

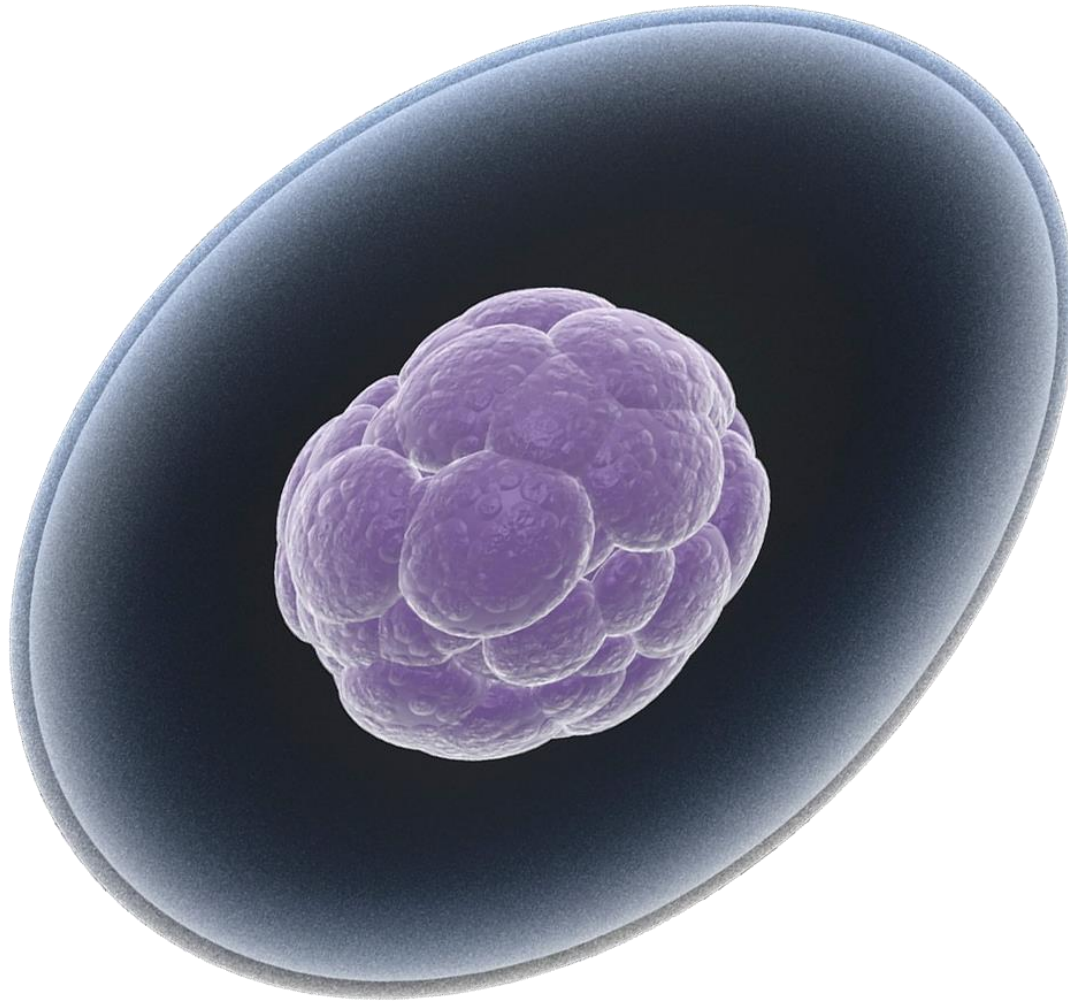
LECTURE 1:INTRODUCTION

Some course materials of this lecture are adopted from the Stanford University CS224W: Social and Information Network Analysis by Prof. Jure Leskovec, and the COMS W4995-1 Introduction to Social Networks by Prof. Augustin Chaintreau from Columbia University

