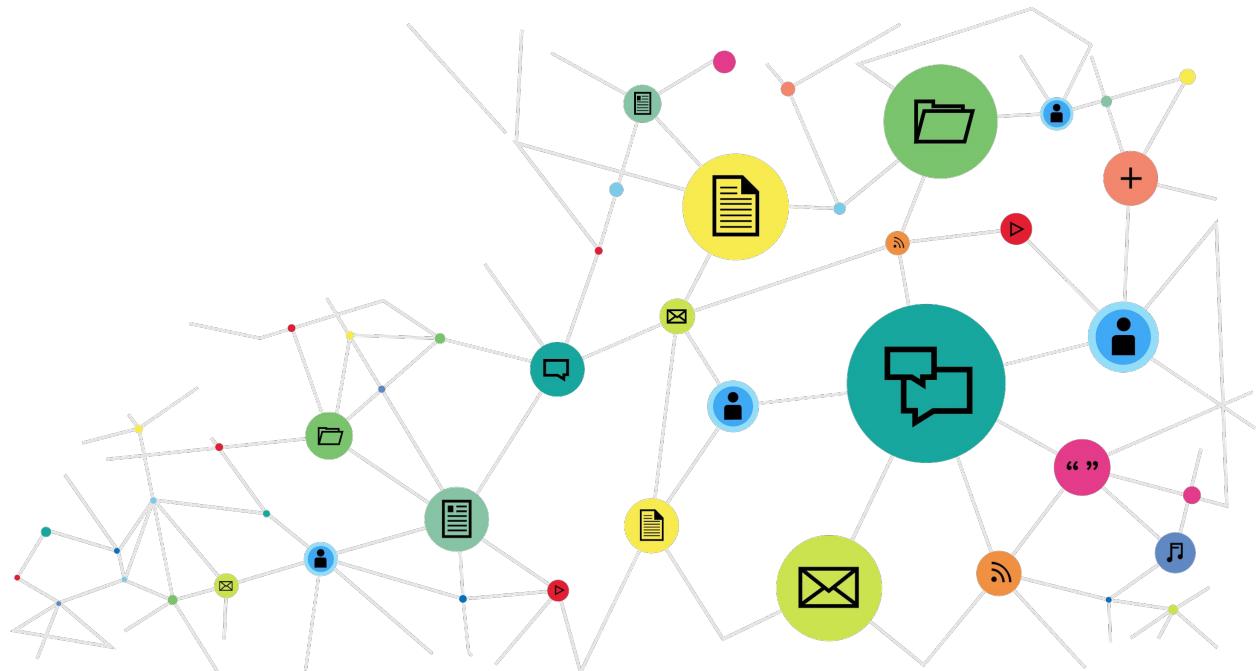
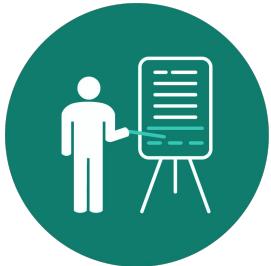


(Social) Network Analysis

University of Pisa, AA22/23



Teachers



Course Schedule

Monday, h 9:00 - 10:45, Fib C
Wednesday, h 9:00 - 10:45, Fib M1



Prof. Dino Pedreschi

dino.pedreschi@unipi.it

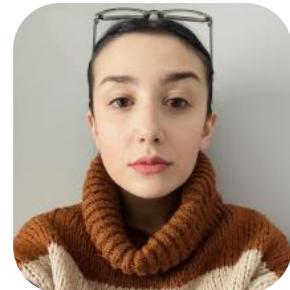
When: upon appointment
Where: Online



Prof. Giulio Rossetti

giulio.rossetti@isti.cnr.it

When: upon appointment
Where: Online



Valentina Pansanella

(teaching assistant)

valentina.pansanella@sns.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>

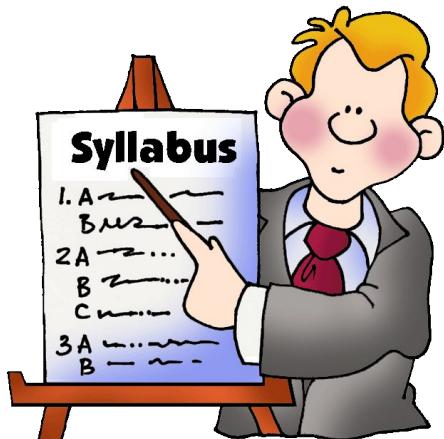


Books:

