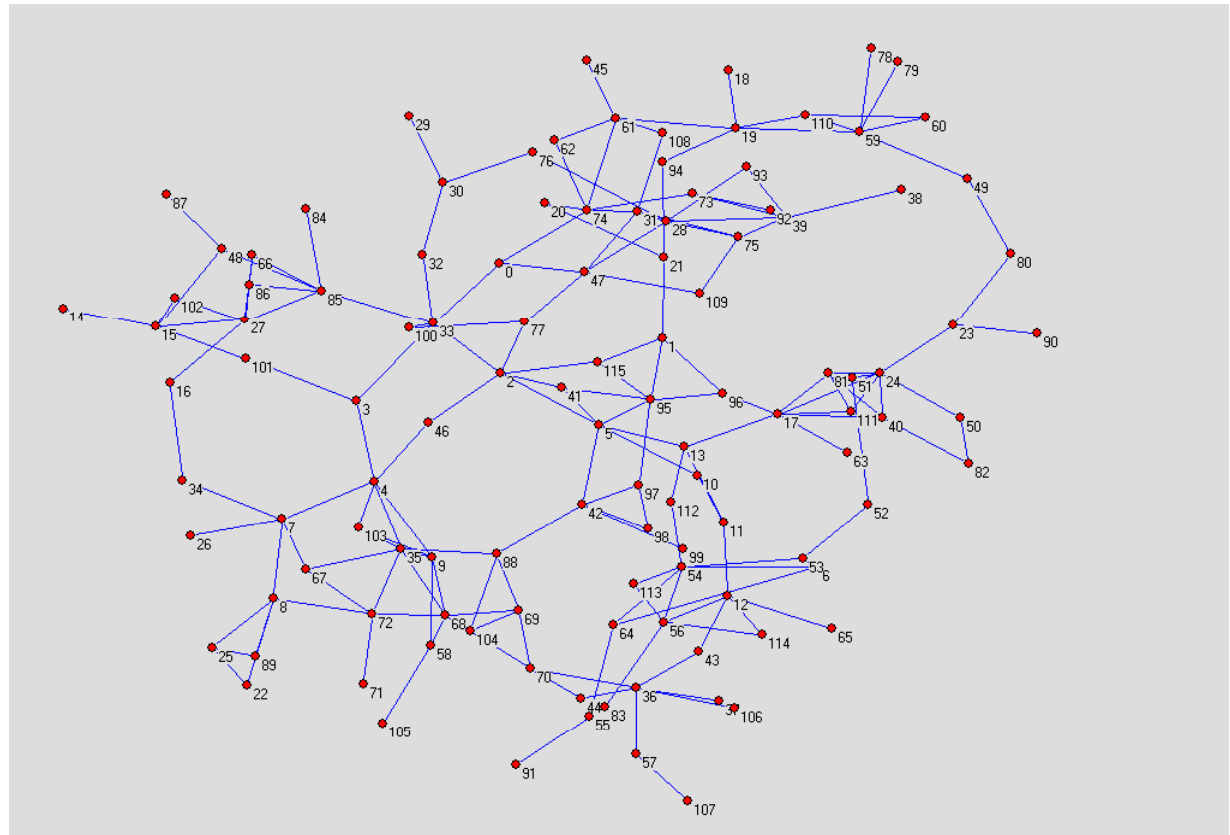
Pajek

Windows program for visualization and analysis of large networks



Pajek input and output

```
*Vertices 116
1 "0" ic Black
2 "1" ic Black
3 "2" ic Black
4 "3" ic Black
5 "4" ic Black
...
116 "115" ic Black
*Edges
1 34
1 48
2 96
2 97
2 116
3 6
3 42
3 47
3 78
3 116
4 5
4 34
4 102
5 8
5 10
5 47
6 11
6 42
7 55
7 65
8 9
8 68
11 12
12 13
14 6
...
```

