

Network theory

Introduction and basic concepts



Complexity in Social Systems
AA 2023/2024
Maxime Lucas
Lorenzo Dall'Amico

Course Organisation

- 48 hours :
 - 24 h about network theory and structure
 - 24 h about dynamical systems on networks + advanced topics
- Theory + practical code notebooks



Complexity in social systems

Search this book...

Coursebook for "Complessità nei Sistemi Sociali"

INTRODUCTION

- 1. Python is easy :)
- 2. Basic network import and representation

NETWORKX BASICS

- 3. Introduction to NetworkX
- 4. How to fit a power law distribution
- 5. Basics of network analysis

SPREADING MODELS

- 6. Epidemic modeling, deterministic and stochastic models
- 7. Epidemics on networks
- 8. Epidemics on temporal networks

Community detection

- 9. Community detection

Next >
1. Python is easy :)

Laurea Magistrale in Fisica Dei Sistemi Complessi A.A. 2021/22
Lecturers: Michele Tizzoni, Giovanni Petri
Course overview
Introduction
NetworkX Basics
Spreading models
Community detection
By G. Petri, M. Tizzoni
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Notebook 01

Some info:

- the notebooks will be available throughout the course at: <https://maximelucas.github.io/complexity-book/>
- The source is at: <https://github.com/maximelucas/complexity-book>
- course material: <https://elearning.unito.it/scienzedellanatura/course/view.php?id=3440>
- Other course page: <https://fisica-sc.campusnet.unito.it/do/didattica.pl/Quest?corso=4ef1>
- Email contacts: maxime.lucas@centai.eu lorenzo.dallamico@isi.it (DO NOT WRITE TO @unito EMAILS please)

Exam modality

Exam is divided in two parts:

- A. Talk/Presentation
- B. Questions on course material

Two options for (A):

- i. Talk (15mins) based on a chosen paper on networks and/or adjacent subjects
 - i.i. **Any paper** is fine, if in doubt, **ASK!**
 - i.ii. "**READ AROUND THE PAPER**": expect questions not just on the paper, but on related ideas/concepts
- ii. Presentation (15min) on small data analysis project on networks
 - ii.i. Again, **any project** is fine, but do ask to check data is appropriate/not too much time, etc.
 - ii.ii. Do present slides, not just code.

Be smart about (B): it's likely we will ask questions on topics:
1.related to talk (**READ AROUND**)
2.**AND** to something completely different (**STUDY EVERYTHING!**)

Complex

[adj., v. kuh m-pleks, kom-pleks; n. kom-pleks]

—adjective

1.

composed of many interconnected parts; compound; composite: a complex highway system.

2.

characterized by a very complicated or involved arrangement of parts, units, etc.: complex machinery.

3.

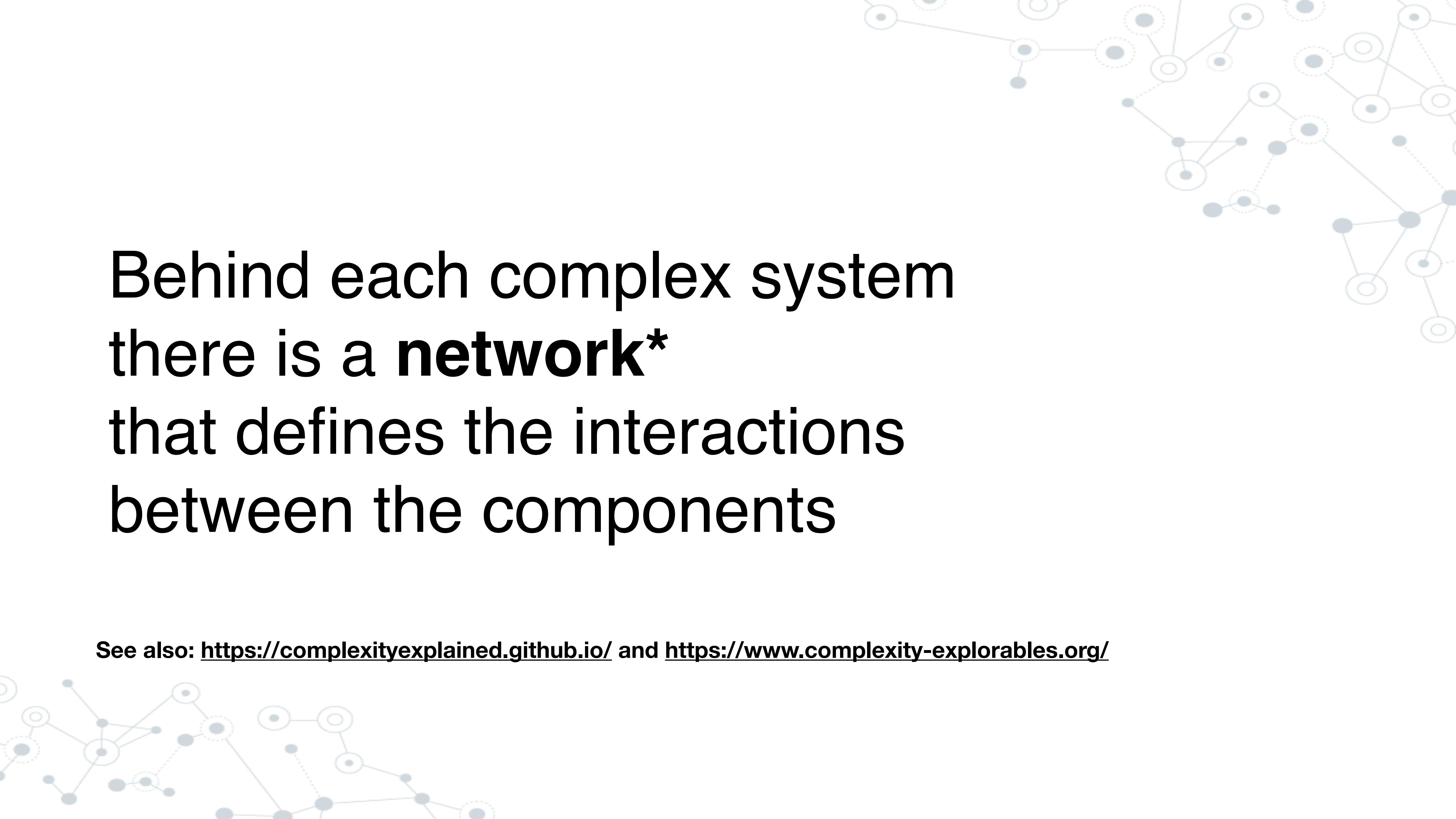
so complicated or intricate as to be hard to understand or deal with: a complex problem.

Source: Dictionary.com

Complexity, a **scientific theory** which asserts that some systems display behavioral phenomena that are completely inexplicable by any conventional analysis of the systems' constituent parts. These phenomena, commonly referred to as emergent behaviour, seem to occur in many complex systems involving living organisms, such as a stock market or the human brain.

Source: John L. Casti, Encyclopædia Britannica

Complexity



Behind each complex system
there is a **network***
that defines the interactions
between the components

