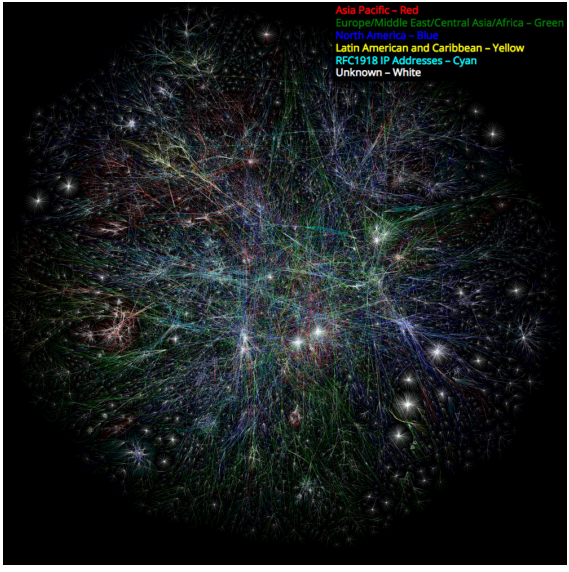
Chapter 2

Networks - An Introduction

Network Types

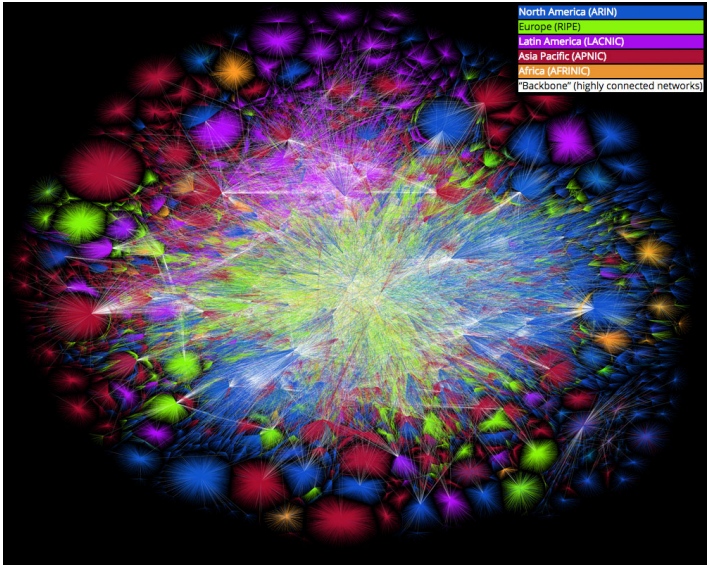
In many systems, individual entities or components are connected with each other in some way, for example:

- **The Internet** (a physical network of computers)
- **Human societies** (acquaintance among people)
- **The World Wide Web** (a network of information stored on web pages)
- **Food webs** (an ecological network that represents predator-prey relationships between species)
- **Online Social Networks** (communication between people)
- **Citation Networks** (references to published work in literature)
- **Infrastructures** (road networks, pipelines, power grids, transportation networks)
- **Brains** (synapses connecting neurons)
- **Reputation networks** (rated transactions between buyers and sellers)



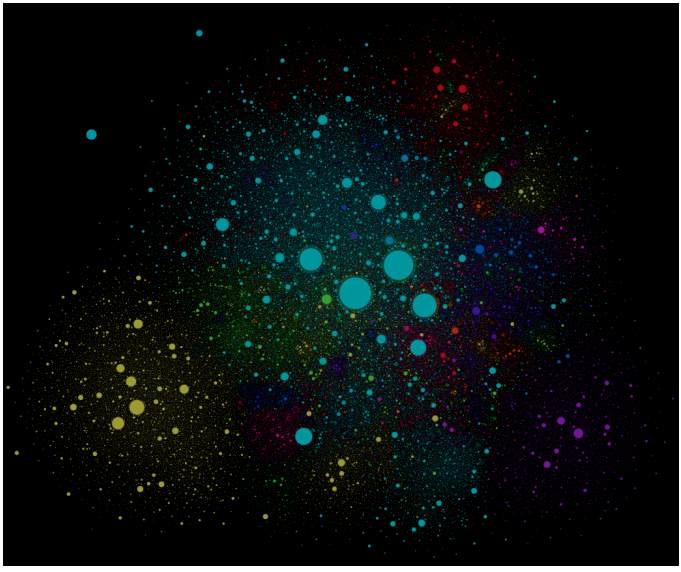
The Internet 2003[1]

