

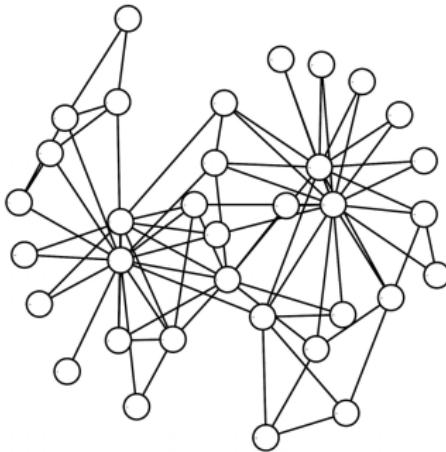
networks *motivation*

introduction to *network analysis* (*ina*)

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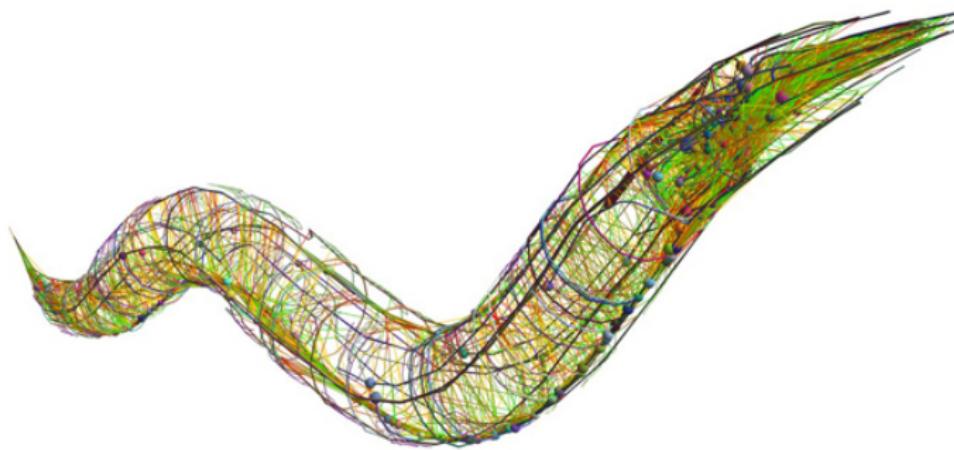
motivation *network*

- *network/graph* wiring diagram
- points called *nodes/vertices*
- connected by *links/edges*



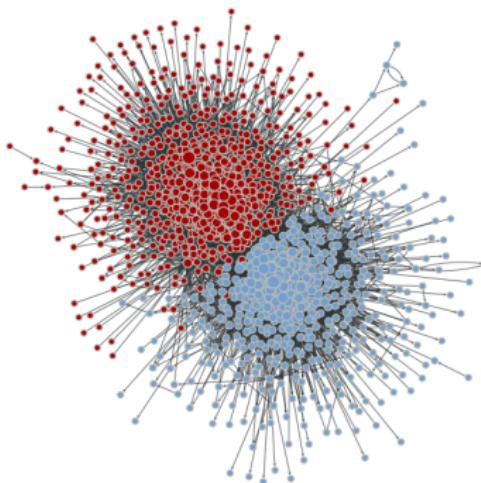
motivation *neural wiring*

- *human brain* $\approx 10^{11}$ neurons
- nodes are *C. elegans neurons*
- links are *synapses*



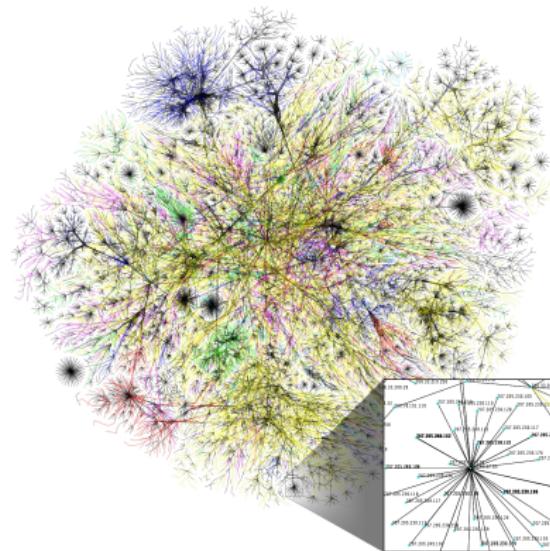
motivation *Web*

- *Web graph* $> 10^{12}$ pages
- nodes are *web pages*
- links are *hyperlinks*



motivation *Internet*

- Internet *overlay map*
- nodes are *class C subnets*
- links are *packet routes*