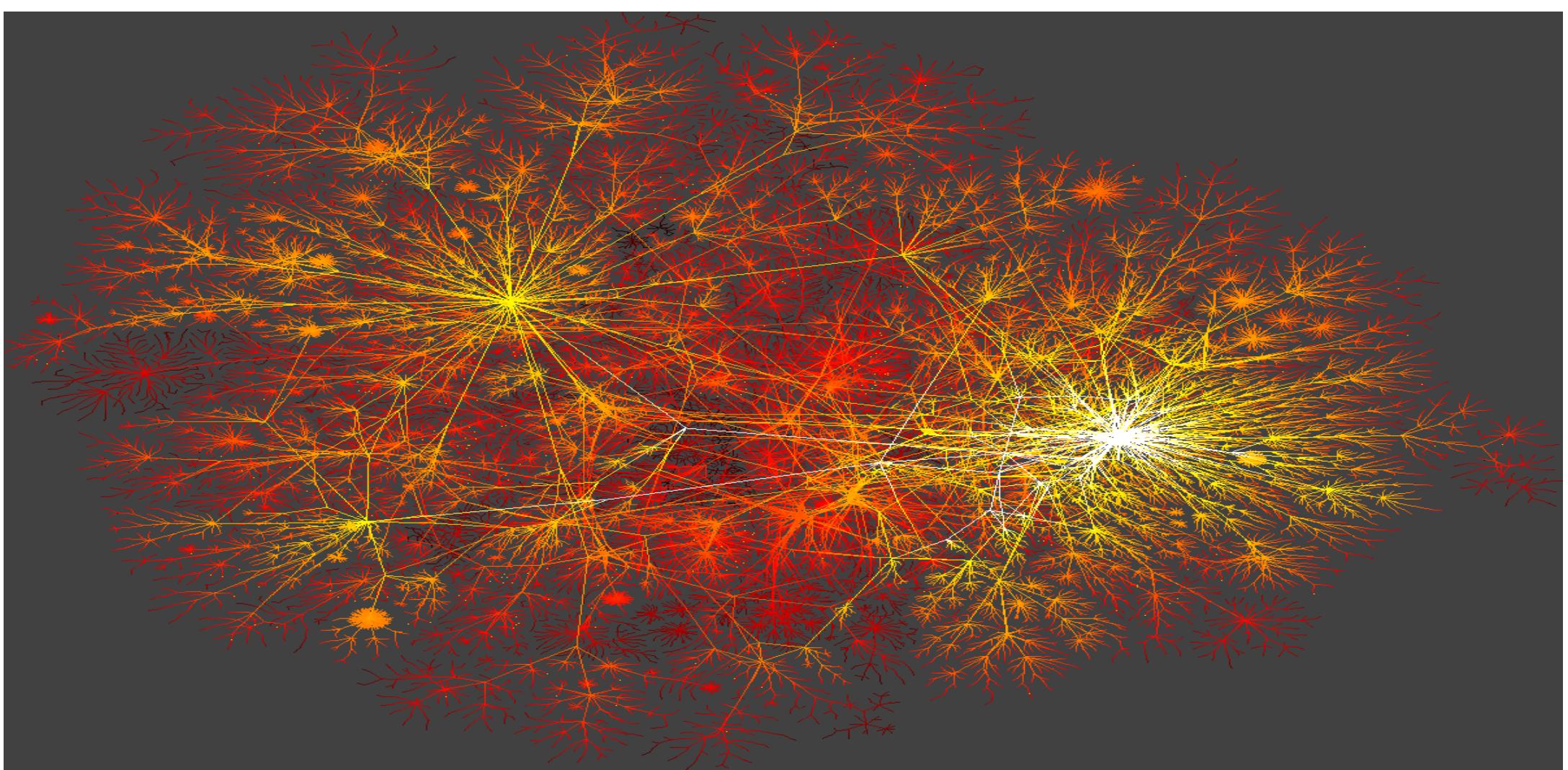
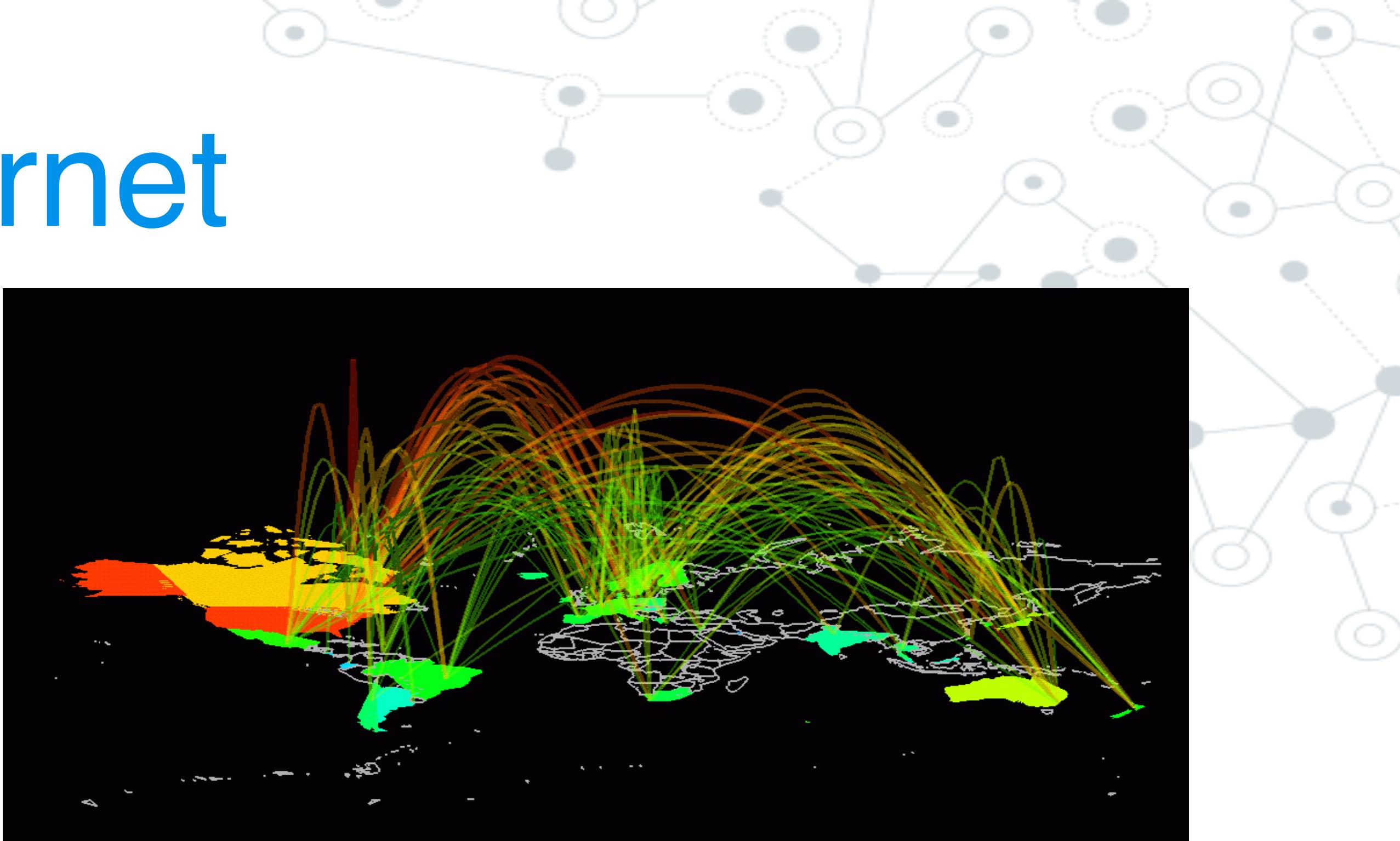
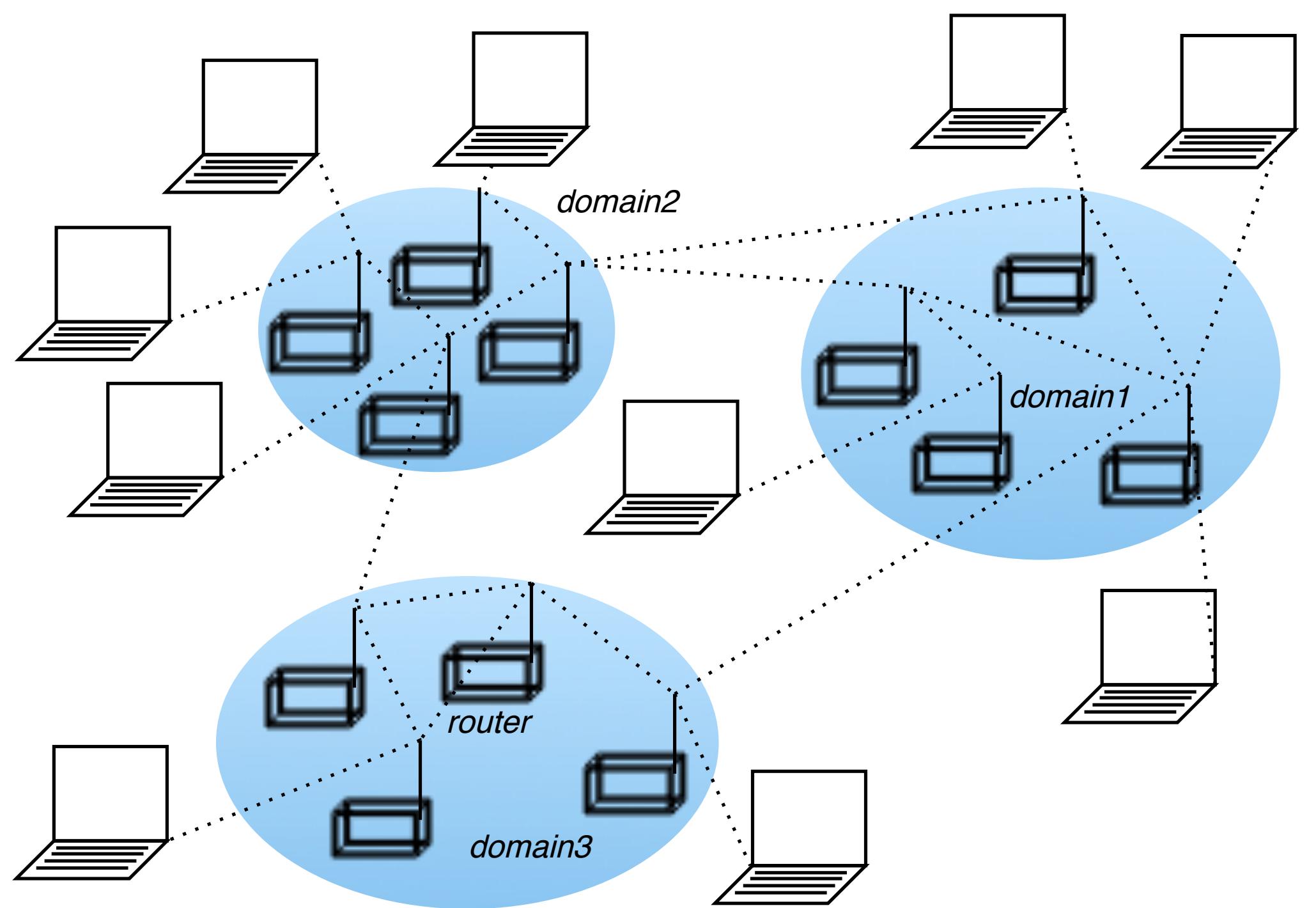
See also: <https://complexityexplained.github.io/> and <https://www.complexity-explorables.org/>

