(Social) **N**etwork **A**nalysis

Teachers

Course Schedule

Monday, h 11:00 - 13:00, online
Wednesday, h 11:00 - 13:00, online

Prof. Dino Pedreschi

dino.pedreschi@unipi.it

When: upon appointment
Where: Online

Prof. Giulio Rossetti

giulio.rossetti@isti.cnr.it

When: upon appointment
Where: Online

Virginia Morini
(teaching assistant)
virginia.morini@isti.cnr.it

When: upon appointment
Where: Online

Course Materials

E-learning:

- Lessons schedule
- Slides
- Announcements
- https://elearning.di.unipi.it/

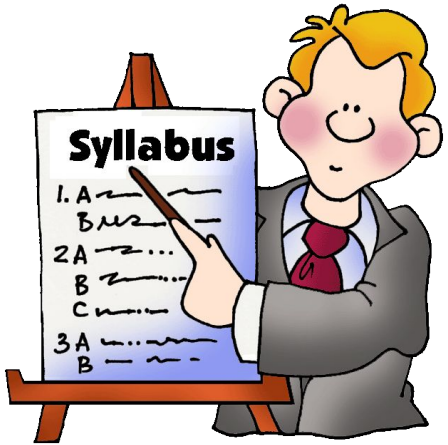
GitHub Repositories:

- Past Exams
- Final Project (at the end of the course!)
- Tutorials
- https://github.com/sna-unipi

Books:

- D. Easley, J. Kleinberg:
  Networks, Crowds, and Markets.
- A. L. Barabasi:
  Network Science
- D. Zinoviev:
  Complex Network Analysis in Python
- M. Coscia:
  The Atlas for Aspiring Network Scientists

General Outline



1st part: Network Characterization

- Networks and Graphs
- Random graphs
- It's a Small world
- Scale Free Networks
- Centrality & Assortative Mixing
- Tie Strength & Resilience

2nd part: Applications

- Community Discovery
- Dynamic of networks
- Link Prediction
- Dynamic Community Discovery
- Diffusion: Decision based models
- Diffusion: Epidemics
- Diffusion: Opinion Dynamics

Exams

Standard Exam:

1. Written Test
2. Group Project + Oral discussion
    - Network construction & analysis
    - Python code + Report

Mid Term Exams:

- Exercises on the two part of the course
- Substitute the full written test
- Examples from past years (exercises may vary): https://github.com/sna-unipi/Exams

Chapter 1

Why should we care about Complex Networks?

Summary

- Complexity
- Real world networks
- Emergence of Network Science

Reading

- Chapter 1 & 2 of Kleinberg's book
- Chapter 1 of Barabasi's book.
- Complexity Explained

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.

Suggested Reading
Complexity Explained
https://complexityexplained.github.io/

Examples of

Complex Systems

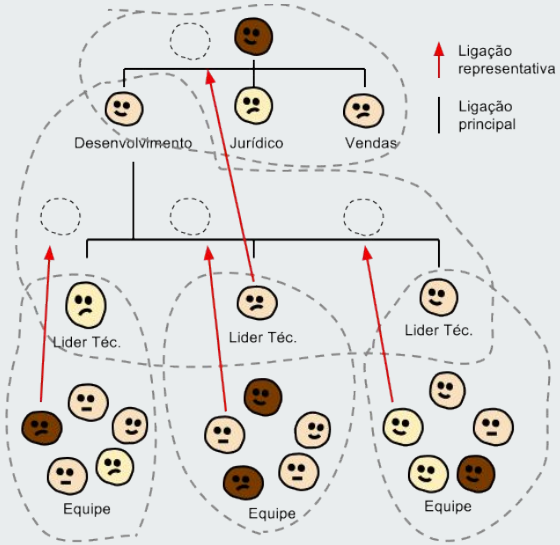
The Facebook “Social Graph”

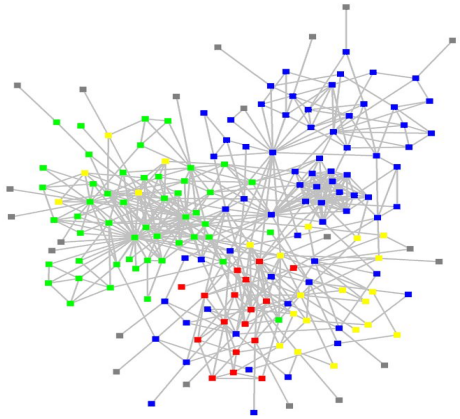
Keith Shepherd's "Sunday Best".
http://baseballart.com/2010/07/shades-of-greatness-a-story-that-needed-to-be-told/