- 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: **The Architecture of Complex Networks**

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

2nd part: **The Dynamics of Complex Networks**

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

Hands-On
- Gephi & Cytoscape
- Python

3rd part: **Case Studies**

Cognitive Network Science (guest lecturer: Prof. Massimo Stella, Uni. Exeter)
Polarization, Echo Chambers and Online Debates
SNA @ KDD Laboratory

Exams



Standard Exam:

1. Written Test (TBD)
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

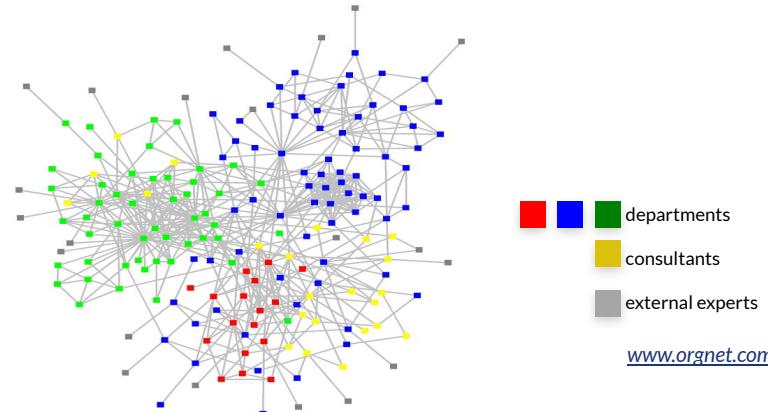
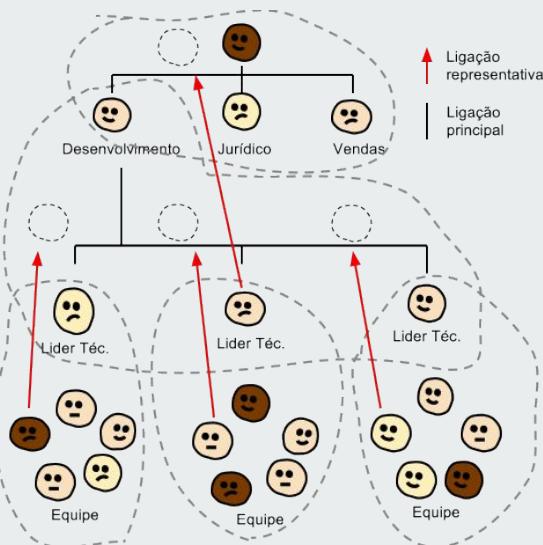
The Facebook “Social Graph”