data mining and relational data

- Big Data not natively in structured format
- “The value of data explodes when it can be linked”
- “at the end of the 90s a new analytical trend joined data mining and machine learning: the emergence of **network science**”

Amato, G., et al. (2018). How Data Mining and Machine Learning Evolved from Relational Data Base to Data Science. Springer

internet



online interactions

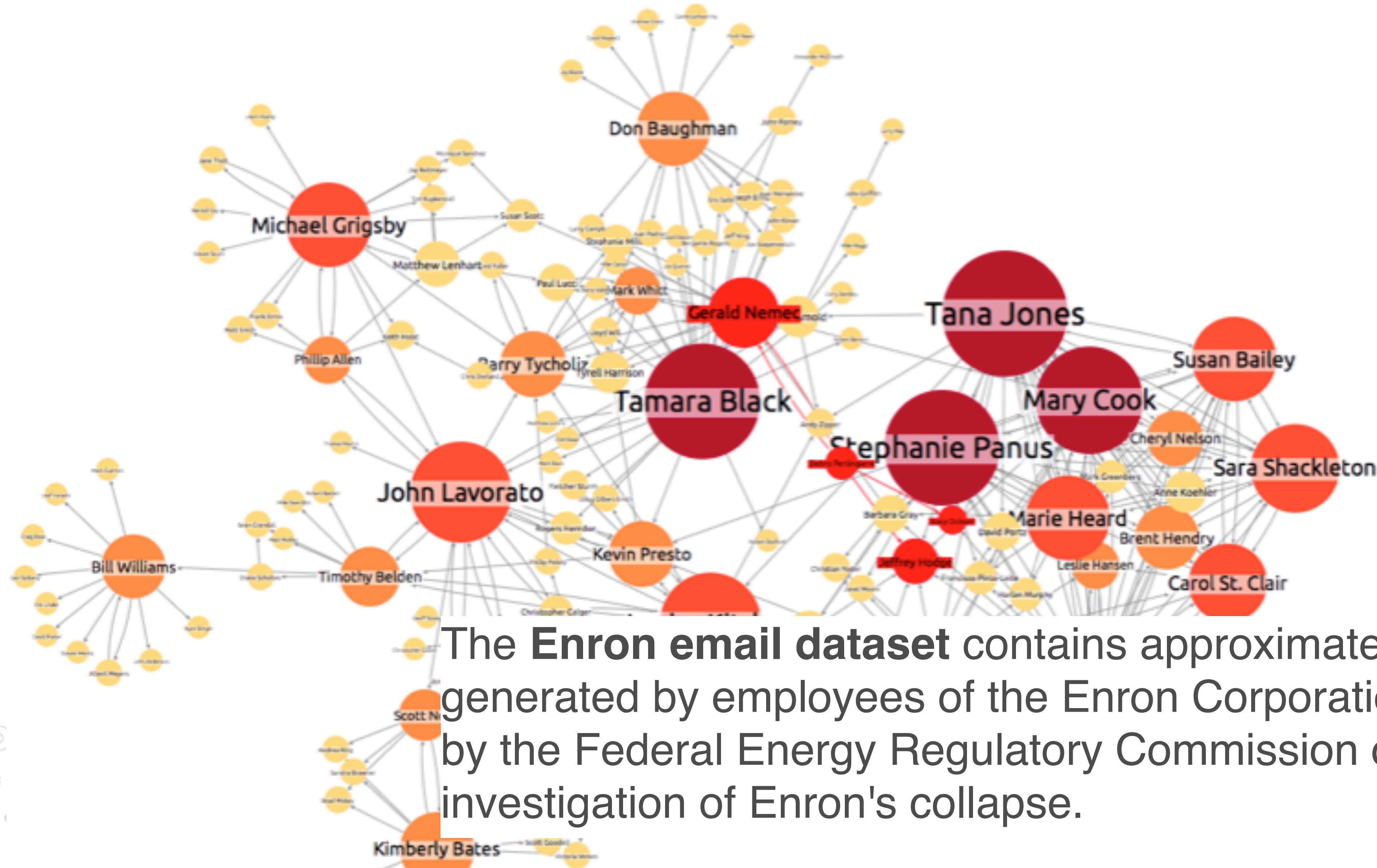


facebook

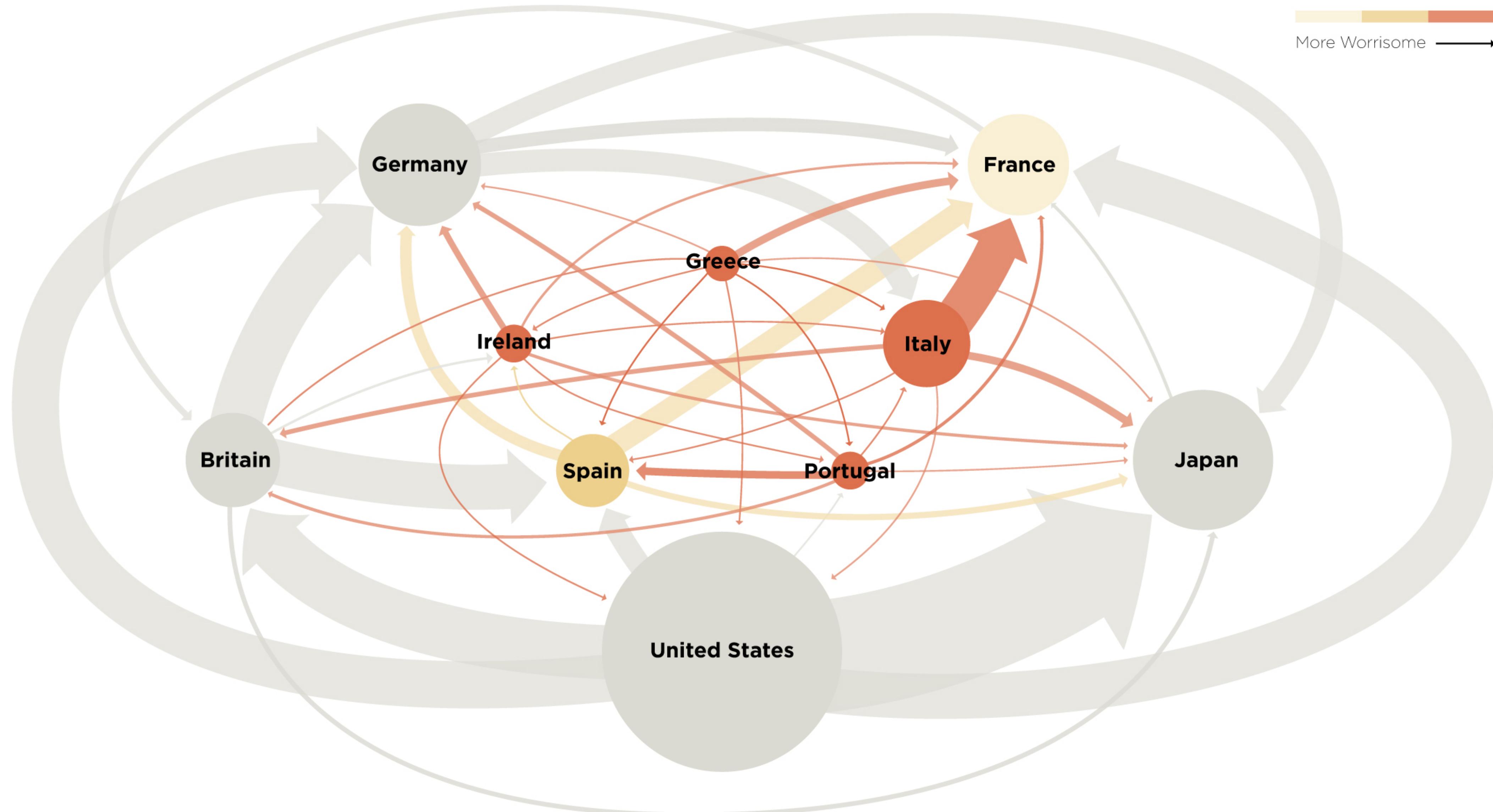
P. Butler

December 2010

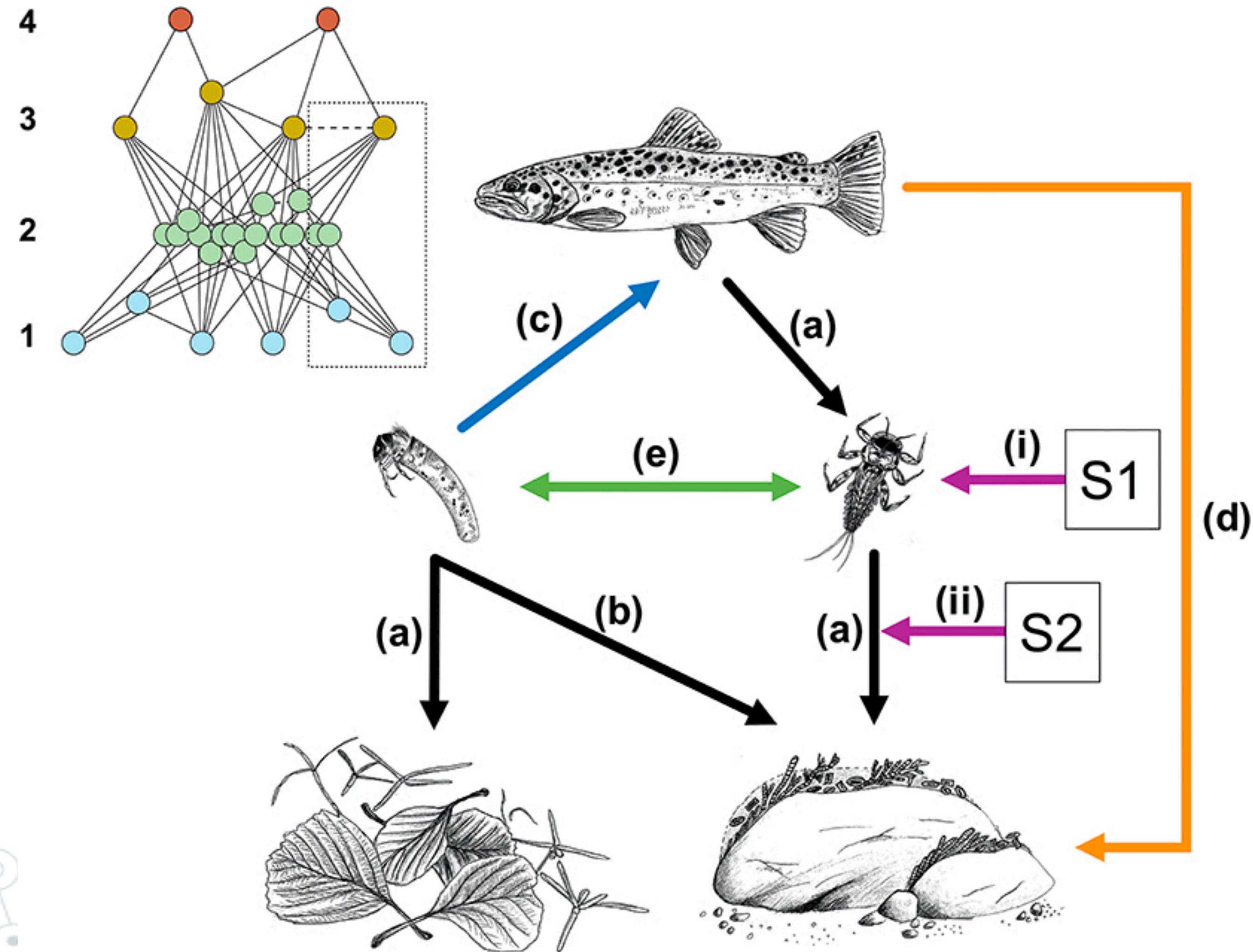
email communication



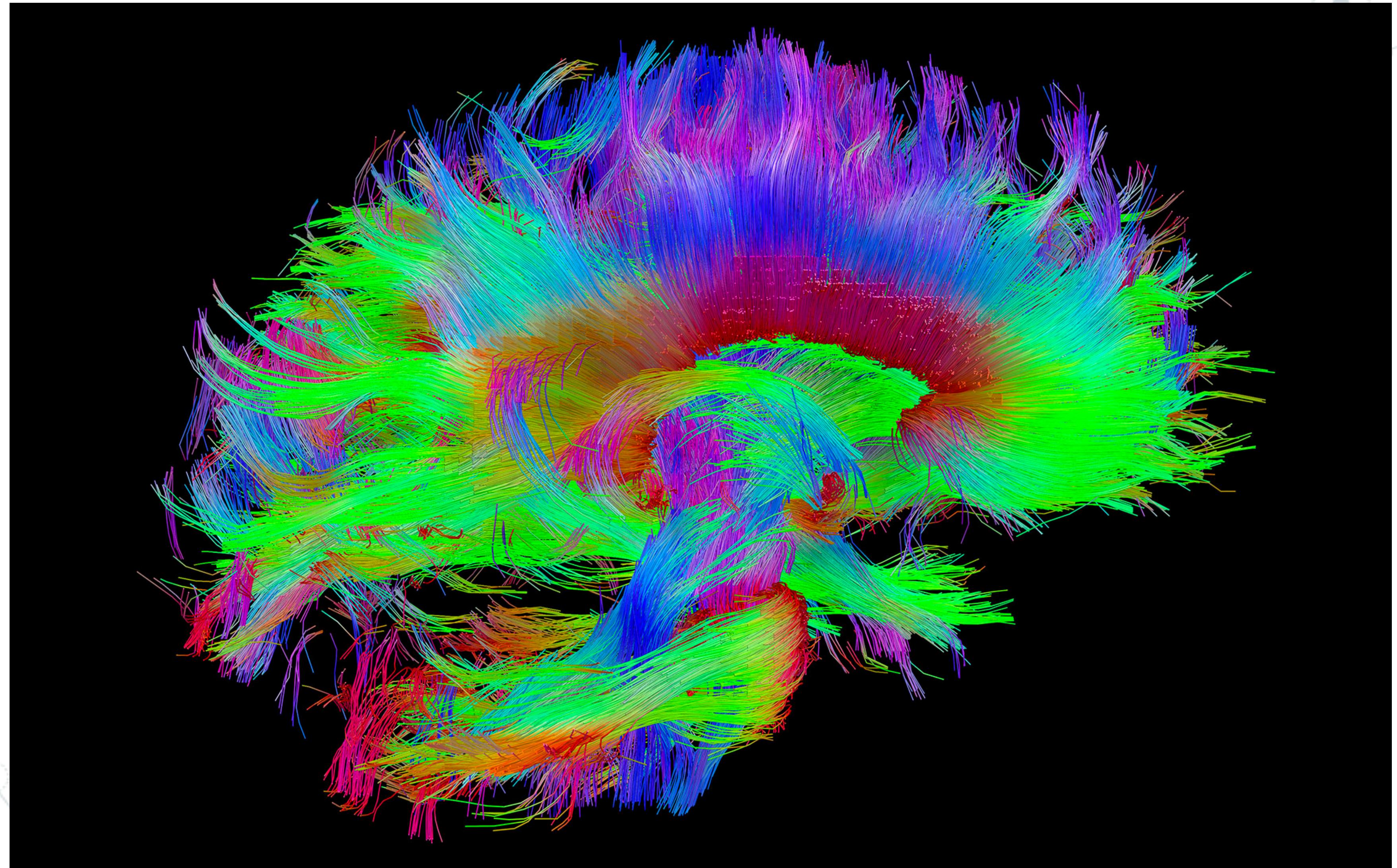
financial networks

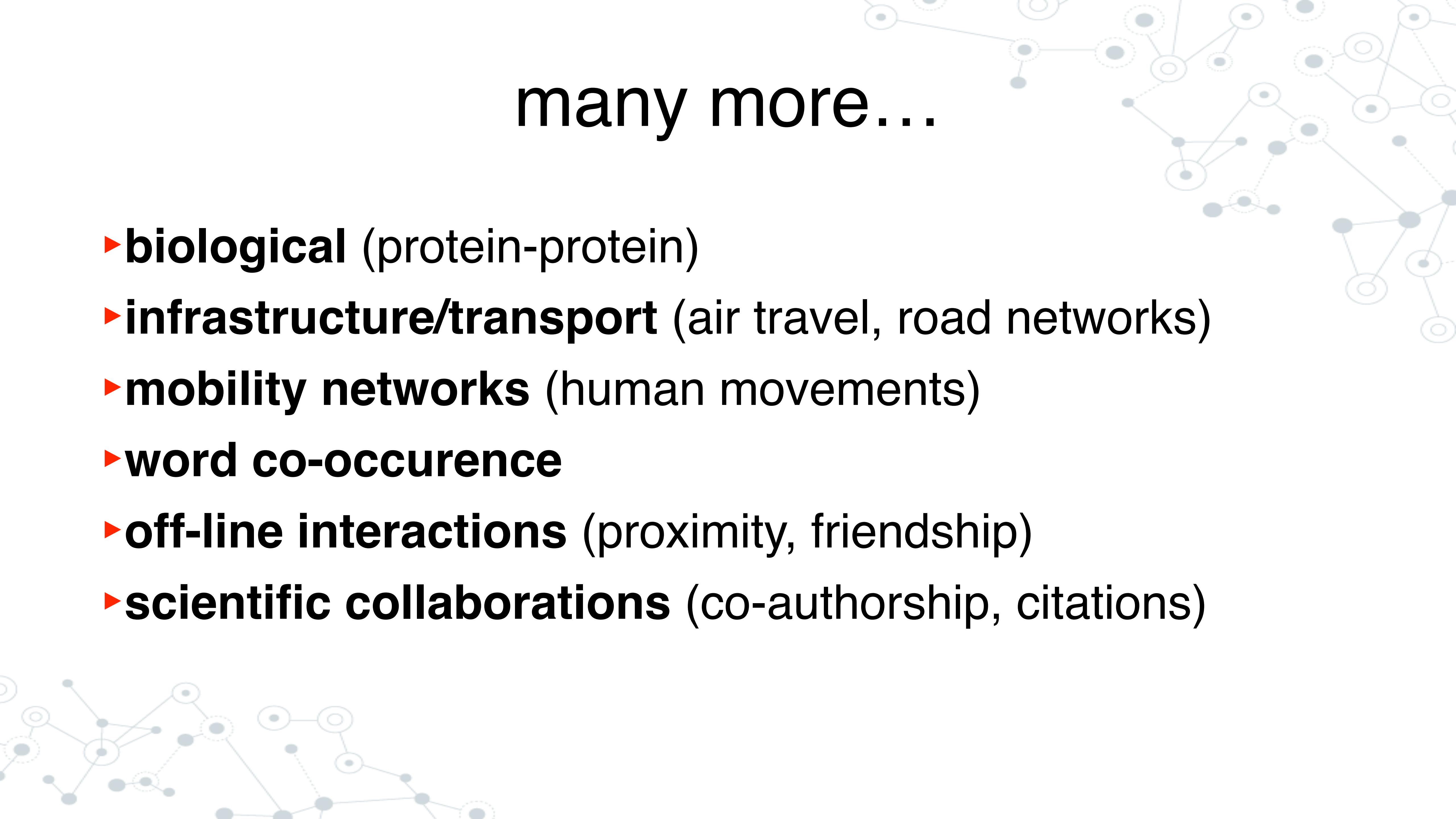


Ecological networks



Brain networks





many more...

- ▶ **biological** (protein-protein)
- ▶ **infrastructure/transport** (air travel, road networks)
- ▶ **mobility networks** (human movements)
- ▶ **word co-occurrence**
- ▶ **off-line interactions** (proximity, friendship)
- ▶ **scientific collaborations** (co-authorship, citations)

network datasets

<http://snap.stanford.edu>

By Jure Leskovec

STANFORD
UNIVERSITY



- [SNAP for C++](#)
- [SNAP for Python](#)
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Stanford Large Network Dataset Collection

- [Social networks](#) : online social networks, edges represent interactions between people
- [Networks with ground-truth communities](#) : ground-truth network communities in social and information networks
- [Communication networks](#) : email communication networks with edges representing communication