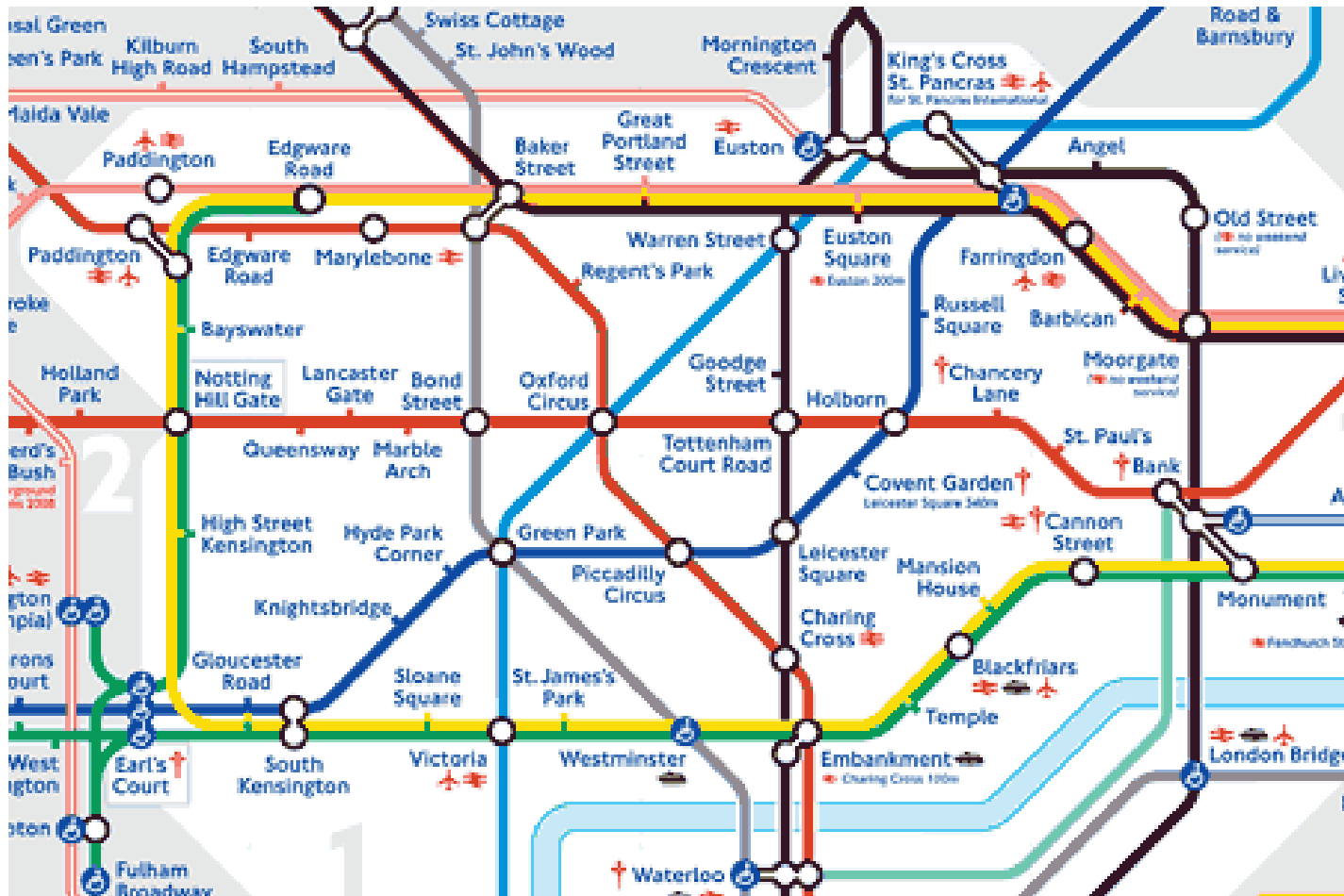
**What do the
following things
have in common?**