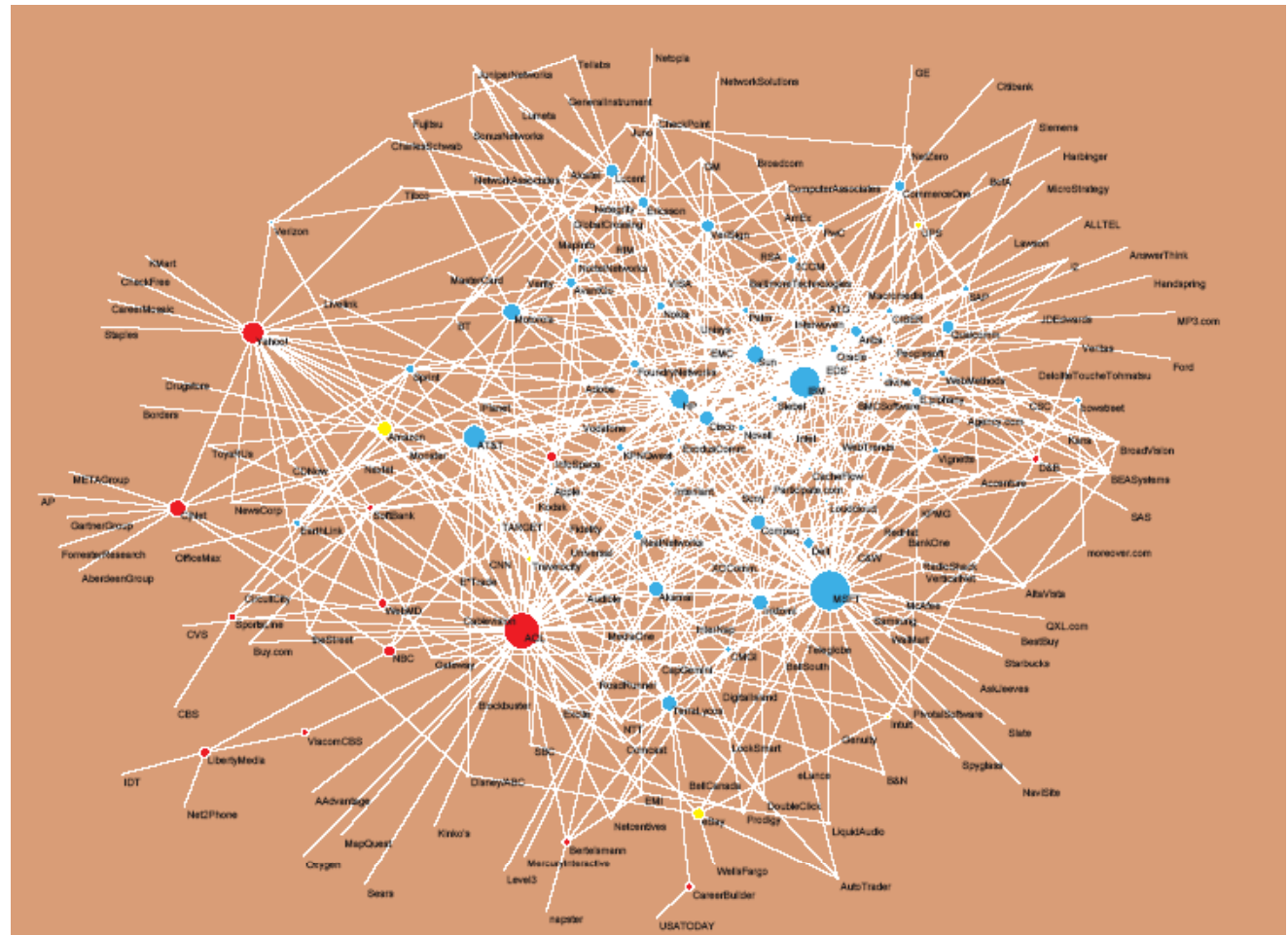


Basic layout circular, easy to change to energy-minimizing layout.