- [Citation networks](#) : nodes represent papers, edges represent citations
- [Collaboration networks](#) : nodes represent scientists, edges represent collaborations (co-authoring a paper)
- [Web graphs](#) : nodes represent webpages and edges are hyperlinks
- [Amazon networks](#) : nodes represent products and edges link commonly co-purchased products
- [Internet networks](#) : nodes represent computers and edges communication
- [Road networks](#) : nodes represent intersections and edges roads connecting the intersections
- [Autonomous systems](#) : graphs of the internet
- [Signed networks](#) : networks with positive and negative edges (friend/foe, trust/distrust)
- [Location-based online social networks](#) : Social networks with geographic check-ins
- [Wikipedia networks, articles, and metadata](#) : Talk, editing, voting, and article data from Wikipedia
- [Temporal networks](#) : networks where edges have timestamps
- [Twitter and Memetracker](#) : Memetracker phrases, links and 467 million Tweets
- [Online communities](#) : Data from online communities such as Reddit and Flickr
- [Online reviews](#) : Data from online review systems such as BeerAdvocate and Amazon

SNAP networks are also available from [SuiteSparse Matrix Collection](#) by [Tim Davis](#).

tools

- network visualization
 - Gephi
 - D3
 - igraph

- Python libraries
 - NetworkX
 - Graph-tool
 - SNAP



NetworkX

approaches

- ▶ **Physics of complex systems**
 - ▶ microscopic modeling
 - ▶ statistical physics tools (mean-field)
 - ▶ universal features

- ▶ **Computer science**
 - ▶ machine learning
 - ▶ link prediction