World economy



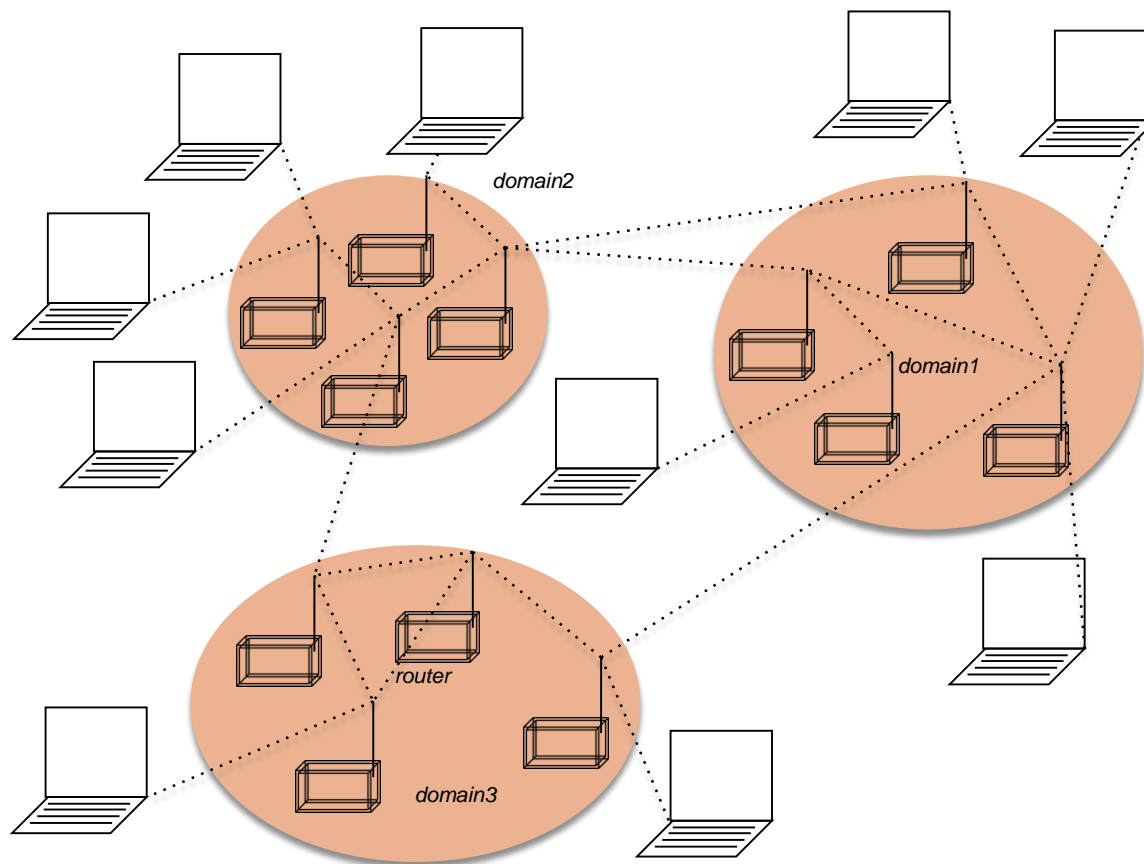
Human cell



Roads



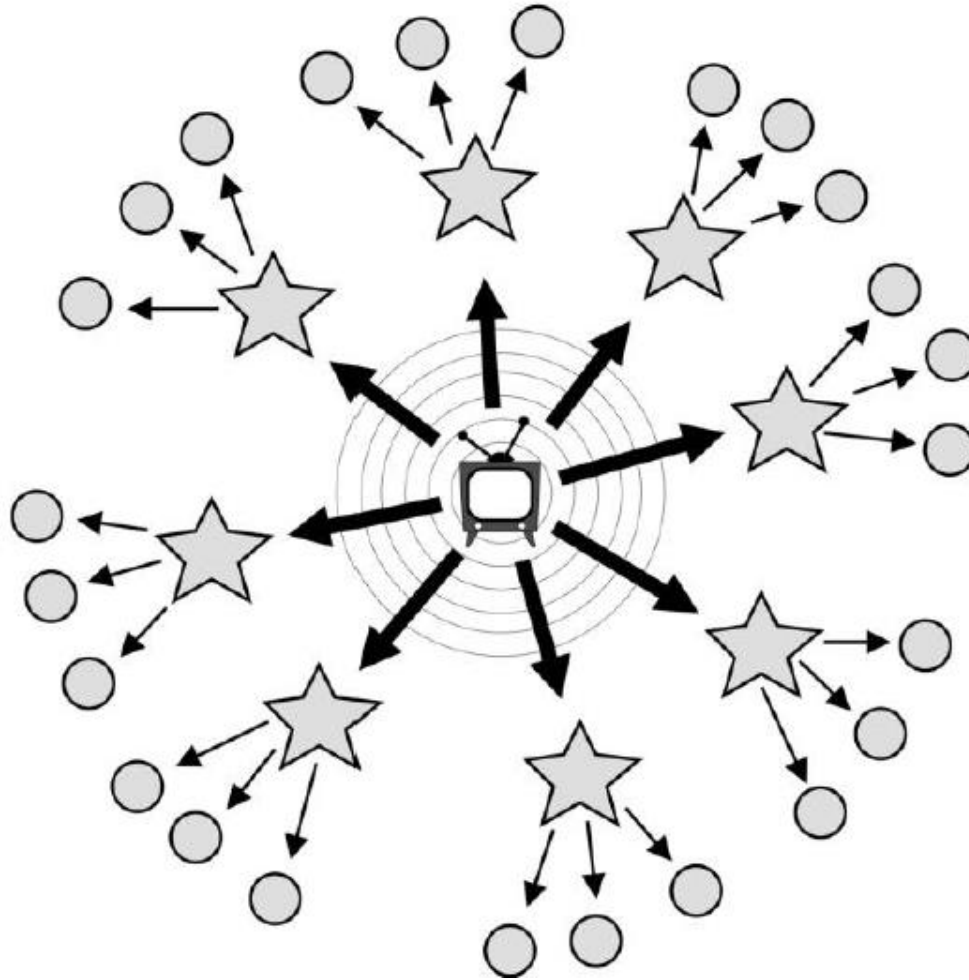
Brain



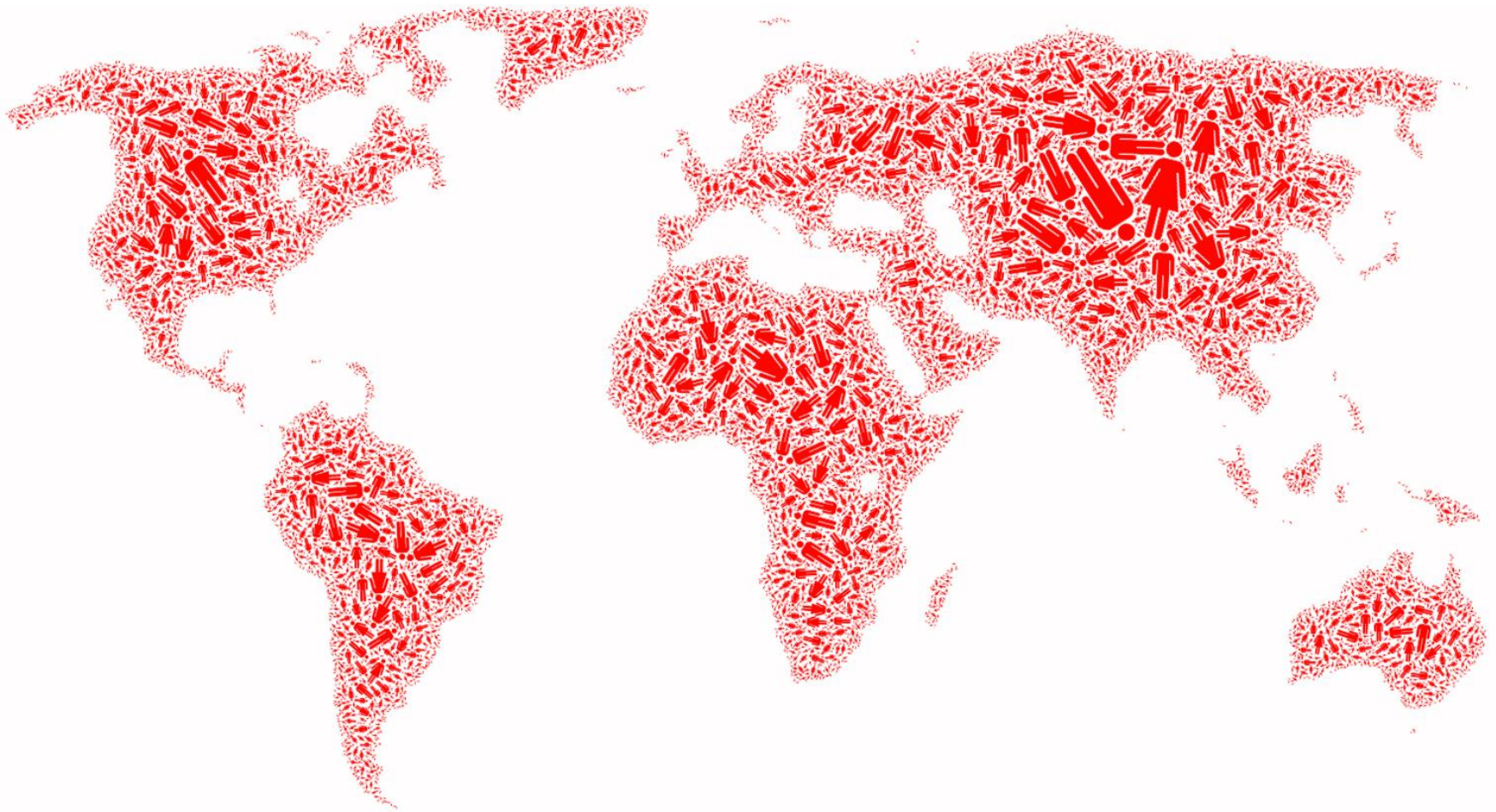
Internet



Friends & Family



Media & Information



Society

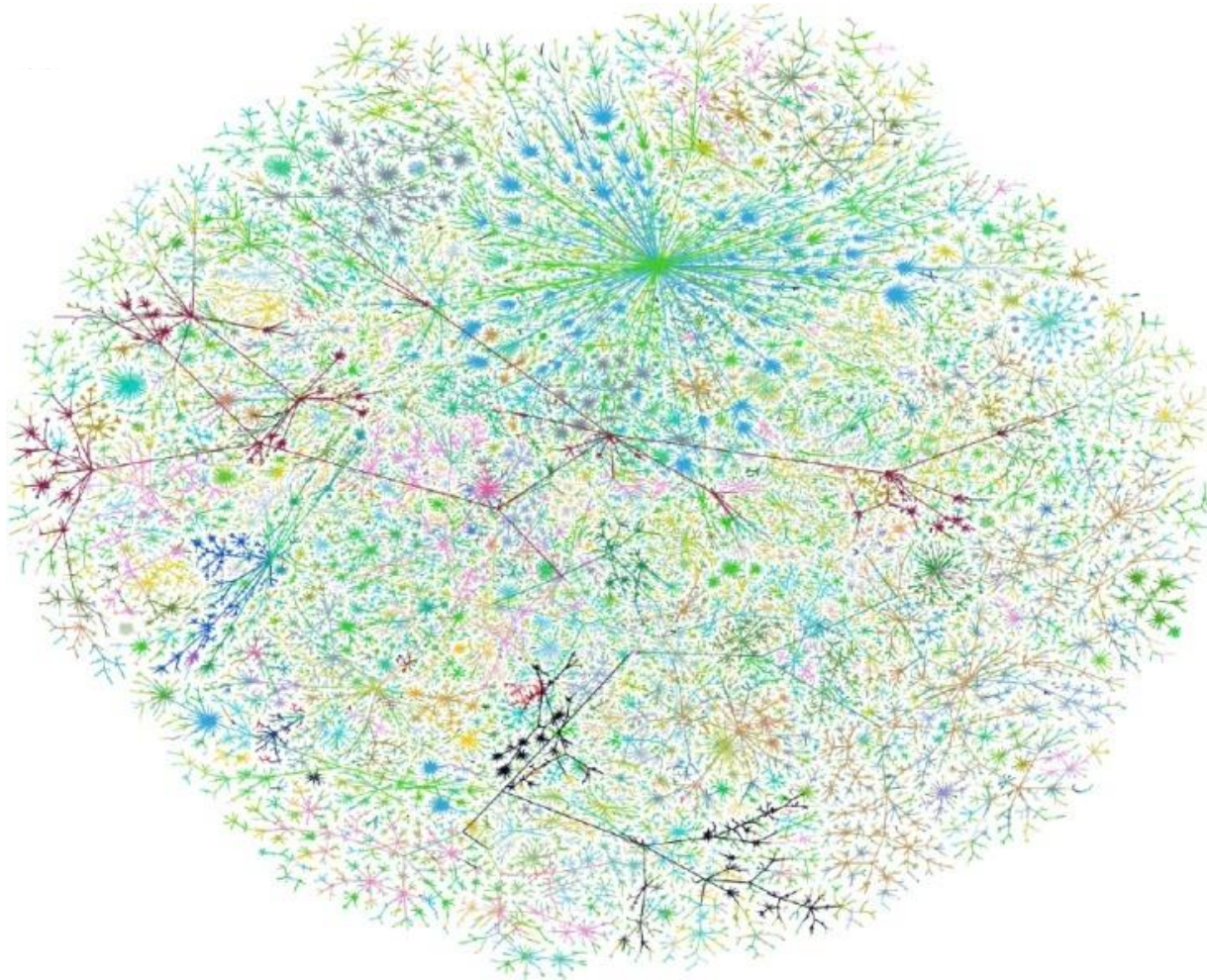
Networks & Complex Systems

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□ Hopelessly complex systems are around us:

- **Society** is a collection of six billion individuals
- **Communication systems** link electronic devices
- **Information** and **knowledge** is organized and linked
- Thousands of **genes** in our cells work together in a seamless fashion
- Our **thoughts** are hidden in the connections between billions of neurons in our brain

What do these systems have in common?
How can we represent them?



The Network!

Networks!!

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Behind each such system there is an intricate wiring diagram, **a network**, that defines the **interactions** between the components

We will never understand these systems unless we understand the networks behind it