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

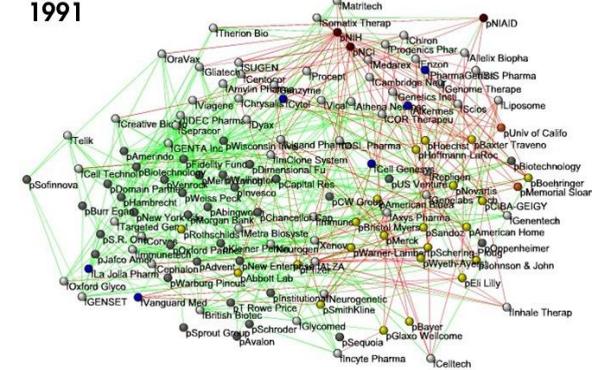
Examples of Complex Systems

The structure of an organization



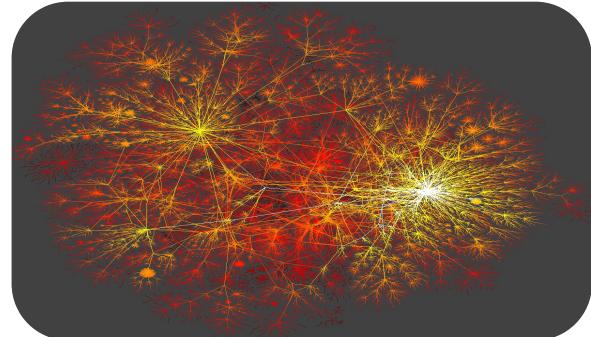
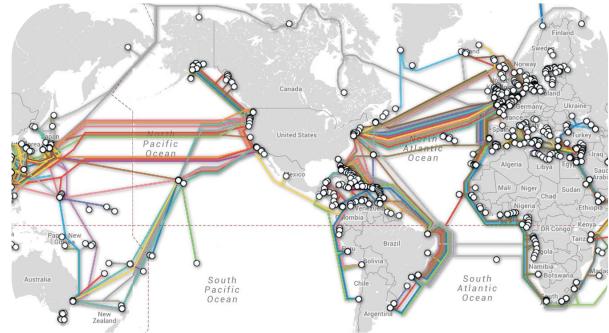
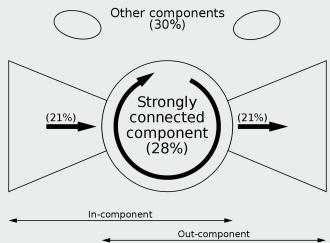
- Links:**
- Collaborations
 - Financial
 - R&D
- Nodes:**
- Companies
 - Investment
 - Pharma
 - Research Labs
 - Public
 - Biotechnology

1991



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.

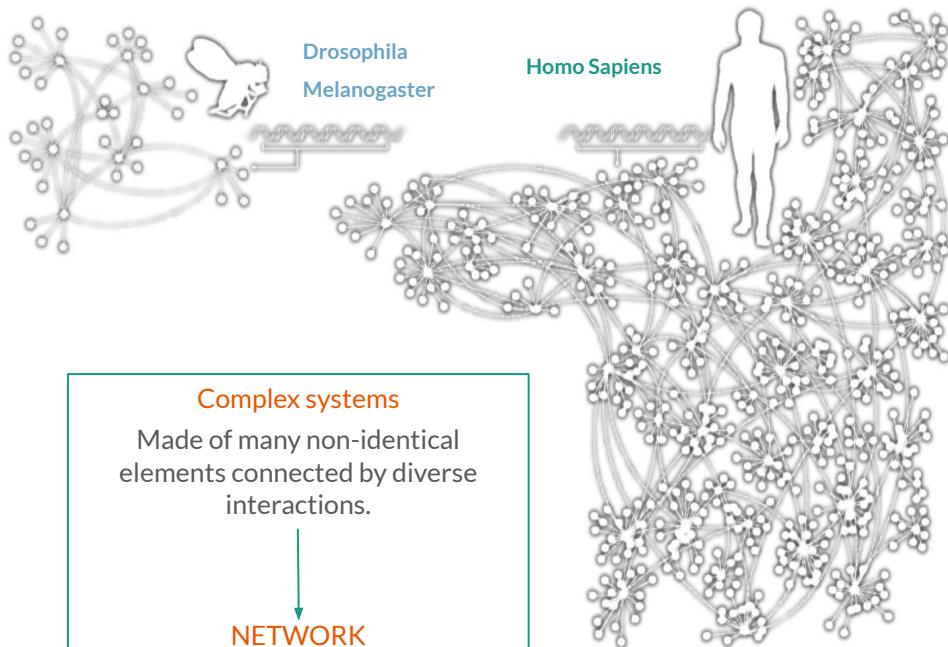


Examples of

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

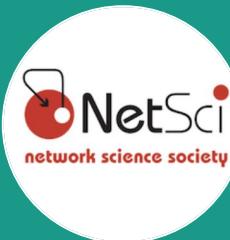
Real world Networks



Type: Social
Nodes: Individuals
Links: Social relationship



Type: Actor connectivity
Nodes: Actors
Links: Cast jointly



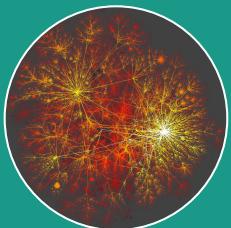
Type: Scientific Collaborations
Nodes: Researchers
Links: Co-Authorships