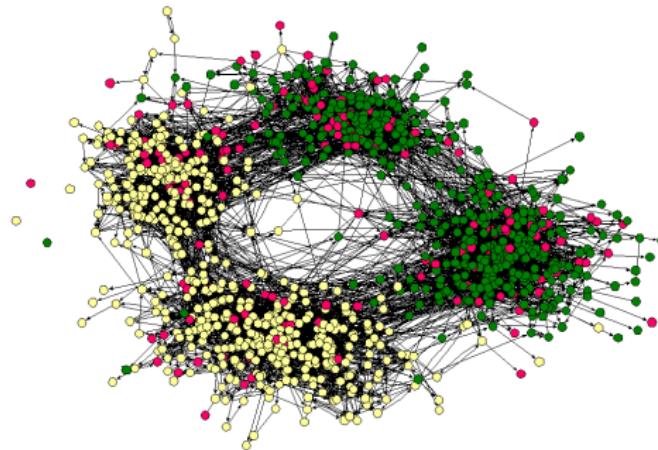
motivation *Facebook*

- *online social* network $> 10^9$ users
- nodes are *Facebook users*
- links are *social connections*



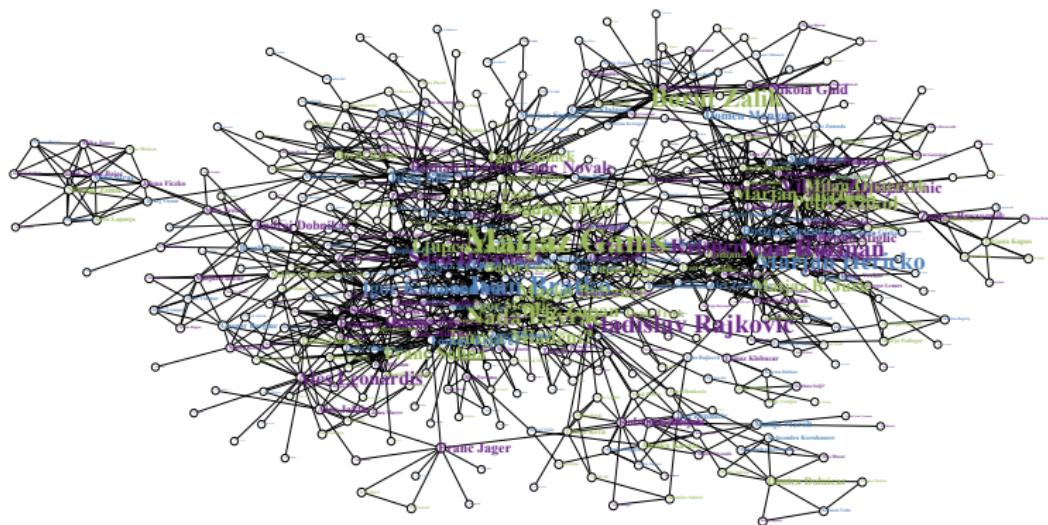
motivation *society*

- *offline social* network
- nodes are *school children*
- links are *friendship ties*



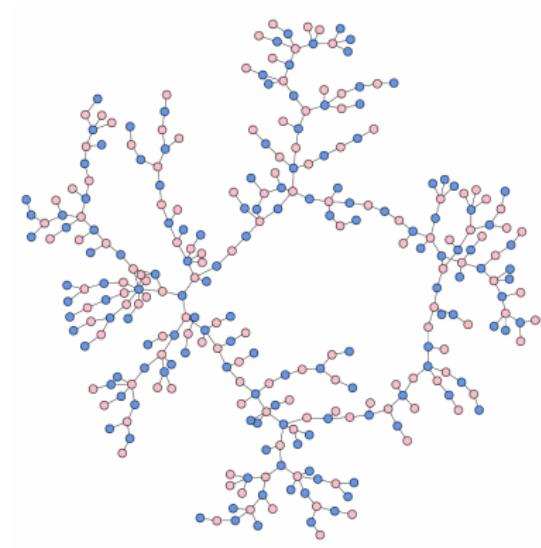
motivation *collaboration*

- *author collaboration* network
 - nodes are *Slovenian computer scientists*
 - links are *paper coauthorships* until 2000