Networks: Social

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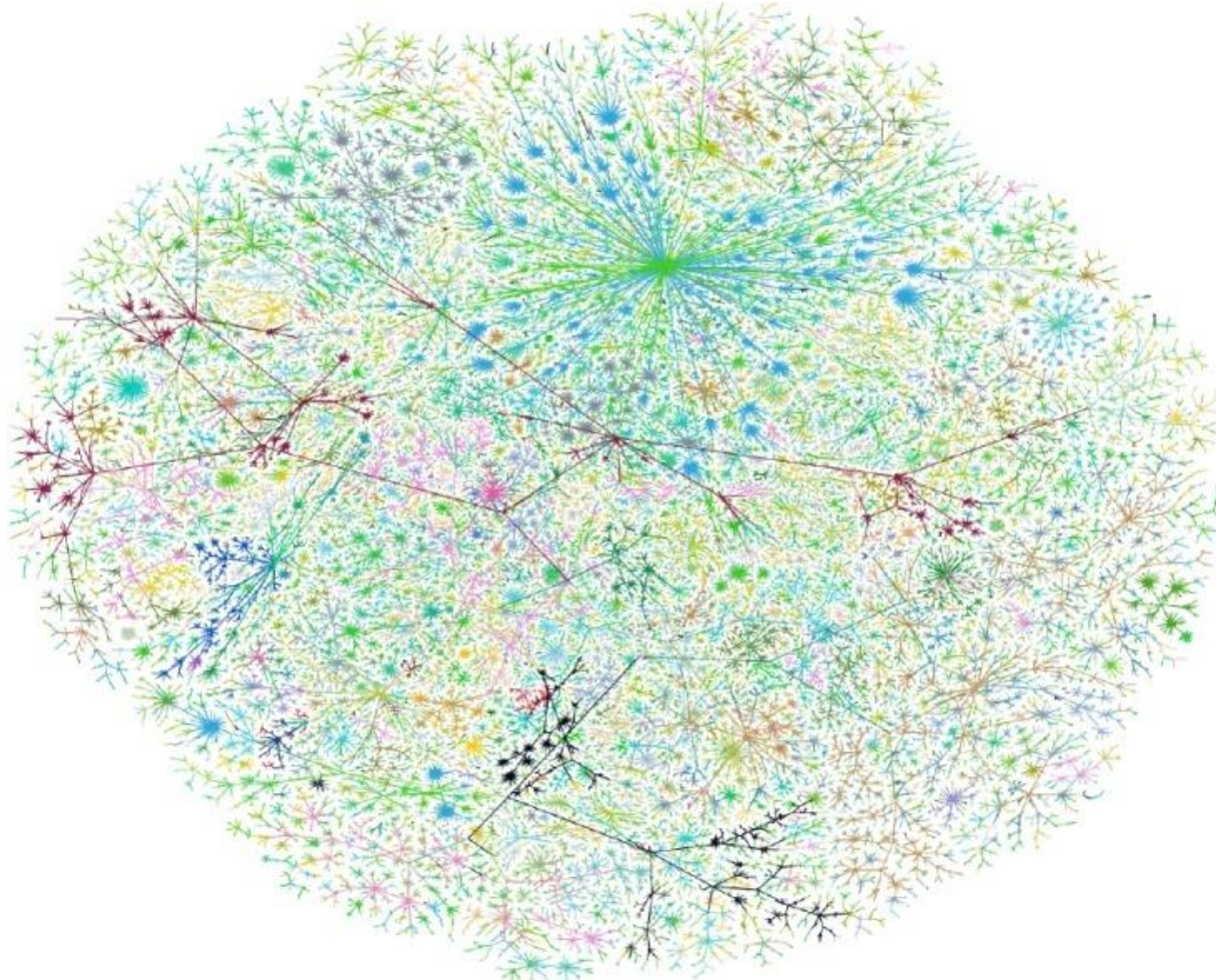


Facebook social graph

4-degrees of separation [Backstrom-Boldi-Rosa-Ugander-Vigna, 2011]