 - ▶ classification
 - ▶ clustering

ranking

Google network science

Tutti Immagini Notizie Libri Video Altro Impostazioni Strumenti

Circa 2.790.000.000 risultati (0,53 secondi)

Suggerimento: Cerca risultati solo in italiano. Puoi specificare la lingua di ricerca in Preferenze.

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Network science is an academic field which studies complex networks such as telecommunication networks, computer networks, biological networks, cognitive and semantic networks, and social networks, considering distinct elements or actors represented by nodes (or vertices) and the connections between the elements or ...

Network science - Wikipedia
https://en.wikipedia.org/wiki/Network_science

Informazioni su questo risultato Feedback

Network science - Wikipedia
https://en.wikipedia.org/wiki/Network_science ▾ Traduci questa pagina
Network science is an academic field which studies complex networks such as telecommunication networks, computer networks, biological networks, cognitive and semantic networks, and social networks, considering distinct elements or actors represented by nodes (or vertices) and the connections between the elements or ...



Network science

Campo di studi

Tradotto dall'inglese - La scienza di rete è un campo accademico che studia reti complesse come reti di telecomunicazione, reti di computer, reti biologiche, reti cognitive e semantiche e reti sociali, considerando i diversi elementi o attori rappresentati dai nodi e le connessioni tra gli elementi o gli attori come collegamenti. [Wikipedia \(inglese\)](#)