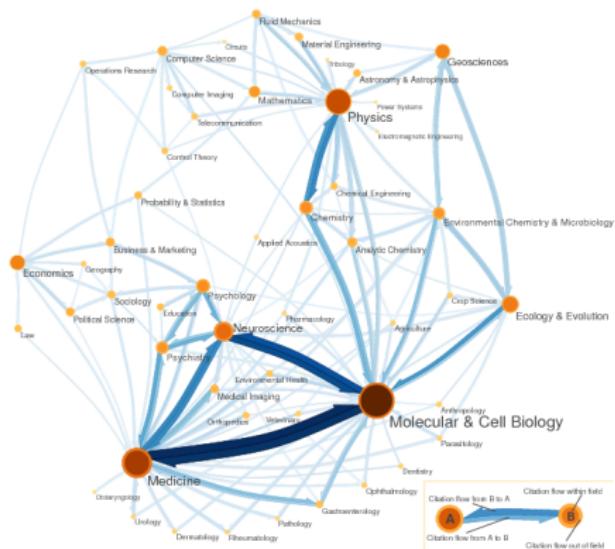
motivation *sex*

- *sexual* network
- nodes are *men/women*
- links are *sexual contacts*



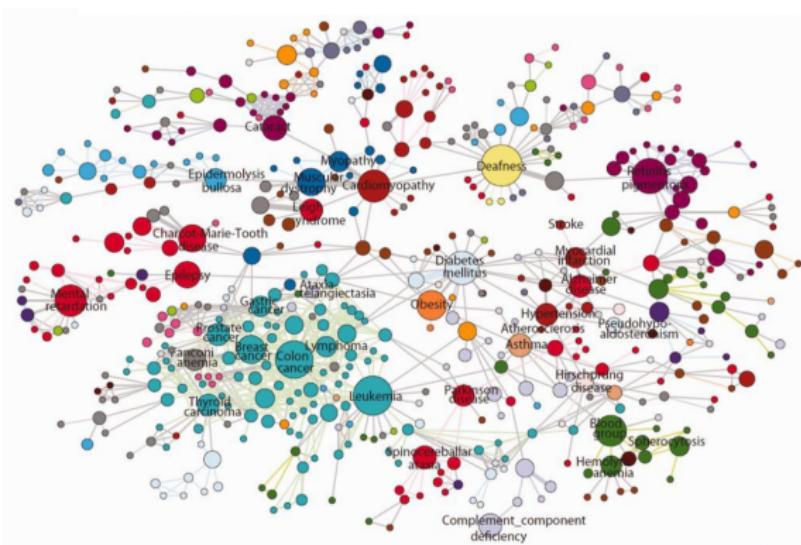
motivation *science*

- map of science network
- nodes are *scientific fields*
- links are *journal citations*



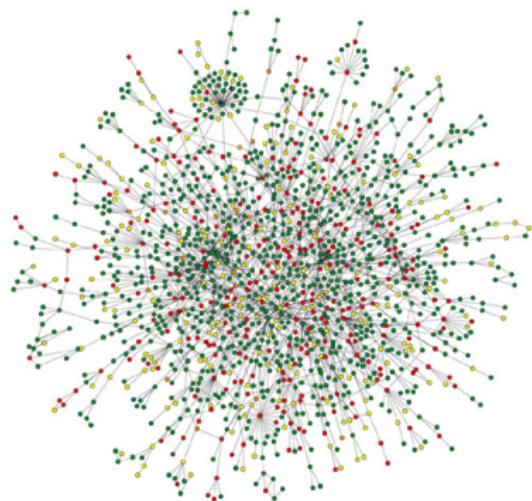
motivation *medicine*

- *human diseaseome* network
- nodes are *human diseases*
- links are *shared genes*