Networks: Communication

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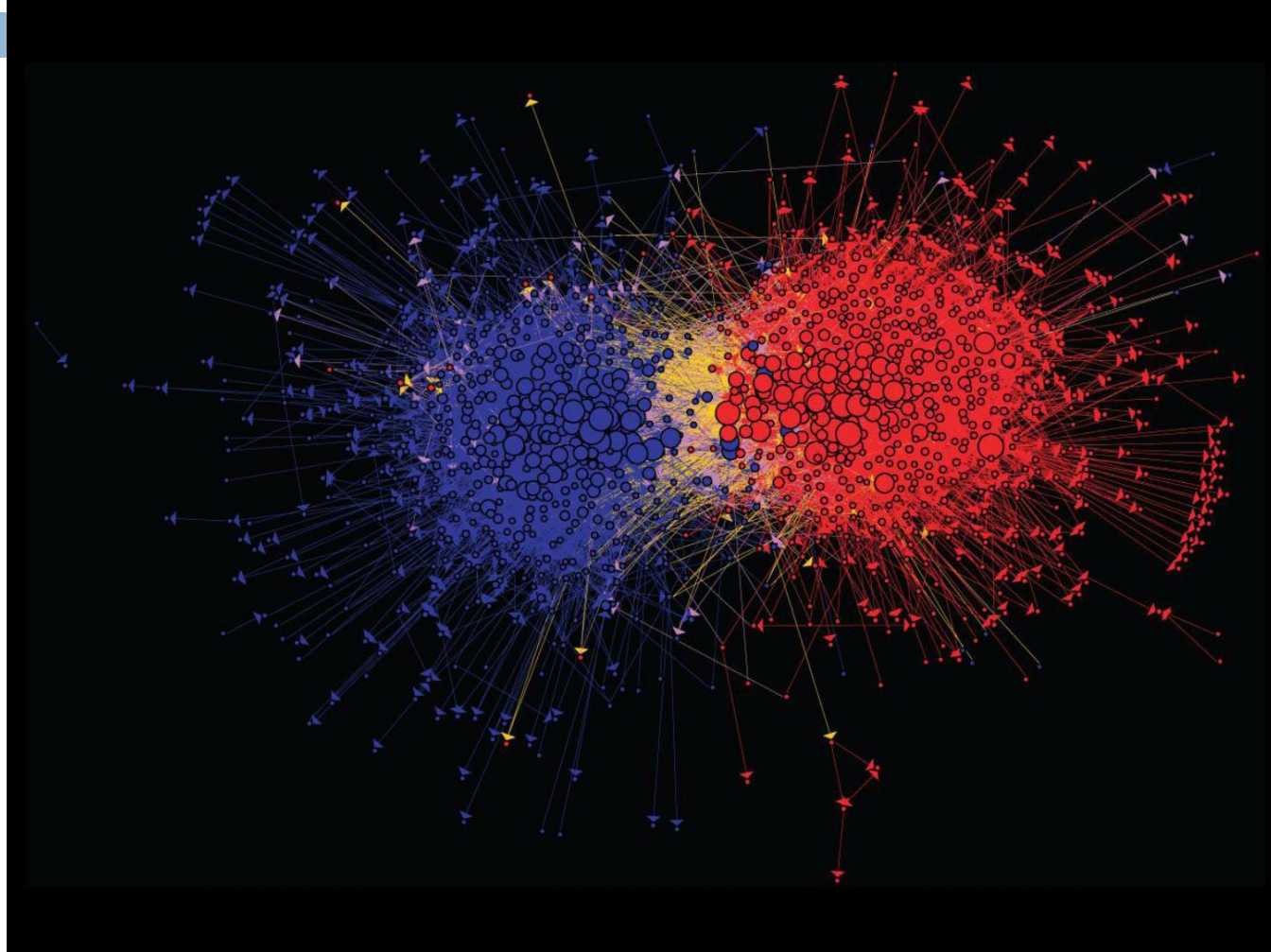
Graph of the Internet (Autonomous Systems)

Power-law degrees [Faloutsos-Faloutsos-Faloutsos, 1999]

Robustness [Doyle-Willinger, 2005]

Networks: Media

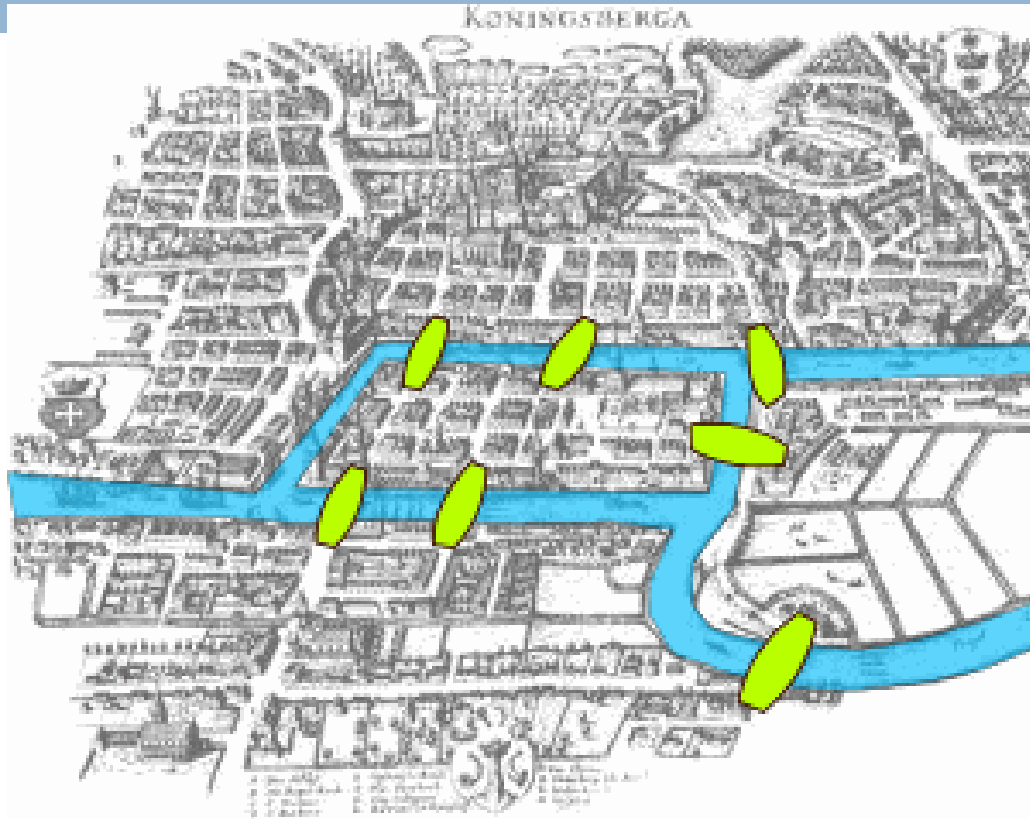
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Connections between political blogs
Polarization of the network [Adamic-Glance, 2005]

