# graph theory $\longrightarrow$ *network science*

introduction to *network science in Python* (*NetPy*)

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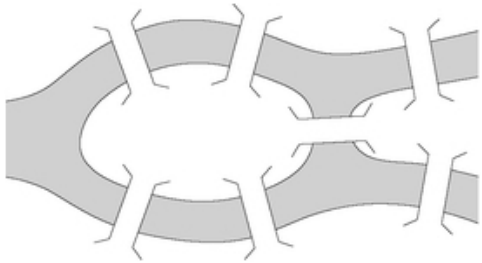
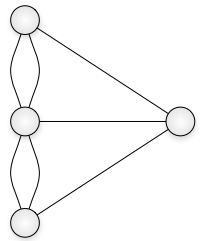
3rd Dec 2022

# history *graph theory*

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

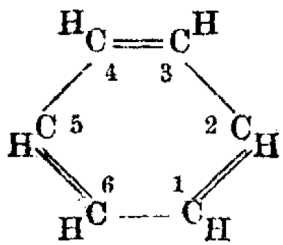
1800s *travelling salesman* problem (William Hamilton)

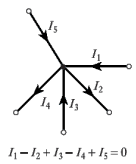


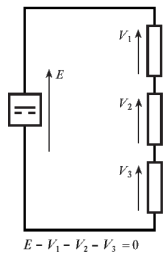


1845 *electrical circuit* laws (Gustav Kirchhoff)

1857 *chemical structure* theory (August Kekulé)



# history *operations research*

1956 *shortest paths* (Edsger Dijkstra)

1956 minimum *spanning tree* (Joseph Kruskal)

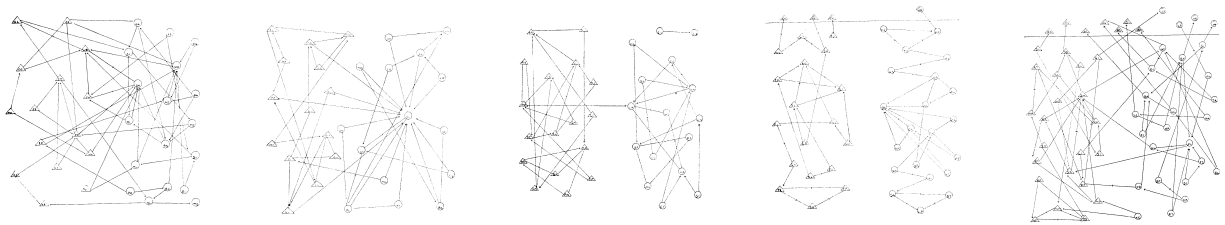
1956 maximum *flow*/minimum *cut* (Ford & Fulkerson)

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

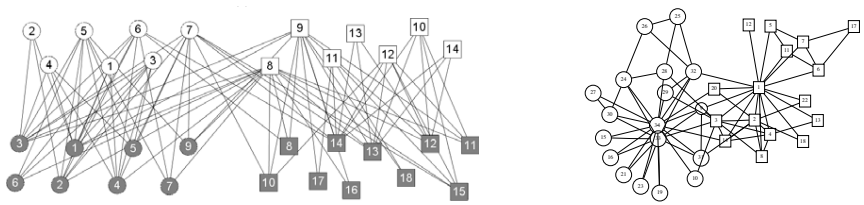
1959 *random graph* theory [ER59] (Erdős & Rényi)

# history *sociometry*

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



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



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

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

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

# revolution *data*

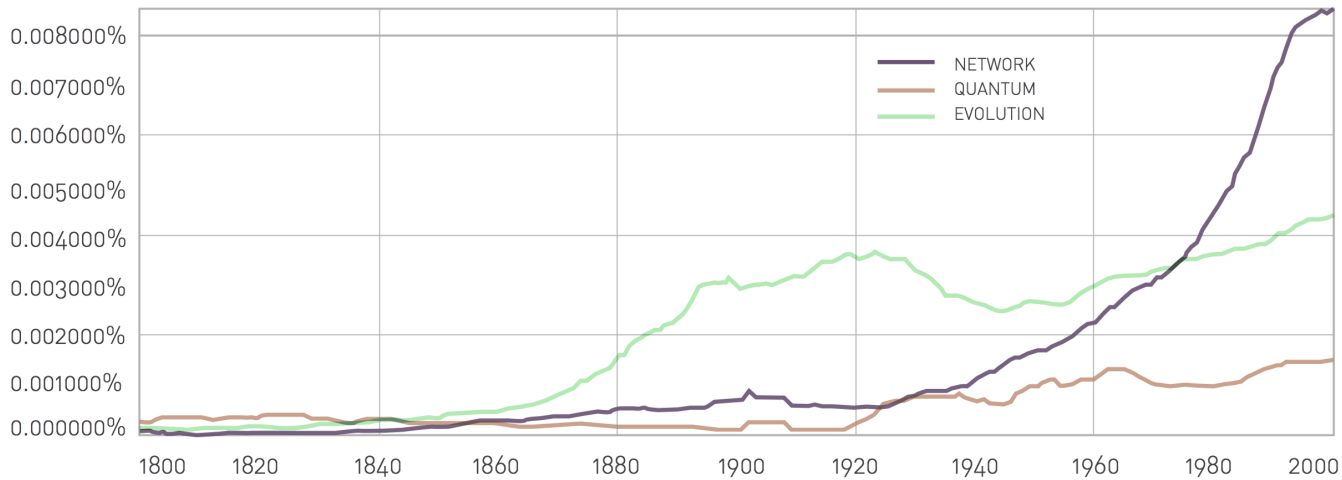
$< 2000$ *small graphs* $10^2$-$10^3$ nodes