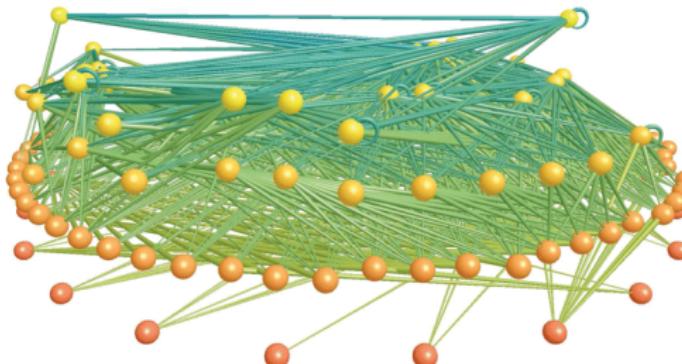
motivation *biology*

- *protein interaction* network
- nodes are *S. cerevisiae proteins*
- links are *physical interactions*



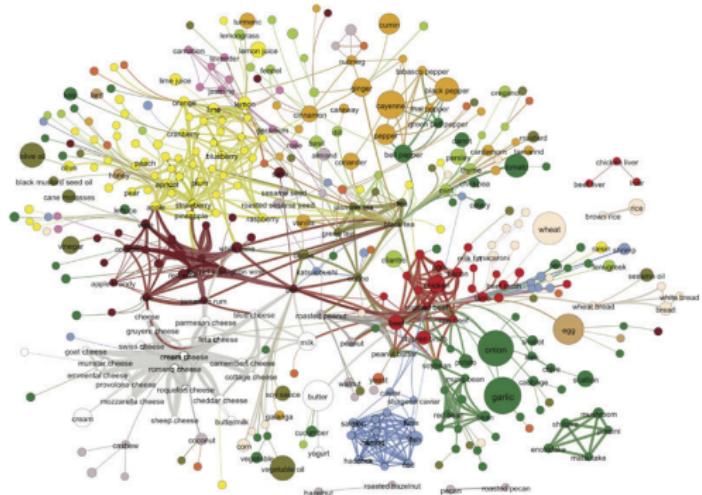
motivation *ecology*

- ecosystem *food web*
- nodes are *lake species*
- links are *predatory interactions*



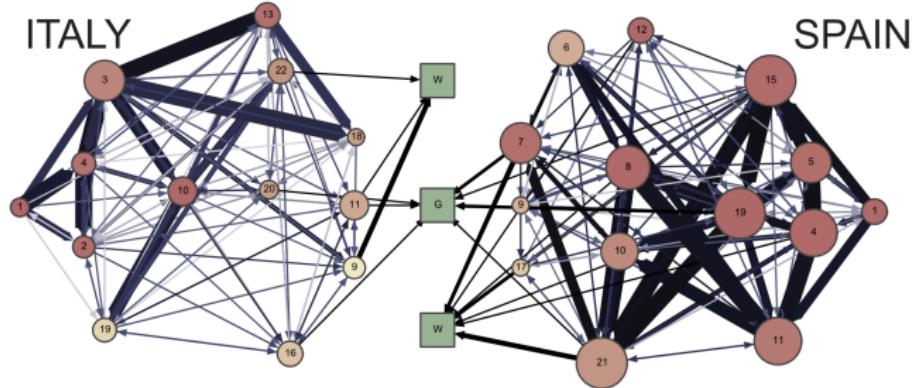
motivation *gastronomy*

- *ingredient/flavor* network
 - nodes are *recipe ingredients*
 - links are *flavor compounds*



motivation *sports*

- *football player* network
- nodes are *football players*
- links are *player passes*