[1] Source: Barrett Lyon / The Opte Project, Visualization of the routing paths of the Internet, www.opte.org



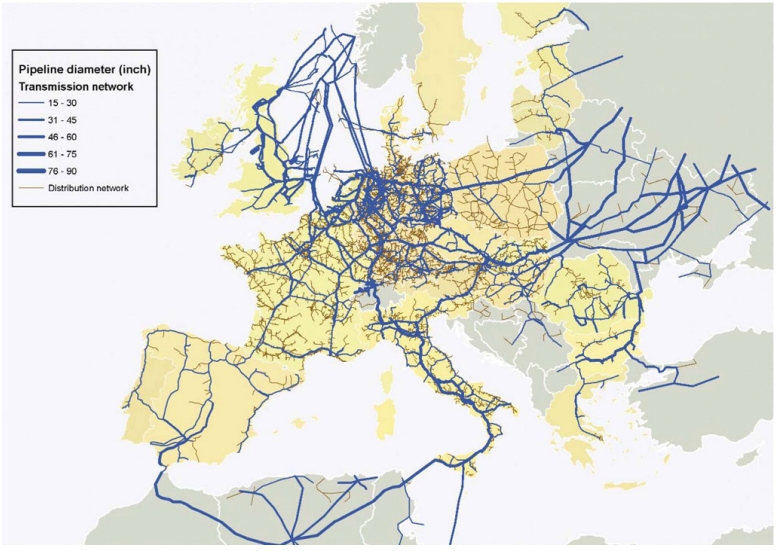
The Internet 2015[1]

[1] Source: Barrett Lyon / The Opte Project, Visualization of the routing paths of the Internet, www.opte.org



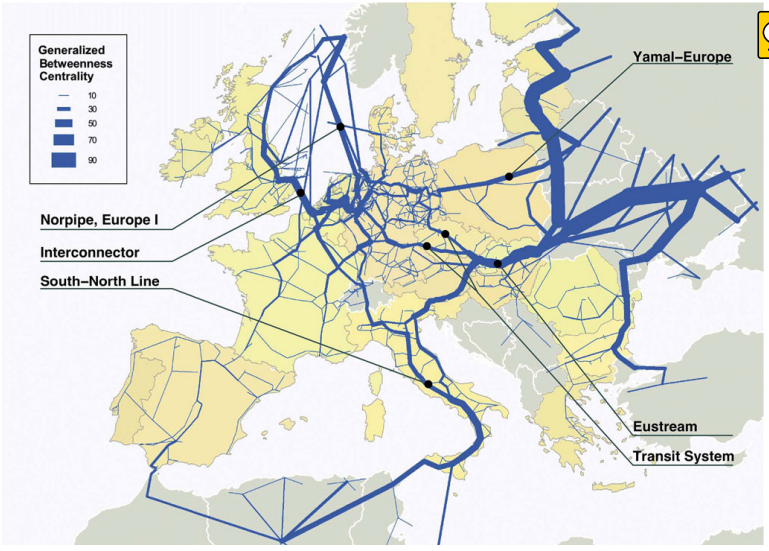
Websites in 2011 (circle size indicates amount of traffic)[1]

[1] Source: http://internet-map.net/



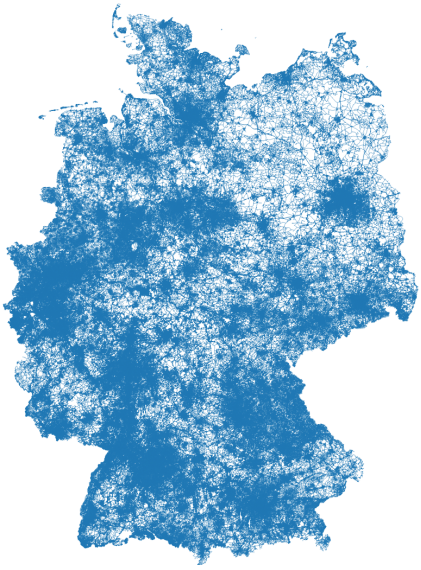
European gas pipeline network[1]