Examples of

Complex Systems

The structure of an organization





departments

consultants

external experts

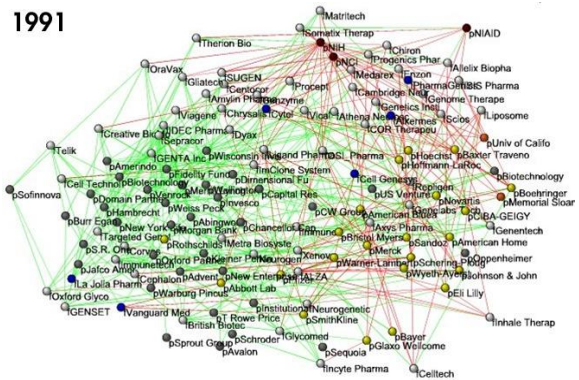
www.orgnet.com

Links:

- Collaborations
- Financial
- R&D

Nodes:

- Companies
- Investment
- Pharma
- Research Labs
- Public
- Biotechnology

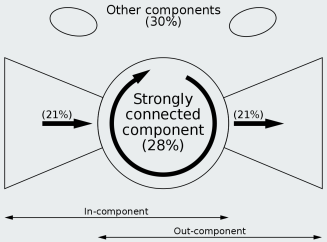


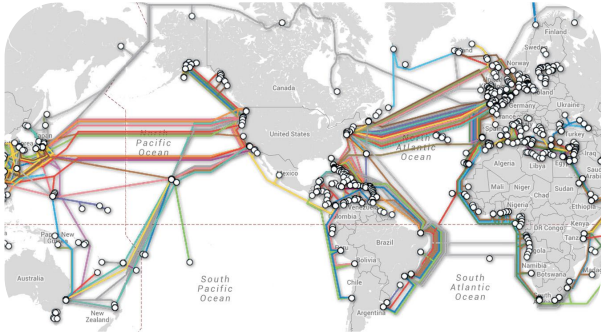
http://ecclectic.ss.uci.edu/~drwhite/Movie

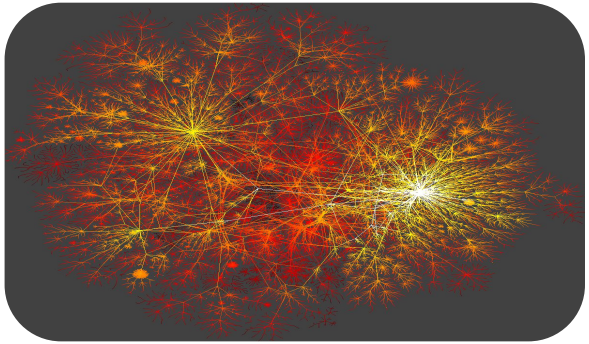
Examples of

Complex Systems

The Internet backbone,
The World Wide Web...







Examples of

Complex Systems

Human Genes

Humans have only about three times as many genes as the fly, so human complexity seems unlikely to come from a sheer quantity of genes.

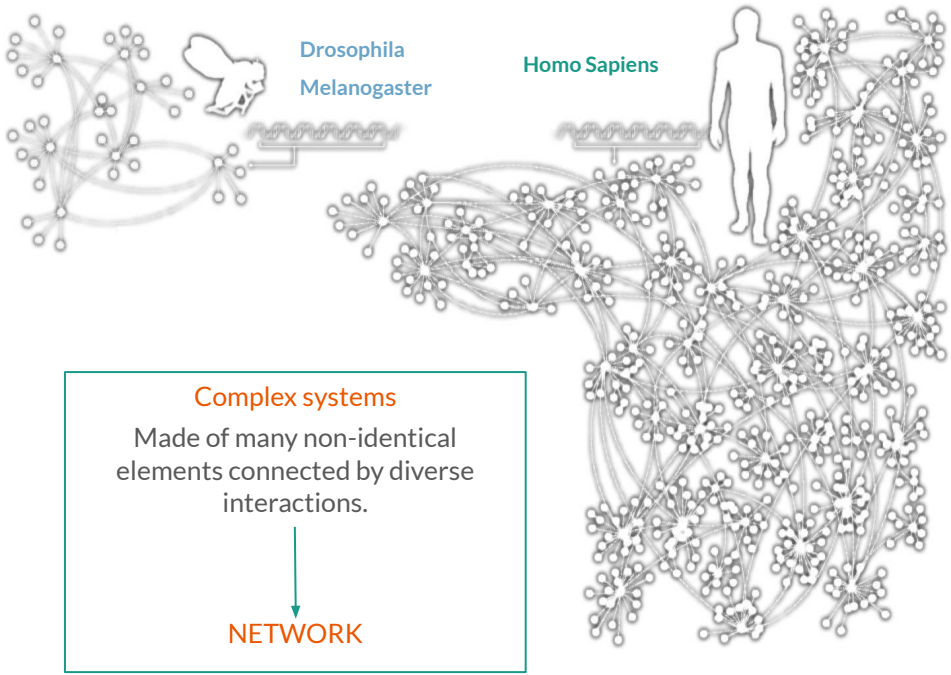
Rather, some scientists suggest, each human has a network with different parts like genes, proteins and groups.