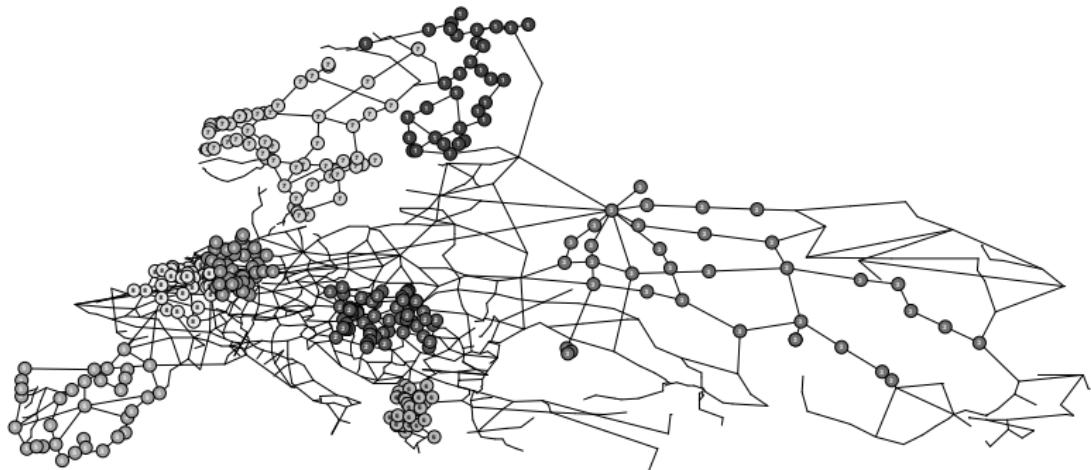
motivation *transport*

- *air transportation* network
- nodes are *world airports*
- links are *passenger flux*



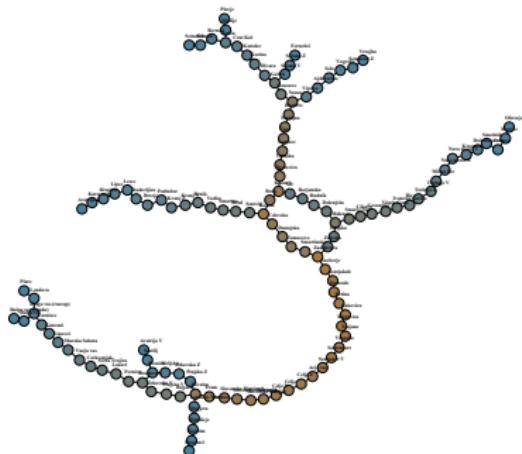
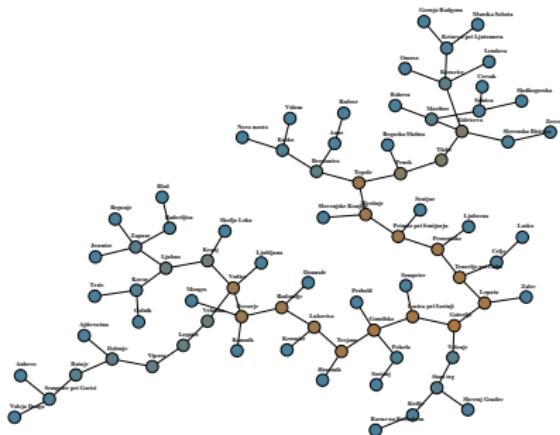
motivation *Europe*

- *road infrastructure* network
- nodes are *European cities*
- links are *highways*