[1]Source: Robustness of trans-European gas networks, Rui Carvalho, Lubos Buzna, Flavio Bono, Eugenio Gutiérrez, Wolfram Just, and David Arrowsmith, Phys. Rev. E 80, 016106, Published 10 July 2009



European gas pipeline network: Generalized Betweenness Centrality[1]

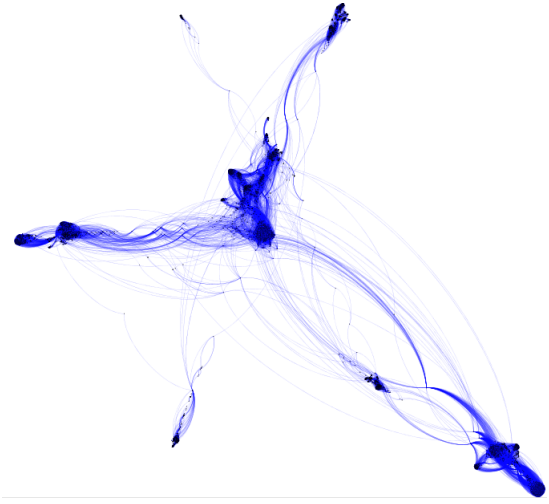
[1]Source: Robustness of trans-European gas networks, Rui Carvalho, Lubos Buzna, Flavio Bono, Eugenio Gutiérrez, Wolfram Just, and David Arrowsmith, Phys. Rev. E 80, 016106, Published 10 July 2009



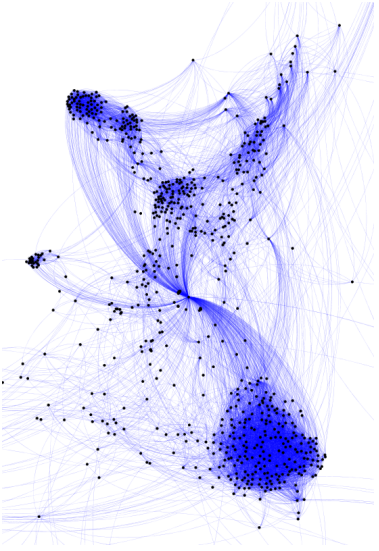
German road network[1]

Berlin/Potsdam road network[1]

[1]Source: Road network data from openstreetmap.org, images by Peter Ruppel

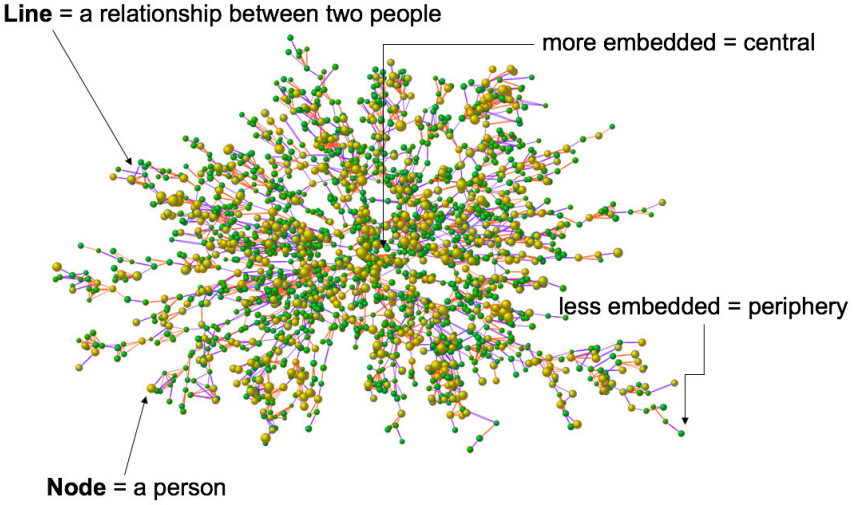


Facebook circles[1]