Examples of

Complex Systems

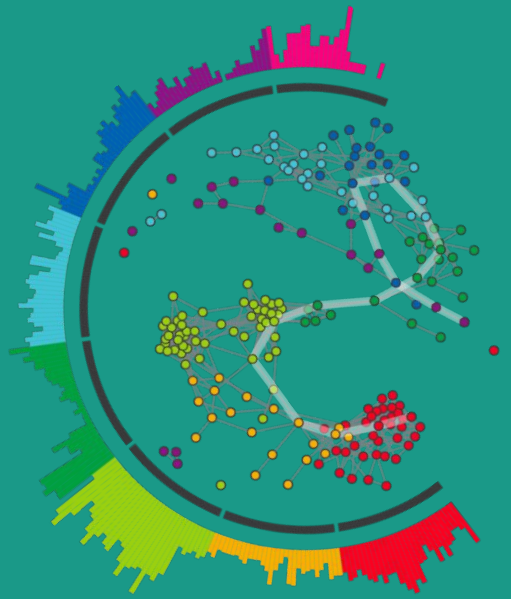
Human Genes (cont'd)

In the generic networks shown, the points represent the elements of each organism's genetic network, and the dotted lines show the interactions between them.



The role of networks

Behind each system studied in complexity there is an intricate wiring diagram, or a **network**, that defines the interactions between the component.



We will never understand **complex system** unless we map out and understand the networks behind them.

Examples of

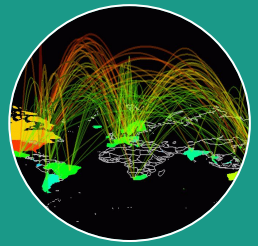
Real world Networks

Type: Social
Nodes: Individuals
Links: Social relationship

NetSci
network science society

Type: Scientific Collaborations
Nodes: Researchers
Links: Co-Authorships

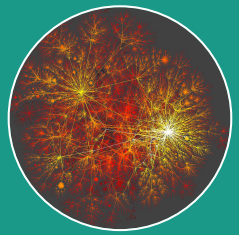
Type: Actor connectivity
Nodes: Actors
Links: Cast jointly



Type: Communication
Nodes: Phones, Airports..
Links: Phone calls, Flights..

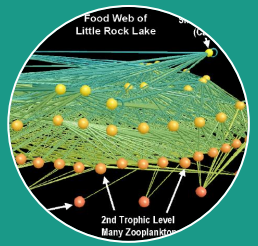
Examples of

Real world Networks (cont'd)



Type: Technological
Nodes: PC, Routers
Links: Physical lines

Type: Scientific Citation
Nodes: Papers
Links: Citations



Type: Biological
Nodes: Species
Links: Trophic interactions

Type: Mobility
Nodes: Individuals, Cars...
Links: Co-Location...

The Emergence of Network Science

The (urgent) need to understand complexity

Despite the challenges complex systems offer us, we cannot afford to not address their behavior, a view increasingly shared both by scientists and policy makers.

Networks are not only essential for this journey, but during the past decade some of the most important advances towards understanding complexity were provided in context of network theory.

Data Availability

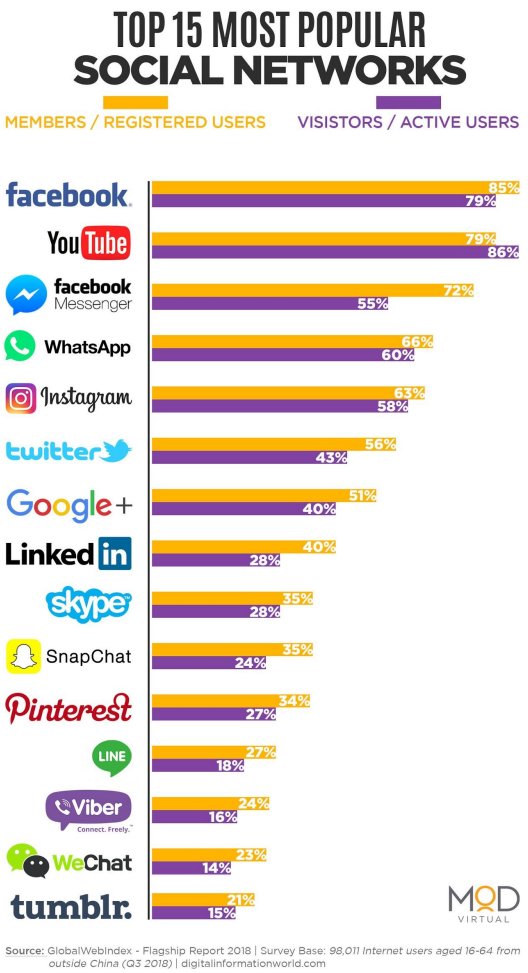
1990 C. elegans neural wiring diagram
1998 - Movie Actor Network
1998 - Citation Networks
1999 -World Wide Web
2000 - Metabolic Networks
2001 - PPI network
2008 - OSNs