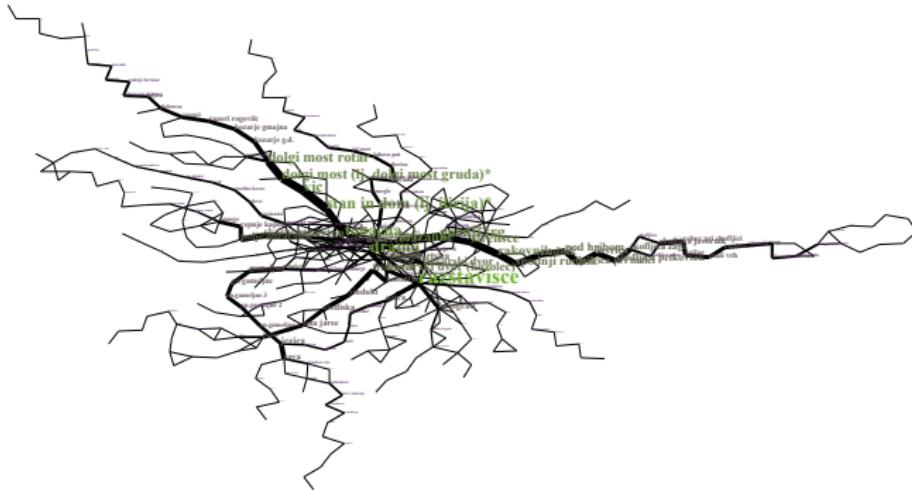
motivation *Slovenia*

- technological/infrastructure networks
- nodes are geographical locations
- links are pipes/highways



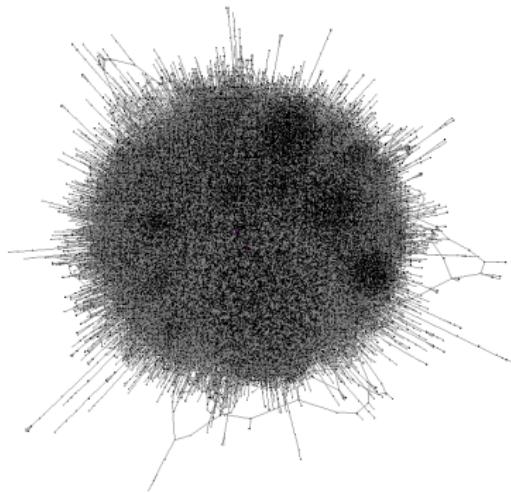
motivation *Ljubljana*

- LPP *bus map*
 - nodes are *bus stops*
 - links are *connections*



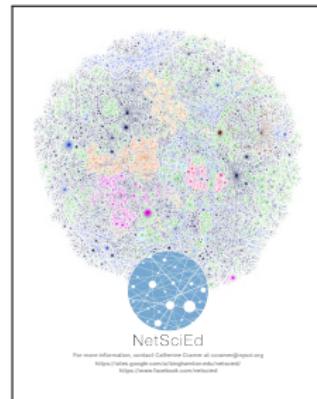
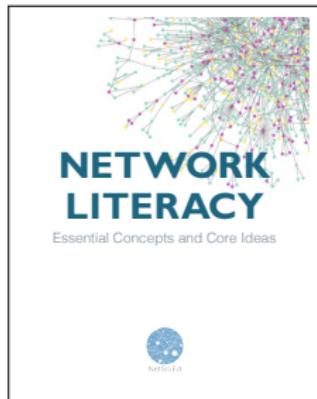
motivation *hairballs*

- most networks are too *large/dense/complex*
- thus visualizations look like *ridiculograms*
visually stunning but scientifically worthless



motivation *networks*

- must *study networks* to *understand real systems*
- how to see what is too complex to visualize?
- through *structure, evolution* and *dynamics*



motivation *documentary*

connected the power of six degrees

documentary on small-world and scale-free networks



[WS98]



[BA99]



[AJB00]

motivation *references*

-  Reka Albert, Hawoong Jeong, and Albert Laszlo Barabasi.
Error and attack tolerance of complex networks.
Nature, 406(6794):378–382, 2000.
-  A.-L. Barabási and R. Albert.
Emergence of scaling in random networks.
Science, 286(5439):509–512, 1999.
-  A.-L. Barabási.
Network Science.
Cambridge University Press, Cambridge, 2016.
-  Wouter de Nooy, Andrej Mrvar, and Vladimir Batagelj.
Exploratory Social Network Analysis with Pajek: Expanded and Revised Second Edition.
Cambridge University Press, Cambridge, 2011.
-  David Easley and Jon Kleinberg.
Networks, Crowds, and Markets: Reasoning About a Highly Connected World.
Cambridge University Press, Cambridge, 2010.
-  Ernesto Estrada and Philip A. Knight.
A First Course in Network Theory.
Oxford University Press, 2015.
-  Mark E. J. Newman.
Networks.
Oxford University Press, Oxford, 2nd edition edition, 2018.
-  D. J. Watts and S. H. Strogatz.
Collective dynamics of 'small-world' networks.
Nature, 393(6684):440–442, 1998.