graph theory → *network science*
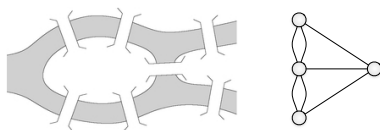
introduction to *network analysis in Python* (*NetPy*)

Lovro Šubelj
University of Ljubljana
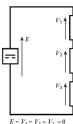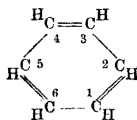10th Dec 2019

history *graph theory*

1736 seven *bridges of Königsberg* [Eul36] (Leonhard Euler)

1800s *travelling salesman* problem (William Hamilton)

1845 *electrical circuit* laws (Gustav Kirchhoff)

1857 *chemical structure* theory (August Kekulé)

1956 *shortest paths* (Edsger Dijkstra)
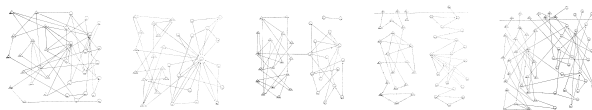
1956 minimum *spanning tree* (Joseph Kruskal)

1956 maximum *flow*/minimum *cut* (Ford & Fulkerson)

1956 *signed graph* theory [CH56] (Cartwright & Harary)

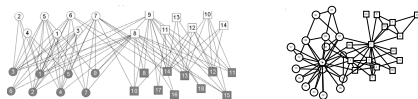1959 *random graph* theory [ER59] (Erdős & Rényi)

history *sociometry*

1934 children *sociograms* [Mor34] (Jacob Moreno)

1967 *small-world* experiment [Mil67] (Stanley Milgram)

1970 university *karate club* [Zac77] (Wayne Zachary)

1973 strength of *weak ties* [Gra73] (Mark Granovetter)

1977 measures of *centrality* [Fre77] (Linton Freeman)
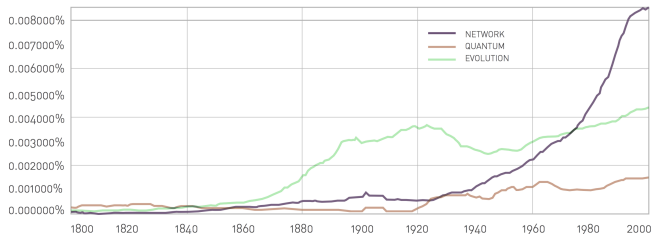
network *data*

< 2000 *small graphs* 10^2-10^3 nodes

≈ 2000 *communication networks* 10^5-10^8 nodes
≈ 2005 *online social networks* 10^8 nodes

today *Facebook graph* $> 10^9$ users
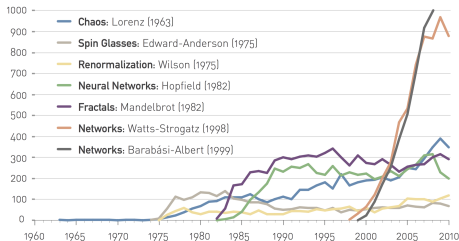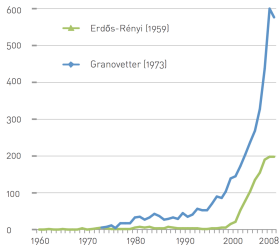today *Web graph* $> 10^{12}$ pages

network *models*

1959 *random graph* theory [ER59]
1973 *valued graphs* theory [Gra73]

1998 *small-world network* structure [WS98]
1999 *scale-free network* structure [BA99]

network *language*

"*A key discovery of network science is that the architecture of networks emerging in various domains of science, nature, and technology are similar to each other, a consequence of being governed by the same organizing principles. Consequently we can use a common set of tools to explore these systems.*"

Albert-László Barabási

"*Networks are ideal structures to describe problems of organized complexity.*"

César A. Hidalgo

"*I think the 21st century will be the century of complexity.*"

Stephen Hawking

problem
understanding *real networks*

means
study of *network properties*
design of *mathematical models*
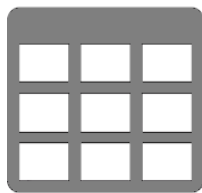*implementation* of *efficient algorithms*

goals
network *structure* and *evolution*
nodes, fragments, clusters, layers, network
network *dynamics* and *processes*
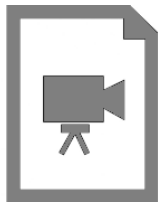spreading, diffusion, epidemics
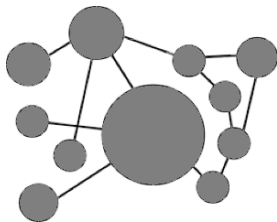
network *analysis*

data mining

text mining

computer vision

network analysis

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