Vedi la descrizione originale ▾

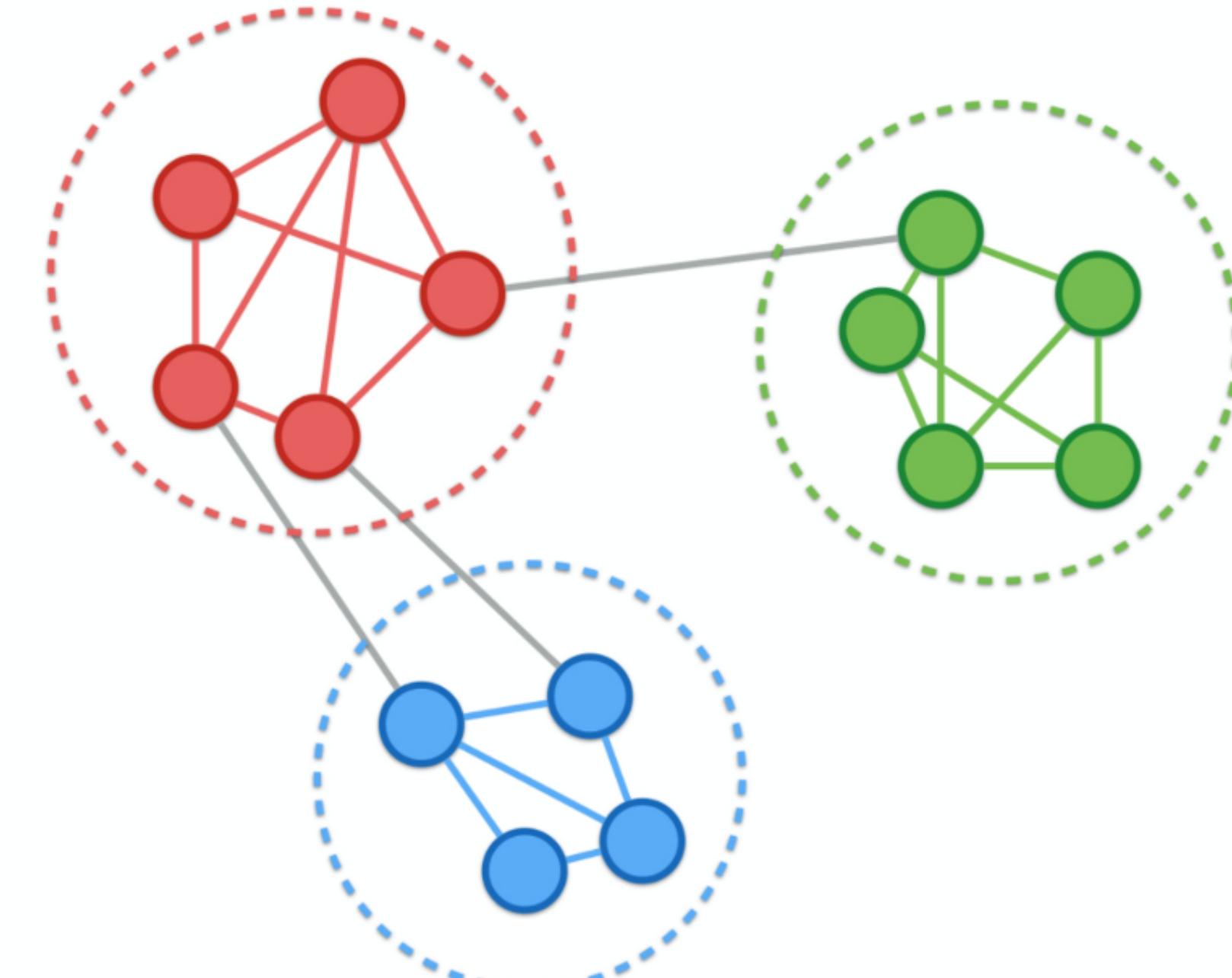
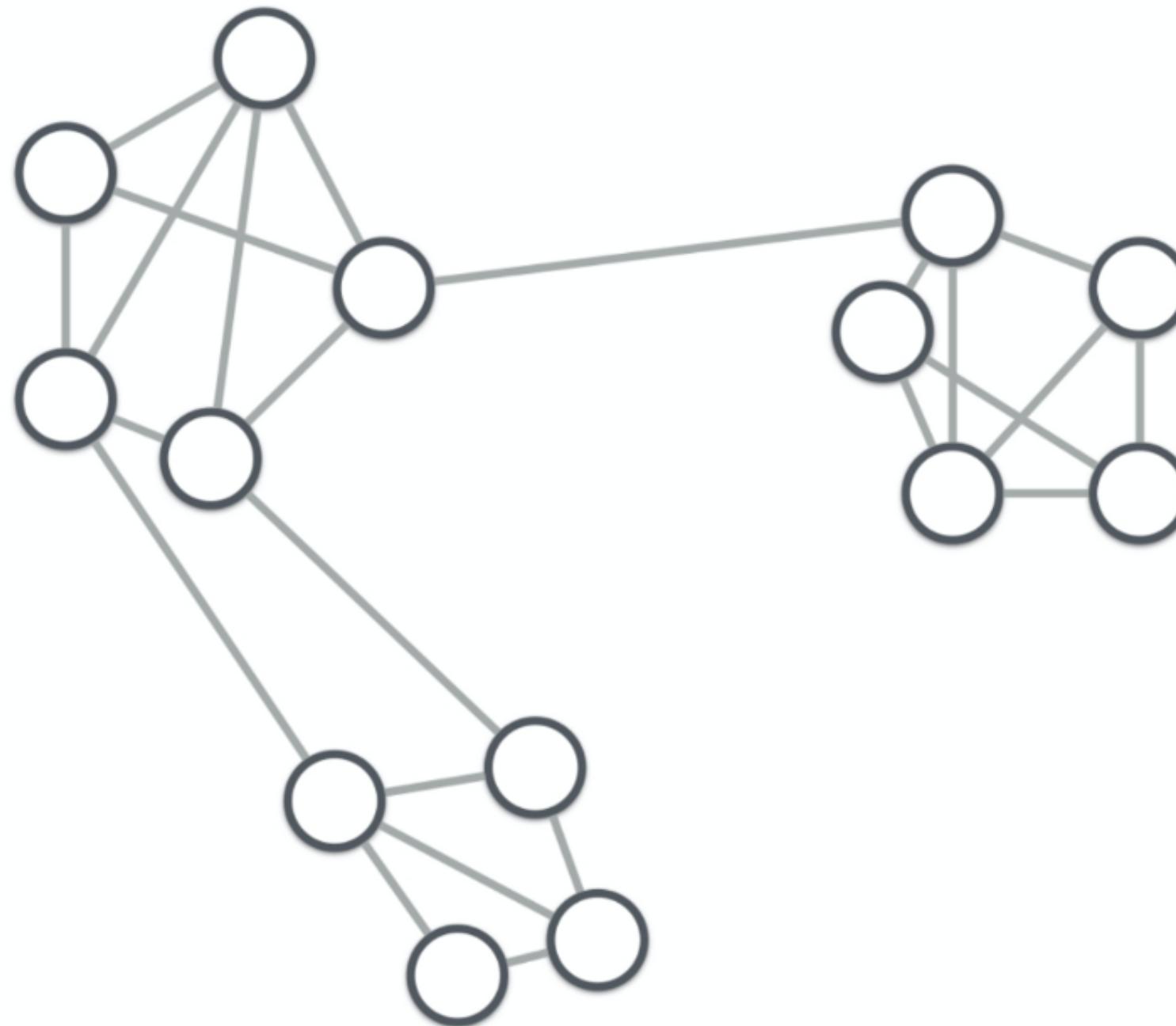
Ricerche correlate

Visualizza altri 10 elementi

Algoritmo Apprendi... automatico Rete di computer Ottimizza... Ricerca scientifica