More sophisticated Pajek example: strategic alliances among companies

red - content,
blue - infrastructure
yellow – commerce

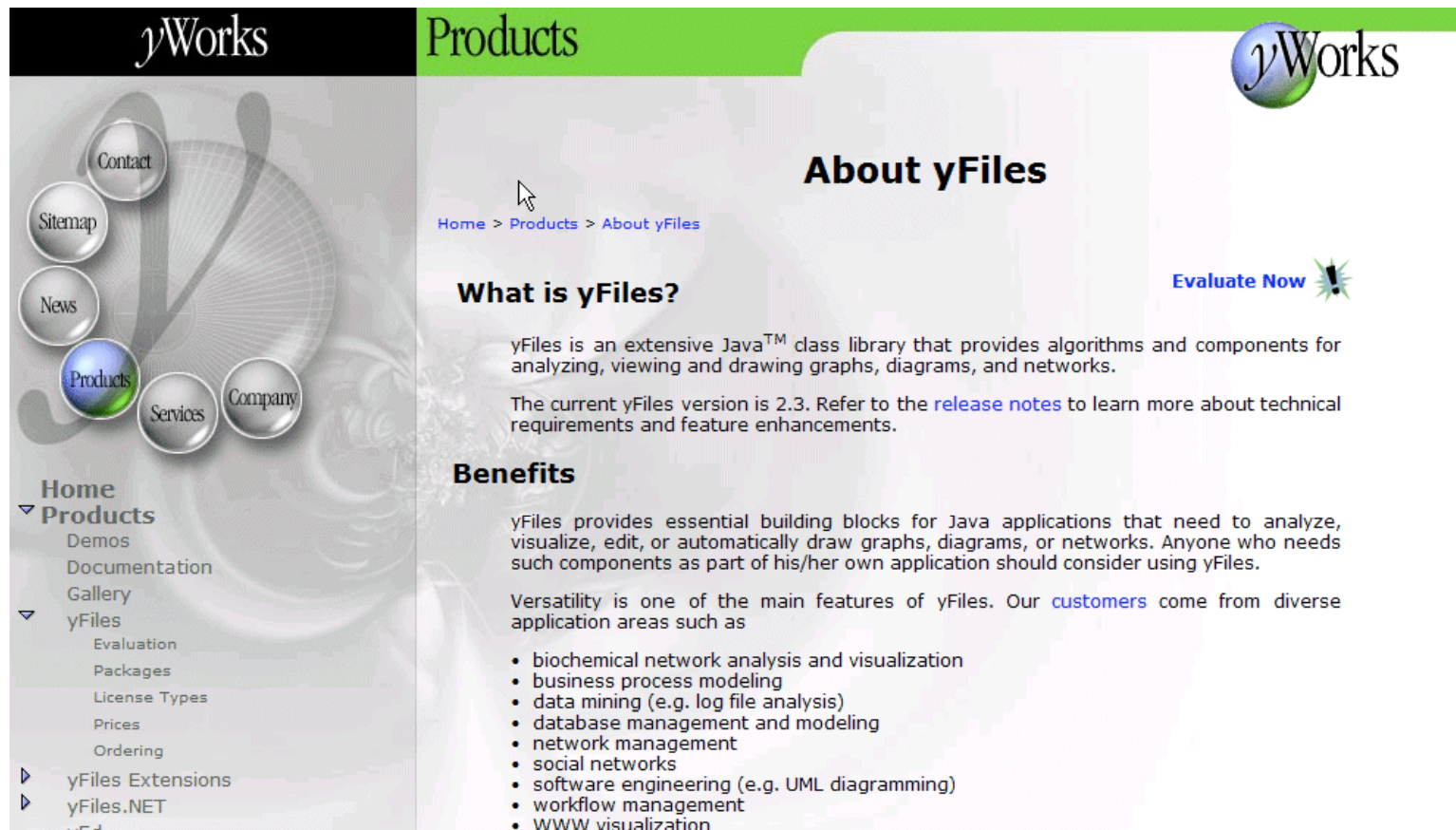
Figure by
Valdis Krebs



yED - yFiles

yED (editor) is free but yFiles costs \$\$\$

<http://www.yworks.com>



The screenshot shows the yWorks website with a navigation menu on the left and a main content area on the right. The navigation menu includes links for Contact, Sitemap, News, Products (highlighted), Services, and Company. Below this is a 'Home' section with a dropdown for 'Products' containing links to Demos, Documentation, Gallery, yFiles (expanded), yFiles Extensions, and yFiles.NET. The 'yFiles' section lists Evaluation, Packages, License Types, Prices, and Ordering. The main content area has a green header with 'Products' and the yWorks logo. The page title is 'About yFiles'. A breadcrumb trail shows 'Home > Products > About yFiles'. A 'What is yFiles?' section describes yFiles as a Java class library for graph visualization. A 'Benefits' section lists various application areas like biochemical network analysis, business process modeling, data mining, database management, network management, social networks, software engineering, workflow management, and WWW visualization. An 'Evaluate Now' button with an exclamation mark icon is also present.

yWorks Products **yWorks**

About yFiles

[Home](#) > [Products](#) > [About yFiles](#)

[Evaluate Now](#) !

What is yFiles?

yFiles is an extensive Java™ class library that provides algorithms and components for analyzing, viewing and drawing graphs, diagrams, and networks.

The current yFiles version is 2.3. Refer to the [release notes](#) to learn more about technical requirements and feature enhancements.