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

Examples of

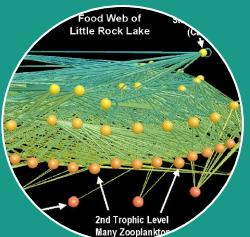
Real world Networks (cont'd)



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

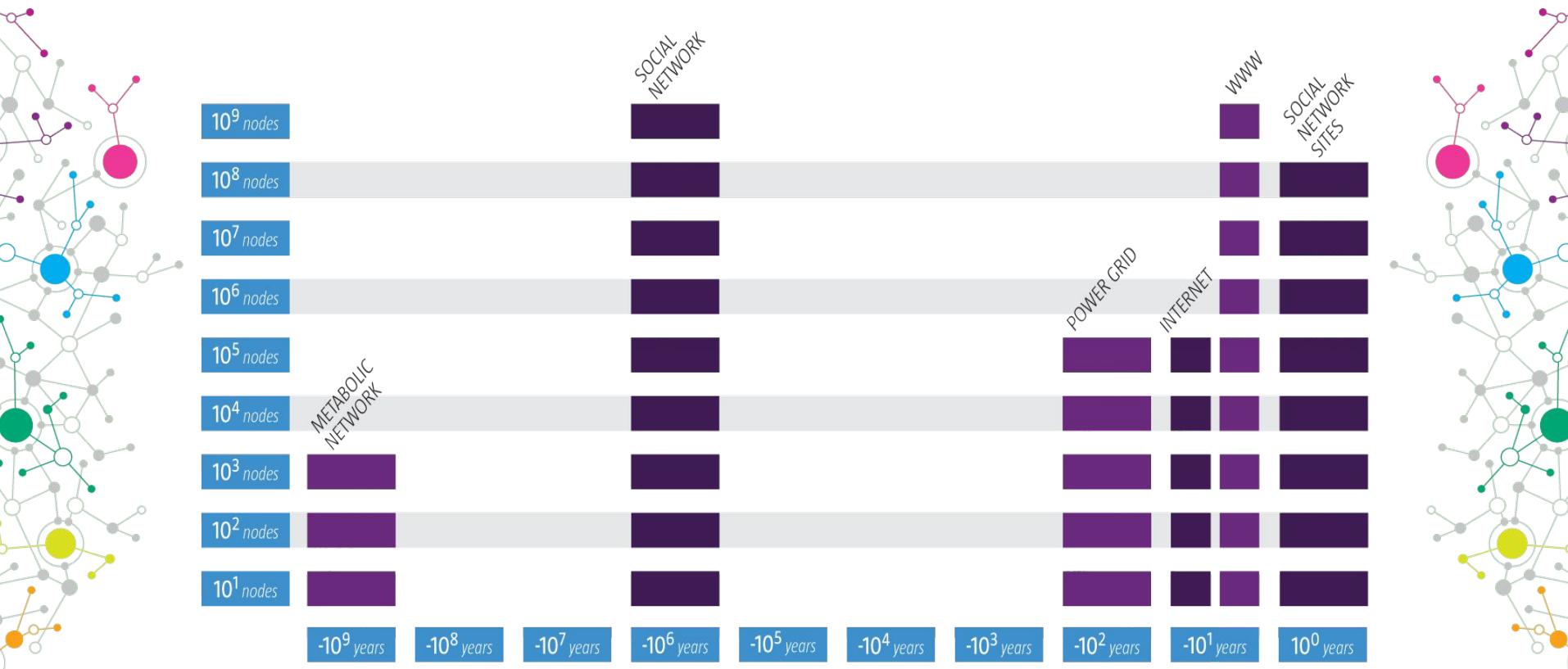
- 1990 C. elegans neural wiring diagram
- 1998 - Movie Actor Network
- 1998 - Citation Networks
- 1999 -World Wide Web
- 2000 - Metabolic Networks
- 2001 - PPI network
- 2008 - OSNs

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.