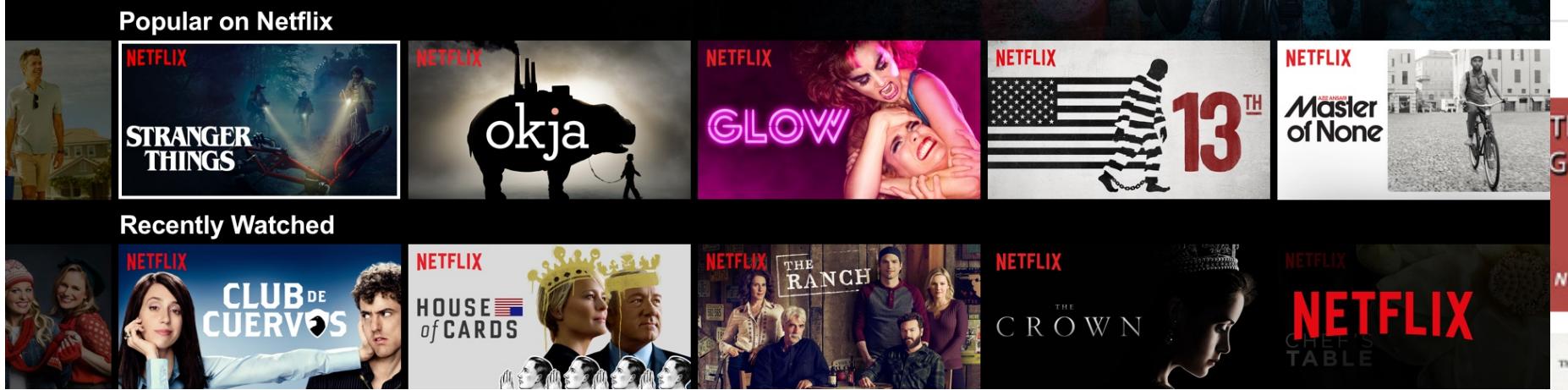
Feedback

community detection



*application: identify similar customers
based on their purchases*

recommendation



Recommended for you, Thomas

<p>Literature & Fiction 62 ITEMS</p> A grid of book covers including 'Think and Grow Rich' by Napoleon Hill, 'The Adventures of Huckleberry Finn' by Mark Twain, 'The Barn in the Woods' by Marcus Aurelius, and 'italo calvino'.	<p>Exercise & Fitness Equipment 8 ITEMS</p> A grid of fitness equipment including a green foam roller, a black kettlebell, and various colored resistance bands.	<p>Health, Fitness & Dieting Books 37 ITEMS</p> A grid of books including 'SUPERHUMAN FOCUS' by Patrick King, 'FANTASTIC VOYAGE' by Ray Kurzweil, 'TURBO MLM SUCCESS' by Ron G Holland, and 'How to Beat Procrastination, Manage Your Time, and Double Your Output' by Mark Twain.	<p>Tableware 12 ITEMS</p> A grid of tableware including a silver thermos, several white rings, a set of metal coasters, and a box of coffee cups.
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<p>Prime Video – Unlimited Streaming for Prime Members 12 ITEMS</p> A grid of Prime Video show posters including 'CATASTROPHE' and 'The Crown'.	<p>Coffee, Tea & Espresso 98 ITEMS</p> A grid of tea tin boxes from Harney & Sons, including 'SOHO CHOCOLATE & COCONUT', 'POMEGRANATE COCONUT', 'PARIS', and 'HT'.	<p>Biographies & Memoirs 17 ITEMS</p> A grid of biographies and memoirs including 'MARK CUBAN WISDOM', 'SAM WALTON Made in America', 'TIP REARDON WITHIN', 'DISPLAY OF POWER', and 'THE BEARD WITHIN'.	<p>Engineering Books 7 ITEMS</p> A grid of engineering books including 'MONETIZING INNOVATION', 'THE SECOND MACHINE AGE', 'Make: FPGAs', 'The E Myth Contractor', and 'The E Myth'.
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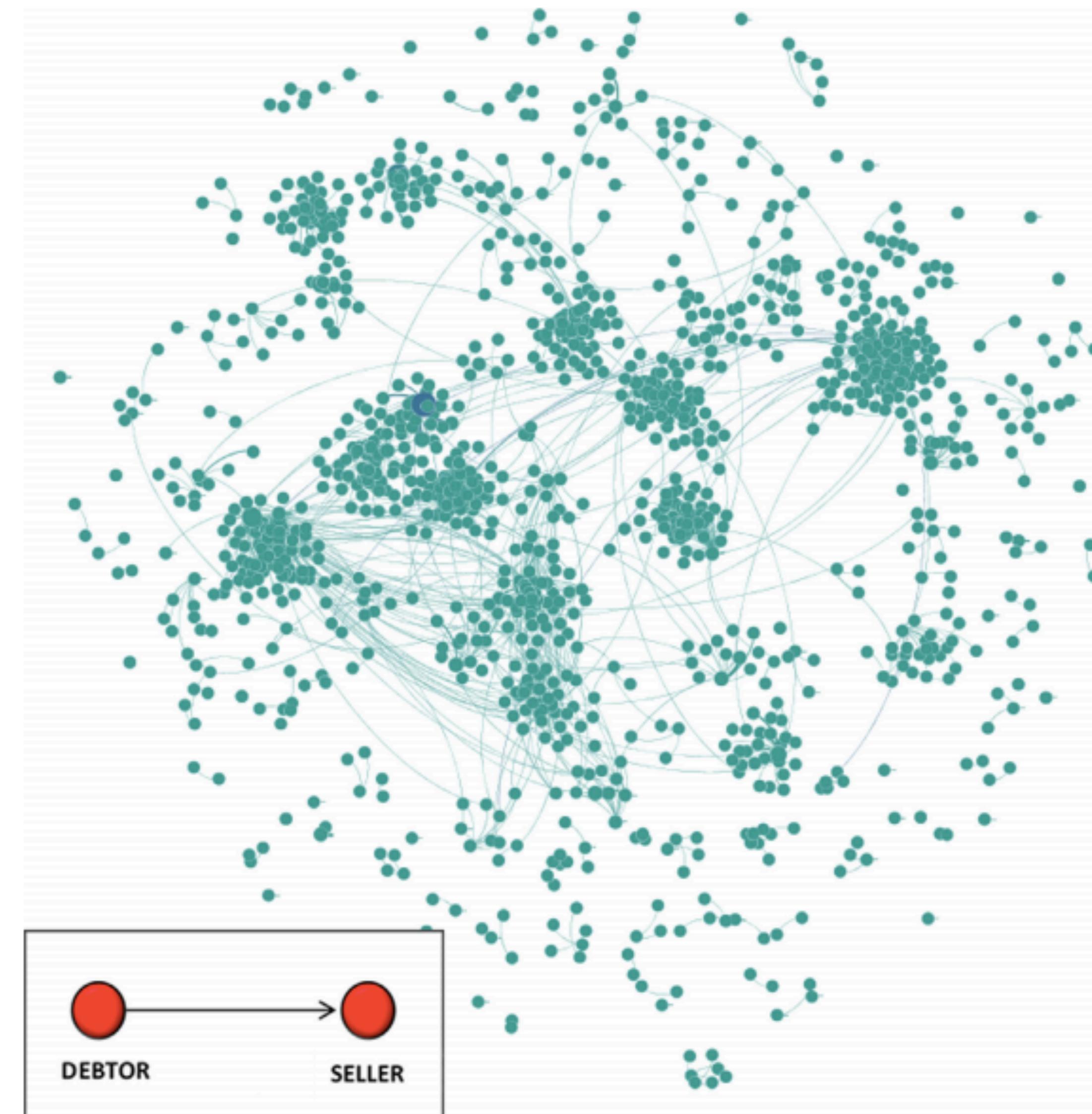
fraud detection

Using social network analysis to prevent money laundering

Andrea Fronzetti Colladon*, Elisa Remondi

University of Rome Tor Vergata, Department of Enterprise Engineering, Via del Politecnico, 1-00133 Rome, Italy

*identify nodes at higher risk of fraud
based on their features and position
in the transaction network*