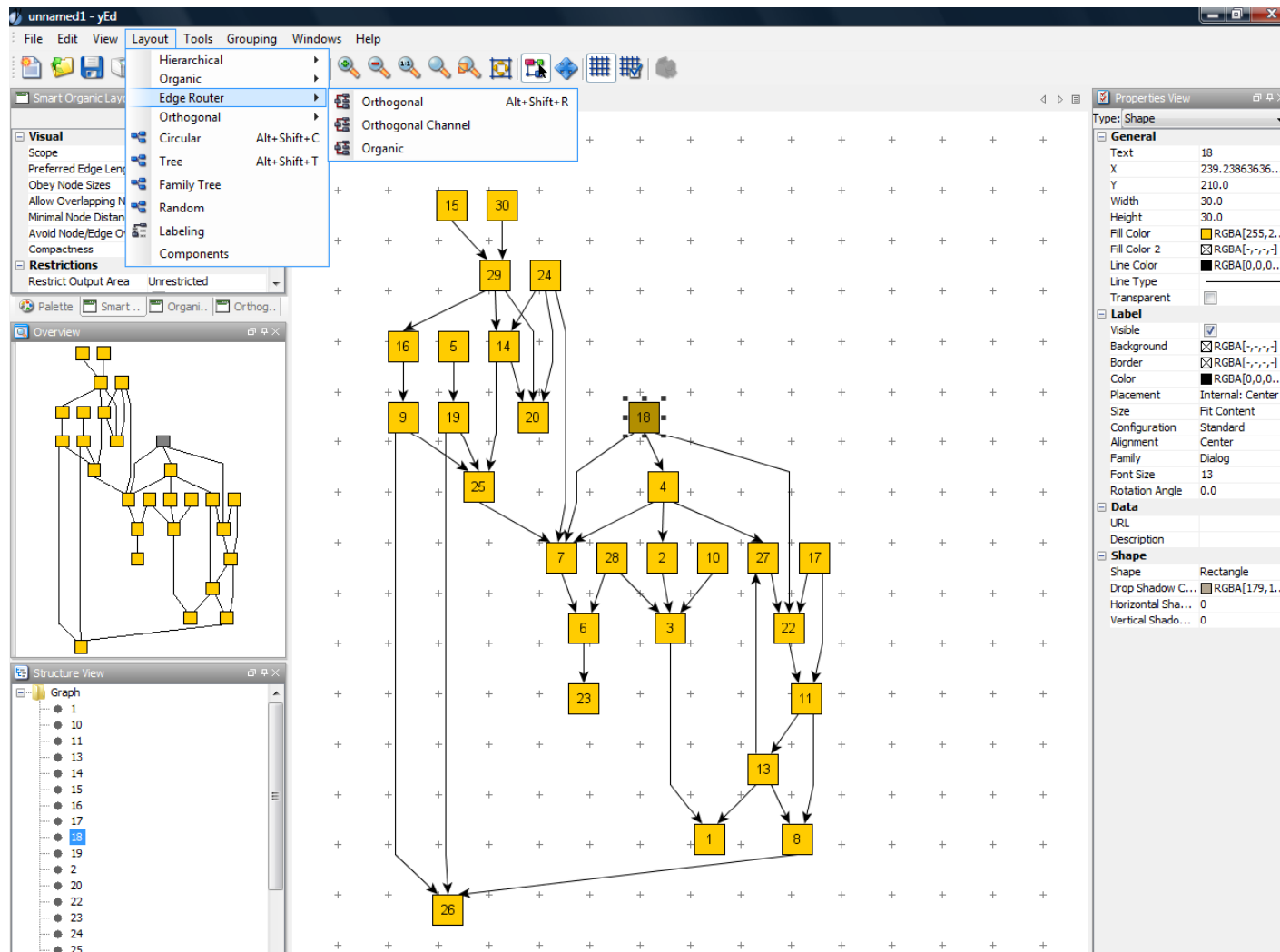
Benefits

yFiles provides essential building blocks for Java applications that need to analyze, visualize, edit, or automatically draw graphs, diagrams, or networks. Anyone who needs such components as part of his/her own application should consider using yFiles.

Versatility is one of the main features of yFiles. Our [customers](#) come from diverse application areas such as

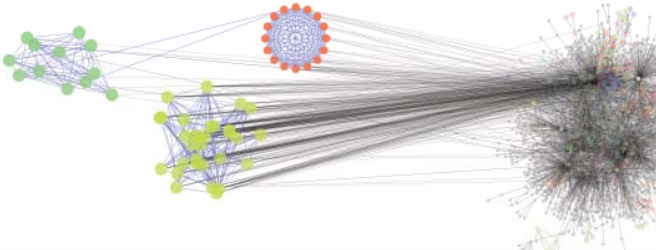

- biochemical network analysis and visualization
- business process modeling
- data mining (e.g. log file analysis)
- database management and modeling
- network management
- social networks
- software engineering (e.g. UML diagramming)
- workflow management
- WWW visualization

yED – Excellent Layout



Cytoscape – biology oriented

Cytoscape



[Download Cytoscape 2.6.1!](#)
[2.6.1 Release Notes »](#)

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<h3>About Cytoscape</h3> <p>Cytoscape is an open source bioinformatics software platform for <i>visualizing</i> molecular interaction networks and <i>integrating</i> these interactions with gene expression profiles and other state data. Read more »</p>	<h3>Download Cytoscape</h3> <p>Download Version 2.6.1 (Requires Java SE 5 or Java SE 6) 2.6.1 Release Notes »</p>	<h3>Online Tutorials</h3> <p>Get Started with the expanded Cytoscape online tutorials. Eight tutorials describe Cytoscape from basic operation to detailed plugin operation.</p>	<h3>Manual</h3> <p>HTML format or PDF format, explains all basic features of Cytoscape. Get Acrobat reader</p>	<h3>Developers</h3> <p>Roadmap Javadoc API Wiki Graph Interface library (GINY) Download Source from SVN</p>					

New! Cytoscape 2.6.1

This is a minor bug-fix release that should work with all 2.6.0 plugins.