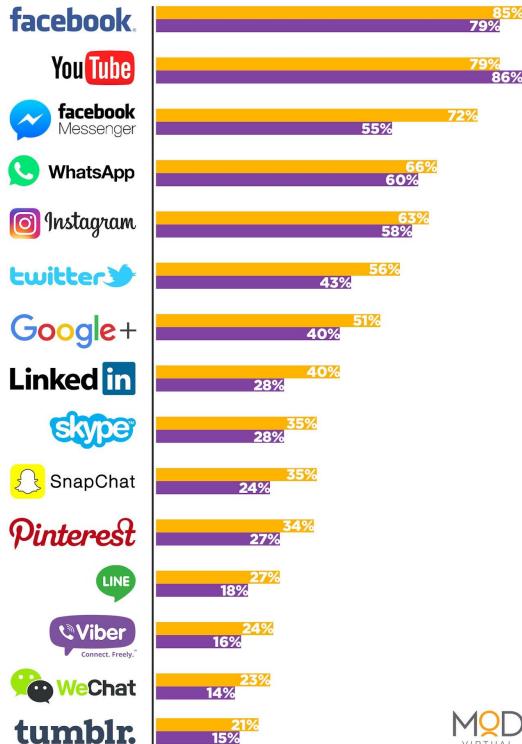
The Life of Networks



TOP 15 MOST POPULAR SOCIAL NETWORKS

MEMBERS / REGISTERED USERS

VISITORS / ACTIVE USERS



THE WALL STREET JOURNAL

* December 2013, Age 18+

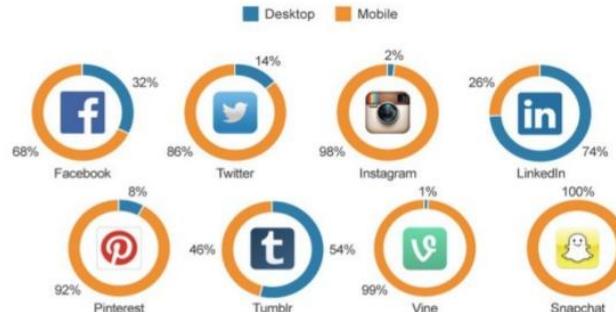
Source: comScore statista

(Online) Social Networks

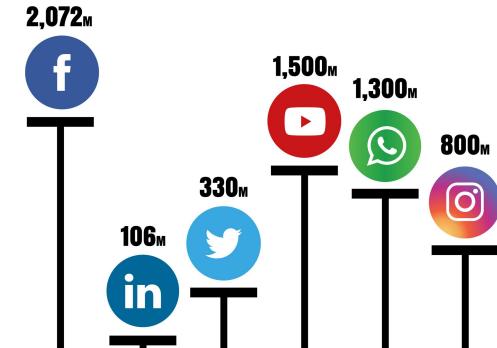
Time Spent on Social Media...

<http://www.statista.com/chart/2109/time-spent-on-social-networks-by-platform/>

Most Social Networks Are Now Mobile-First
% of time spent on social networks in the United States, by platform*