$\approx 2000$ *communication networks* $10^5$-$10^8$ nodes

$\approx 2005$ *online social networks* $10^8$ nodes

today *Facebook graph* $> 10^9$ users

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



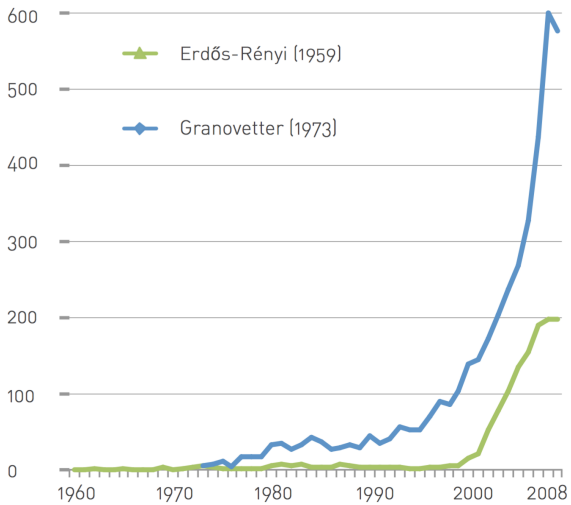
# revolution *models*

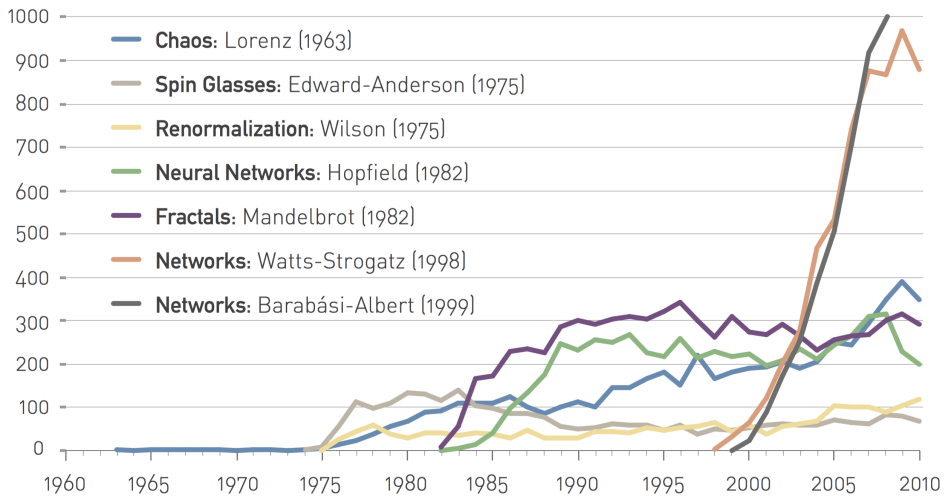
1959 *random graph* models [ER59]

1973 *valued graphs* models [Gra73]

1998 *small-world network* structure [WS98]

1999 *scale-free network* structure [BA99]



# revolution *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*

# network *science*

## problem

understanding *real networks*

## means

*study* of *network properties*

*design* of *mathematical models*

*implementation* of *efficient algorithms*

## goals

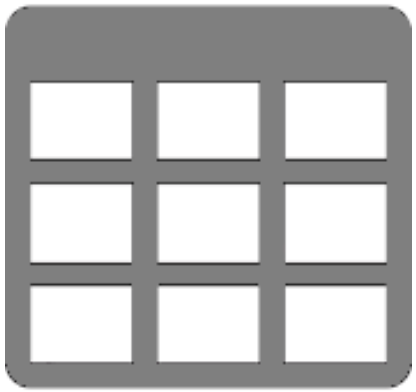
network *structure* and *evolution*

nodes, links, fragments, clusters, layers, network

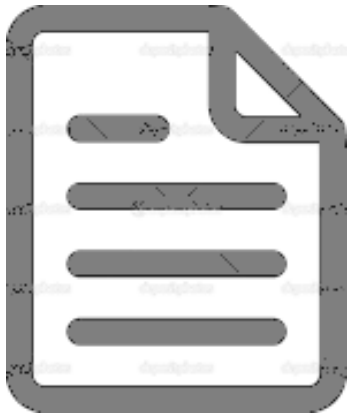
network *dynamics* and *processes*

spreading, diffusion, epidemics

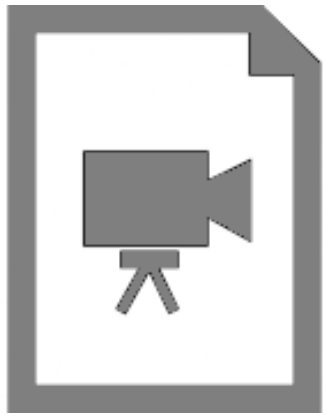
# network *analysis*



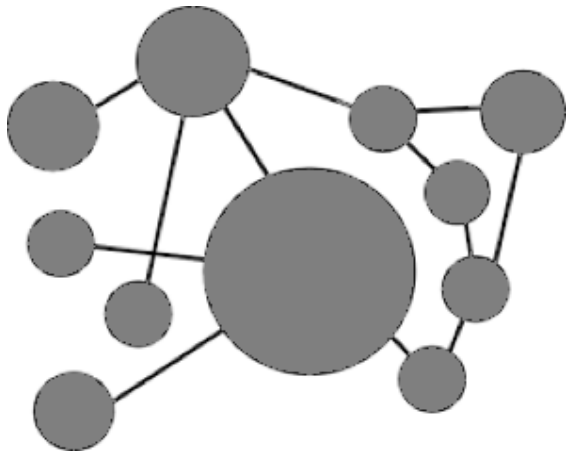
*data mining*



*text mining*



*computer vision*



*network analysis*

# history *references*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