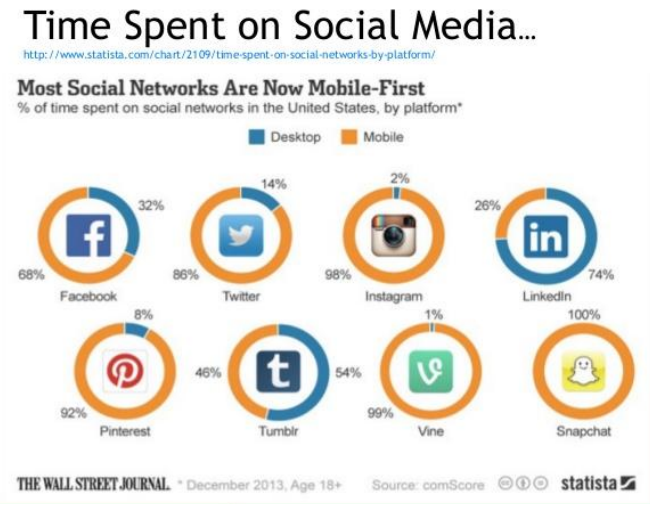
Universality

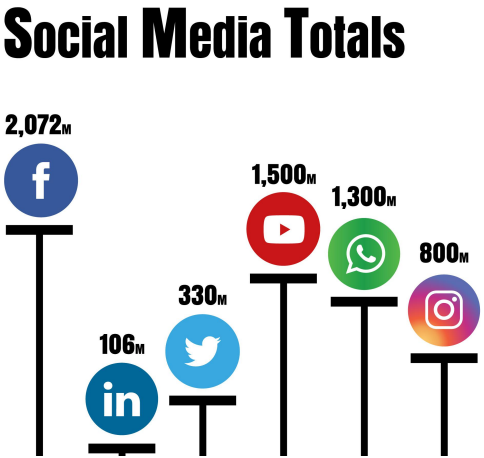
The architecture of networks emerging in various domains of science, nature, and technology are more similar to each other than one would have expected.

The Life of Networks

(Online) Social Networks







(Incomplete)

History of Network Analysis

1735

Graph Theory

Euler

1930s

Social Network Research

Moreno

1960s

Communication Network
Internet

1980s

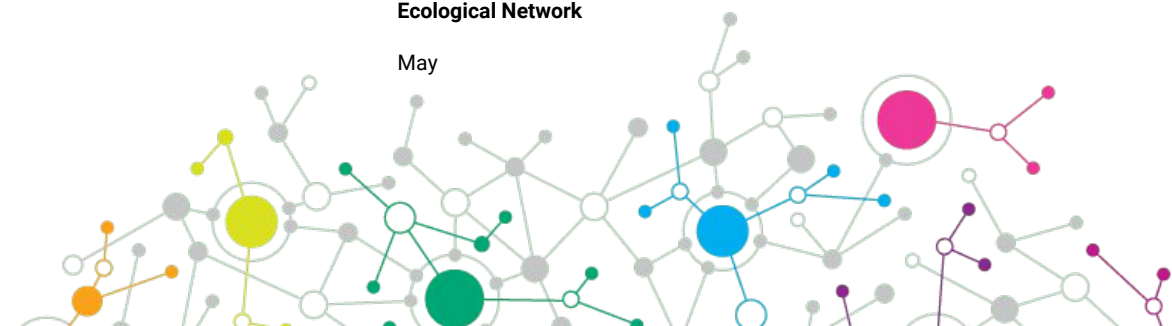
Ecological Network

May

2000s

Network Science

Barabasi



The Tools of

Modern Network Theory

1. Graph Theory
2. Social Network Theory
3. Statistical Physics
4. Computer Science
5. Biology
6. Statistics

Chapter 1

Conclusion

Take Away Messages

1. Complex Systems can be modeled with networks!
2. Node & Edge semantics shape the networks structure
3. Network Science is, by definition, an interdisciplinary field of study

Suggested Readings

- Chapter 1 & 2 of Kleinberg's book
- Chapter 1 of Barabasi's book.
- Complexity Explained

https://complexityexplained.github.io/

What's Next

Chapter 2:
Networks & Graphs: Basic Measures