There are no API changes, however we have added a new centralized logging facility. See **Help->Error Console** to see Cytoscape's startup messages and any warnings or errors that occur during operation.


Some Bugs that have been fixed include:

- Topology filter performance
- XGML loading consistency
- Mac usability issues

Cytoscape 2.6.0

(Updated 4/11/2008) New features include:

- **Web Service Client Manager**
 - Seamless access to Pathway Commons, IntAct, and NCBI



Getting Help:

Need help getting started with Cytoscape? Email our help-desk mailing list.
» [cytoscape-helpdesk: Subscribe](#) | [Browse Archives](#)

Cytoscape Announcements:

Cytoscape programming position. November 29, 2008
» Hi Everyone, We're looking for an experienced Java programmer to work on the Cytoscape project at UCSD. If you're interested, please apply here: [\[link\]](#) thanks, Mike [cont.]

Release 2.0 of DomainGraph plugin. November 17, 2008
» DomainGraph decomposes protein interaction networks into their underlying domain interactions. Gene networks can be loaded to visualize the encoded proteins and their domain compositions. Additionally, DomainGraph supports

UCINET – social science oriented

Description

<http://www.analytictech.com/ucinet/description.htm>



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Description

Capabilities

UCINET is a comprehensive package for the analysis of social network data as well as other 1-mode and 2-mode data. Can read and write a multitude of differently formatted text files, as well as Excel files. Can handle a maximum of 32,767 nodes (with some exceptions) although practically speaking many procedures get too slow around 5,000 - 10,000 nodes. Social network analysis methods include centrality measures, subgroup identification, role analysis, elementary graph theory, and permutation-based statistical analysis. In addition, the package has strong matrix analysis routines, such as matrix algebra and multivariate statistics.

Integrated with Ucinet is the [NetDraw](#) program for drawing diagrams of social networks. In addition, the program can export data to MAGE and Pajek.

Trial Version / Purchase

UCINET

can be [downloaded](#) and used **free** for 60 days. For longer use, individual students pay \$40, faculty, schools & government pay \$150, and corporations pay \$250. In addition, generous volume discounts / site licenses are available. Click [here](#) for ordering information.

Python – Networkx graph library

Uses Graphviz for graph visualization

NetworkX

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This documentation is currently being updated for release 0.99 of NetworkX. This update includes significant changes to the underlying Graph and DiGraph objects to reflect our common use case of weighted graphs and to improve performance. See the [API changes](#) for detailed information.

High productivity software for complex networks

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

Quick Example

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

Documentation

Tutorial <i>start here</i>	Contents <i>a complete overview</i>
Reference <i>guide to all functions and classes</i>	Search Page <i>search the documentation</i>
Examples <i>using the library</i>	General Index <i>all functions, classes, terms</i>
Gallery <i>network drawings</i>	Module Index <i>quick access to all documented modules</i>

Download

Current version: **0.99**

Get NetworkX from the [Python Package Index](#), or install it with:

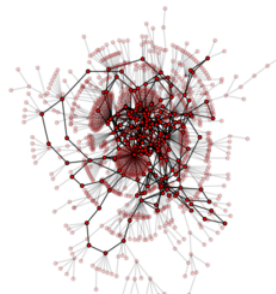
`easy_install networkx`

Questions? Suggestions?

Join the [Google group](#):

You can also open an issue at the on the [developer's site](#).