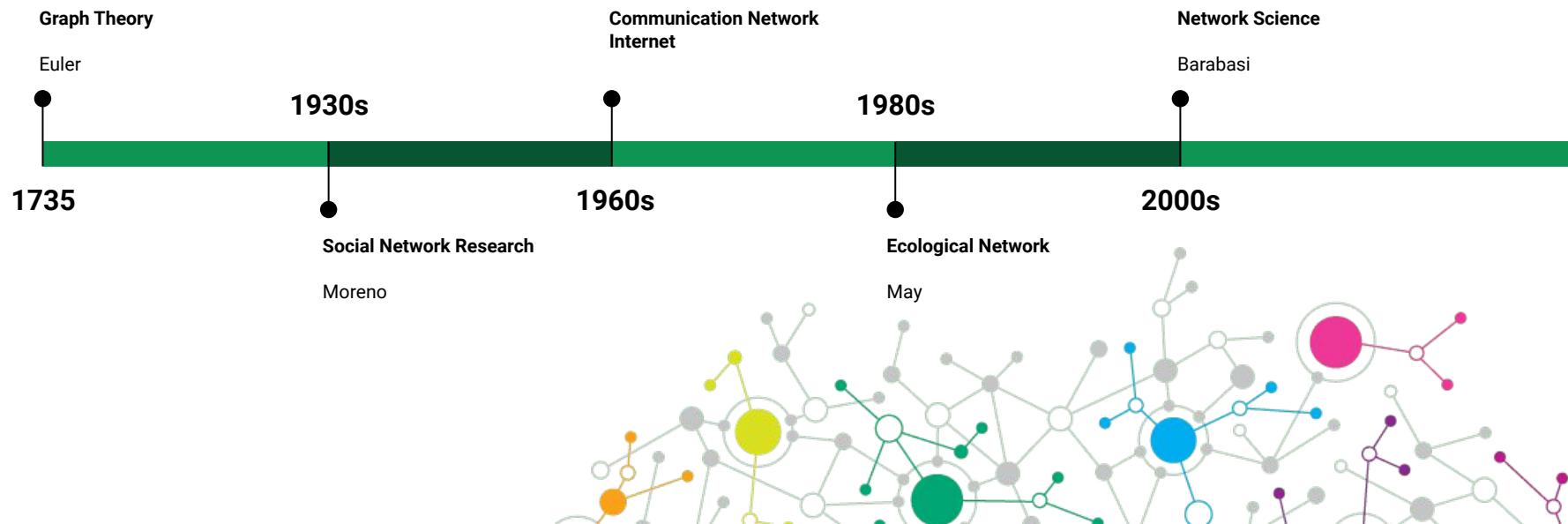
Social Media Totals



Source: GlobalWebIndex - Flagship Report 2018 | Survey Base: 98,011 Internet users aged 16-64 from outside China (Q3 2018) | digitalinformationworld.com

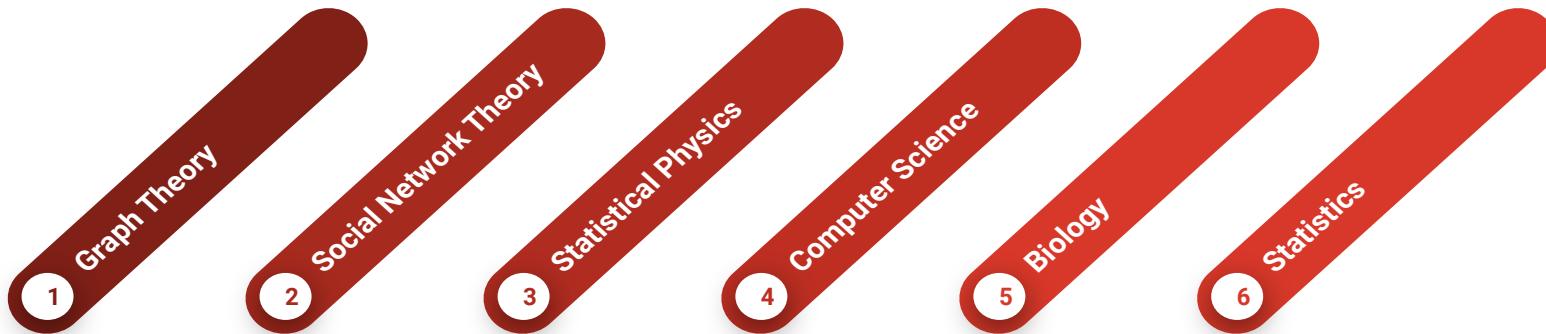
(Incomplete)

History of Network Analysis



The Tools of

Modern Network Theory



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