Facebook circles (excerpt from left graph)[1]

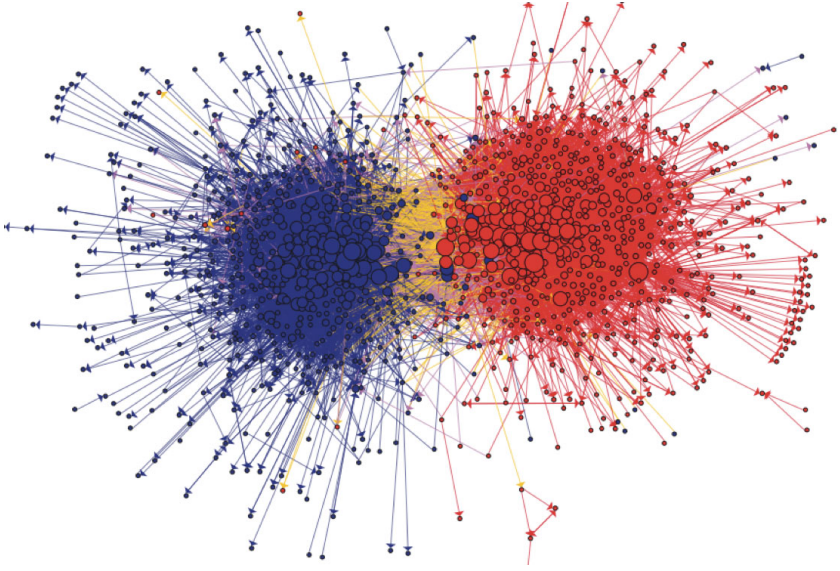
[1]Source: Network data from http://snap.stanford.edu, images by Peter Ruppel



"embedded": the degree to which a person is connected within a network

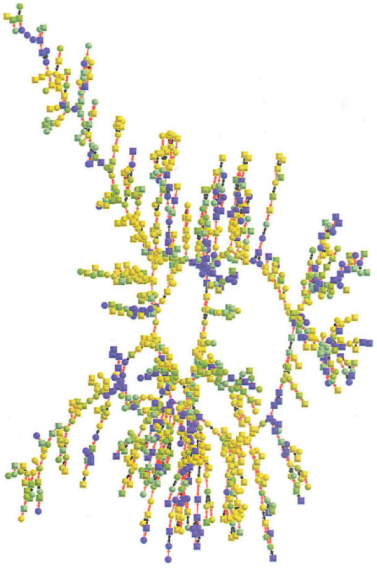
More embedded vs. less embedded nodes[1]

[1] Source: http://www.connectedthebook.com/



Hyperlinks between political blogs[1]

[1] Source: http://www.connectedthebook.com/



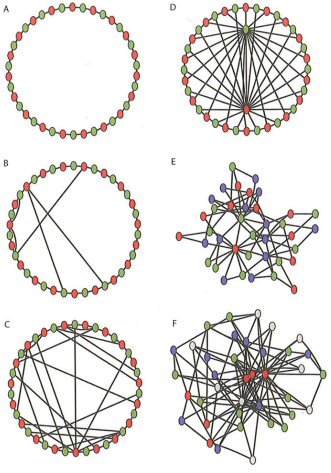
Happiness Network[1]

- A network of 1.020 connected friends, spouses, and siblings from the Framingham Heart Study in the year 2000.
- Each node represents a person and its shape indicate gender (circles are female; squares are male).
- Node colors:
  - Yellow: most happy
  - Green: intermediate
  - Blue: least happy

[1] Source: Nicholas Christakis and James Fowler: Connected, Harper Press, 2011

Challenges for Network Analysis

- When studying networks, we are generally interested in both the **properties of particular nodes** as well as the **properties of the network as a whole**.
- Once certain properties have been found, we can use them within the specific **application domain**.
  - For example, in order to avoid bottlenecks in an infrastructure network or to recommend new contacts within an online social network.



Network configurations[1]

[1] Source: Nicholas Christakis and James Fowler: Connected, Harper Press, 2011