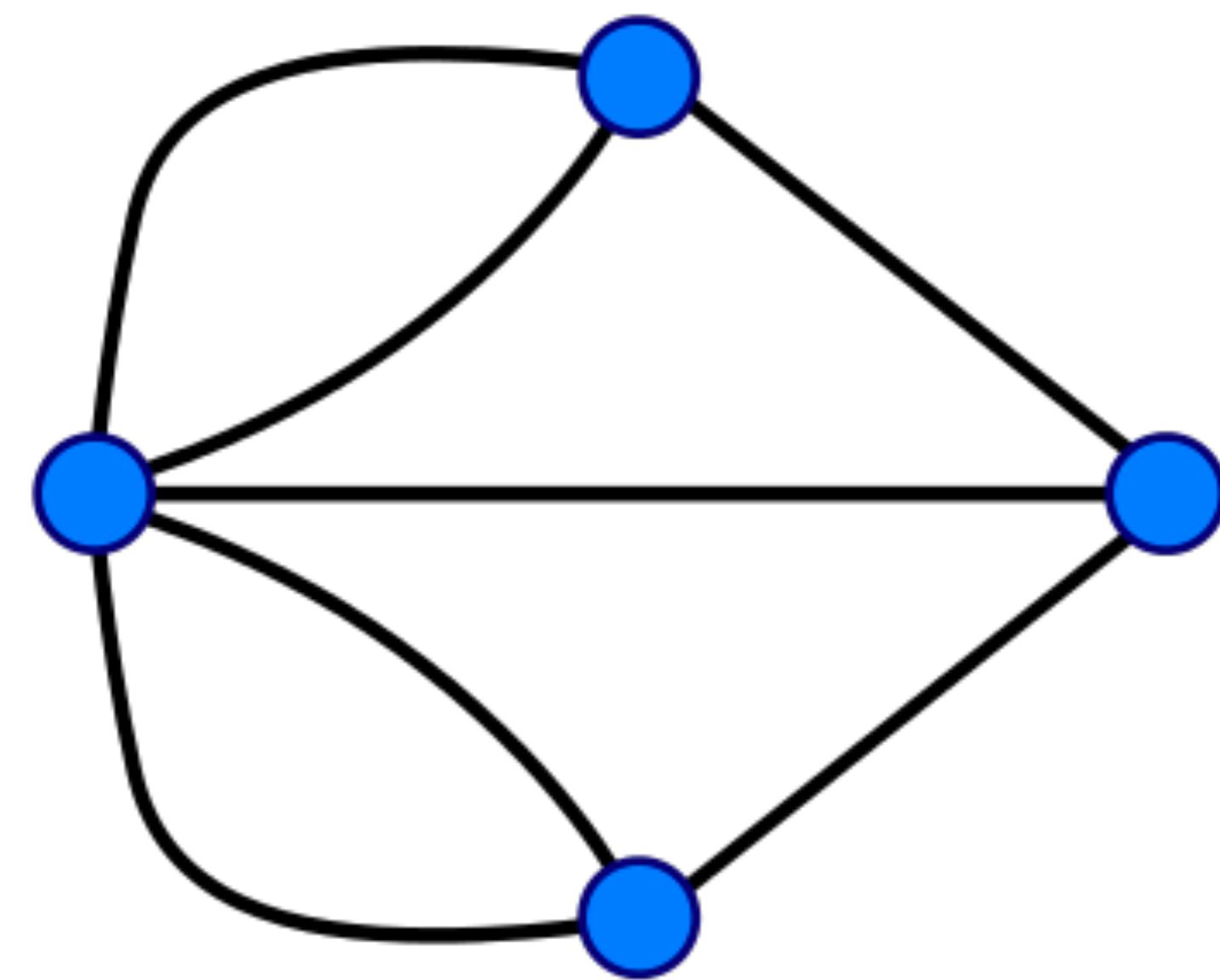
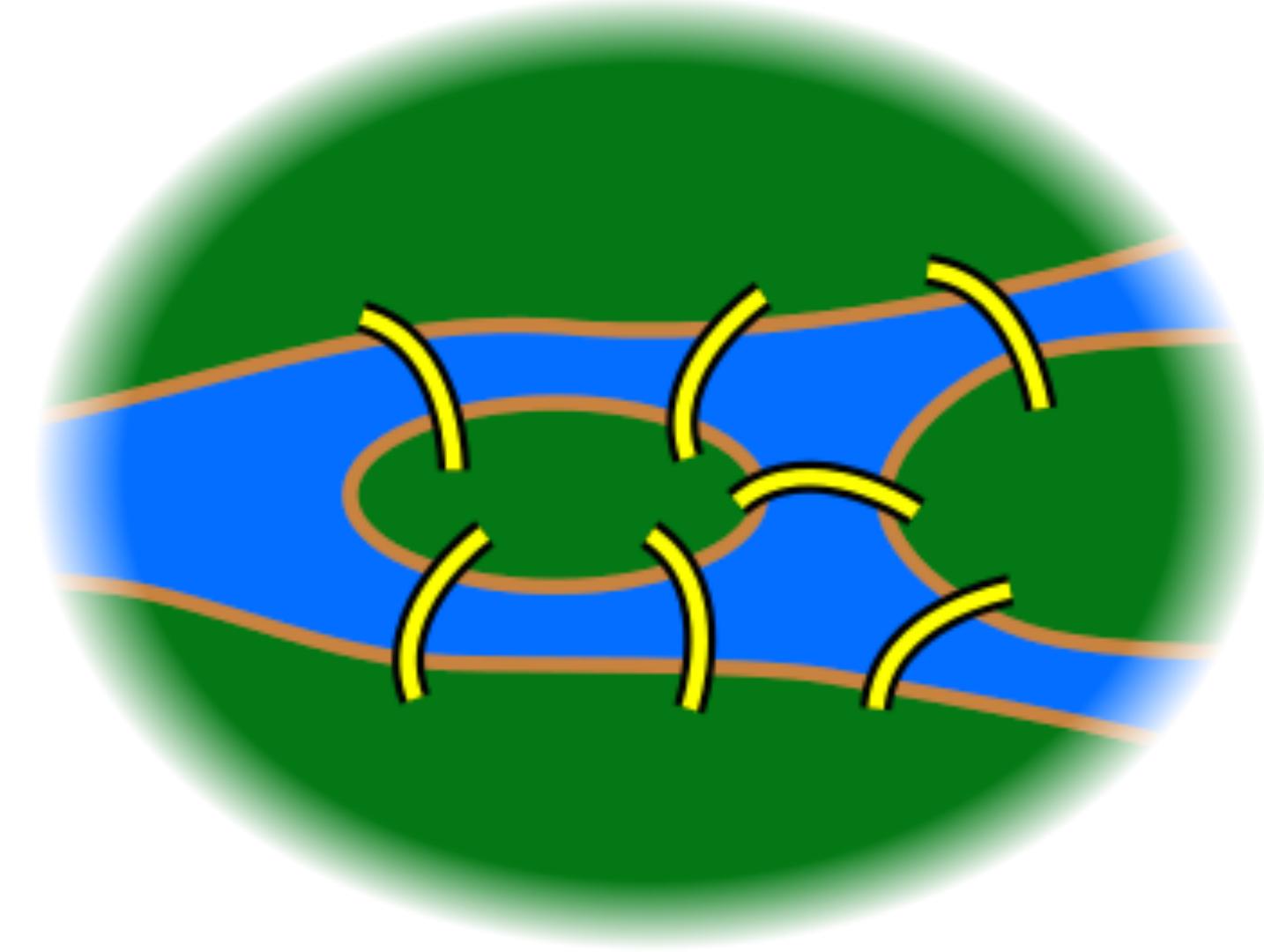
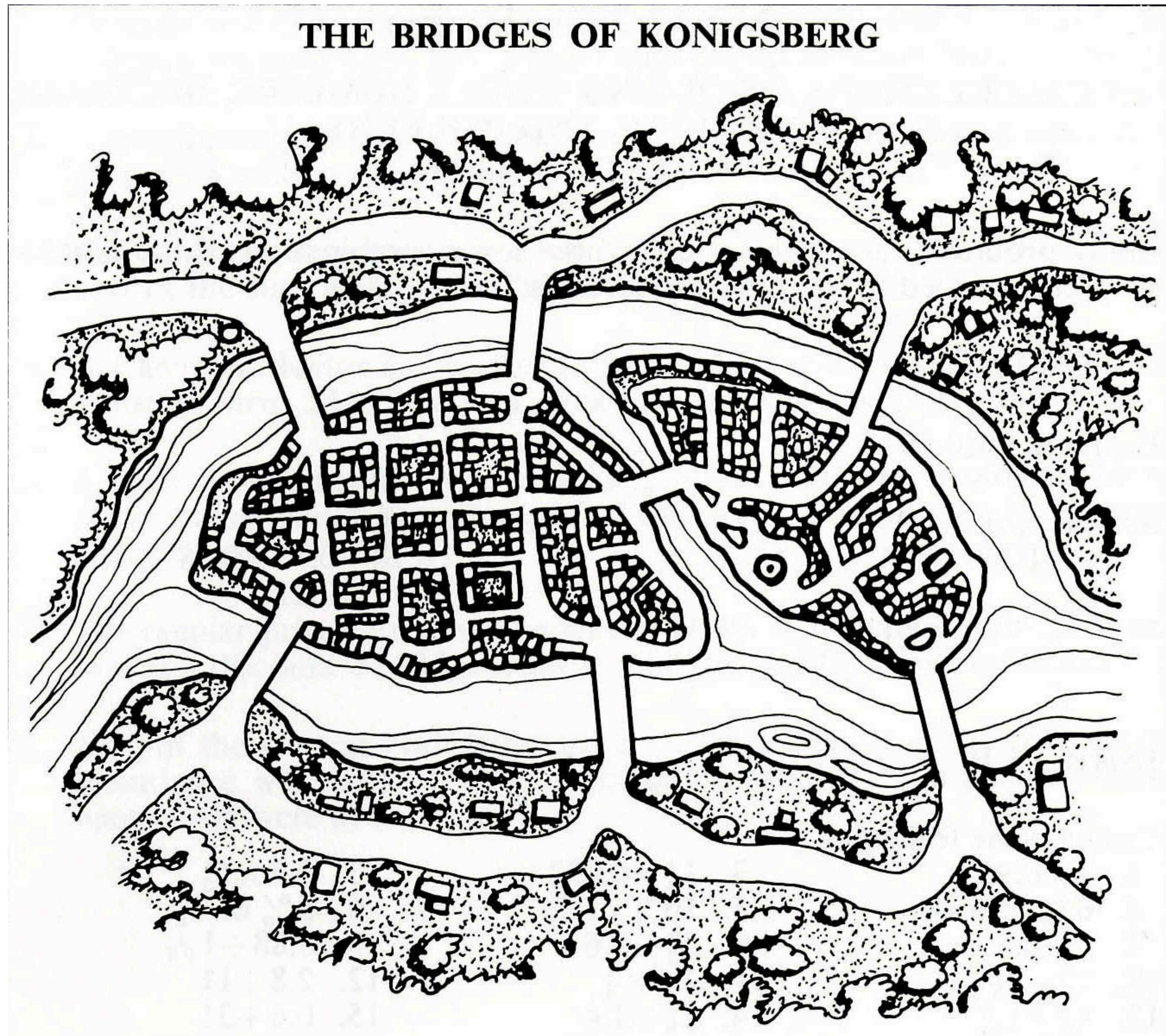


references

- M. E. J. Newman, “Networks: an introduction” Oxford University Press
- Albert-László Barabási, “Network Science” <http://networksciencebook.com/>



THE BRIDGES OF KONIGSBERG





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- Other course page: <https://fisica-sc.campusnet.unito.it/do/didattica.pl/Quest?corso=4ef1>
- Email contacts: maxime.lucas@centai.eu lorenzo.dallamico@isi.it (DO NOT WRITE TO @unito EMAILS please)