Quick search



A networkx example

```
2 import networkx as nx
3
4 # generate a few different types of random graphs
5 er = nx.erdos_renyi_graph( 100, 0.1 )
6 ws = nx.watts_strogatz_graph ( 100, 10, 0.2 )
7 ba = nx.barabasi_albert_graph( 100, 2 )
8
9 # collect them in a list
10 allgen = [ er, ws, ba ]
11
12 # print various network measures
13 for graph in allgen:
14     avg = nx.cluster.average_clustering( graph )
15     diam = nx.distance.diameter( graph )
16     cent = nx centrality.betweenness centrality(graph)
17     print 'Avg=%4.2f, Diameter=%s, BCentral=%s' % (avg, diam, cent)
18
```



```
Avg=0.10, Diameter=4, BCentral={0: 0.016015371933121809, 1: 0.0039172788090537005,
Avg=0.39, Diameter=4, BCentral={0: 0.037242946115432697, 1: 0.023804532988251741, 2:
Avg=0.15, Diameter=6, BCentral={0: 0.17685572133217217, 1: 0.0, 2: 0.29895977927013
```

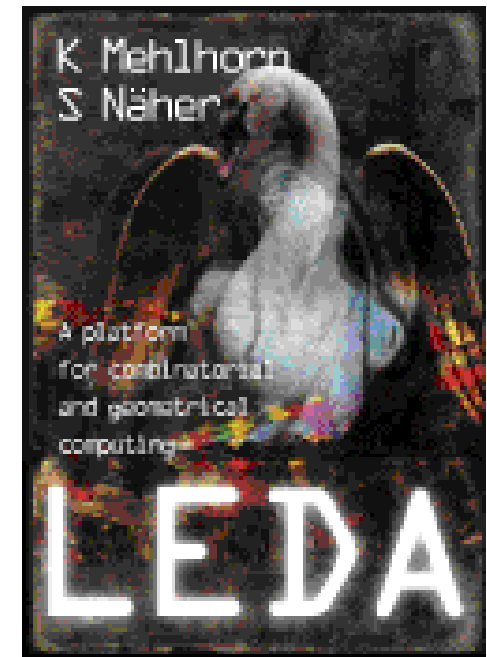

LEDA

Library of efficient data types - written in C++
free versions / \$150 for the academic license

You can buy the Leda Guide from Amazon
(also available free on the web)

High performance, professional product,
covers much more than just graphs.

So abstract that it feels like a
high level programming language



LEDA example

```
#include <LEDA/graph.h>
#include <LEDA/basic_graph_alg.h>
using namespace leda;

int main() {
    graph G;
    list<node> dfs_res ;

    node n0 = G.new_node ();
    ...
    G.new_edge (n0,n1);
    ...
    dfs_res = DFS (G, n0, n5);

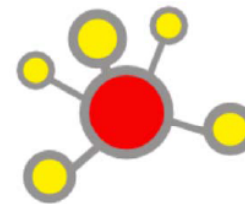
    forall (node, dfs_res)
        G.print_node(node);
}
```

igraph software library

The igraph library						sourceforge
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Bugs	License					

Introduction

igraph is a free software package for creating and manipulating undirected and directed graphs. It includes implementations for classic graph theory problems like minimum spanning trees and network flow, and also implements algorithms for some recent network analysis methods, like community structure search.



Latest version: **0.5.2**

[Release notes](#)

The efficient implementation of **igraph** allows it to handle graphs with millions of vertices and edges. The rule of thumb is that if your graph fits into the physical memory then **igraph** can handle it.

igraph can be installed in several forms:

- **igraph** as a *C library* is useful if you want to use it in your C/C++ projects, or want to implement your own network analysis or model in C/C++ using the data structures and functions **igraph** provides.
- **igraph** as an *R package*. You can use **igraph** as an extension package to [The GNU R project for Statistical Computing](#). The flexibility of the R language and its richness in statistical methods add a great deal of productivity to **igraph**, with a very small speed penalty.
- **igraph** as a *Python* extension module. This way you can combine **igraph** with the huge set of Python functions and modules available, and the ease of the Python language, with a small speed penalty.
- **igraph** as a *Ruby* extension. If you like the Ruby language, then this might be the right choice for you.