Networks: Technology

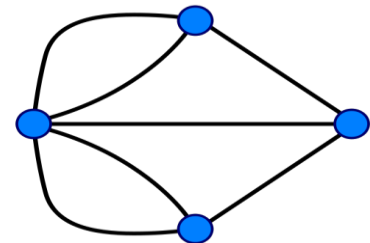
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Seven Bridges of Königsberg

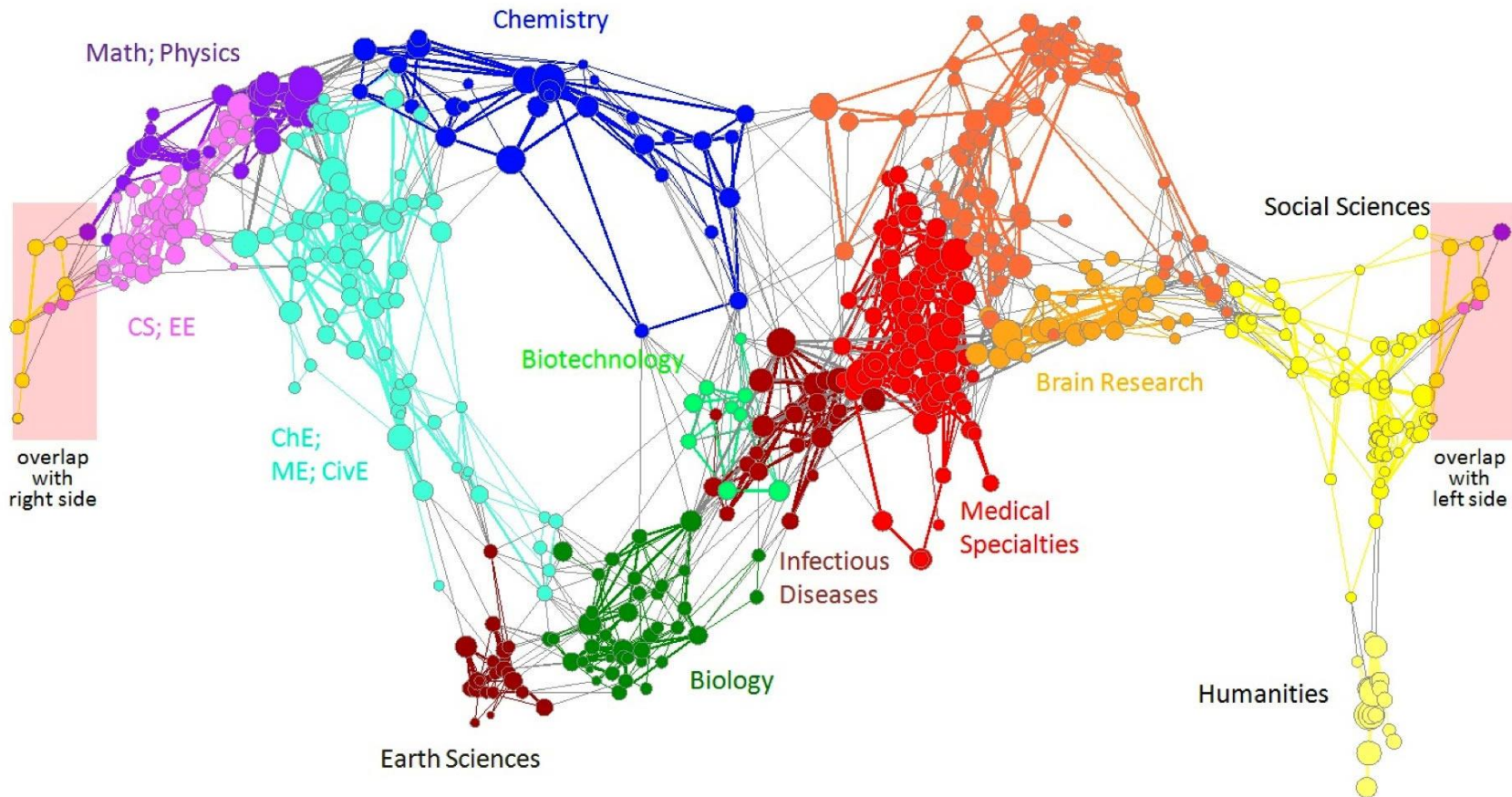
[Euler, 1735]

Return to the starting point by traveling each link of the graph once and only once.



Networks: Information

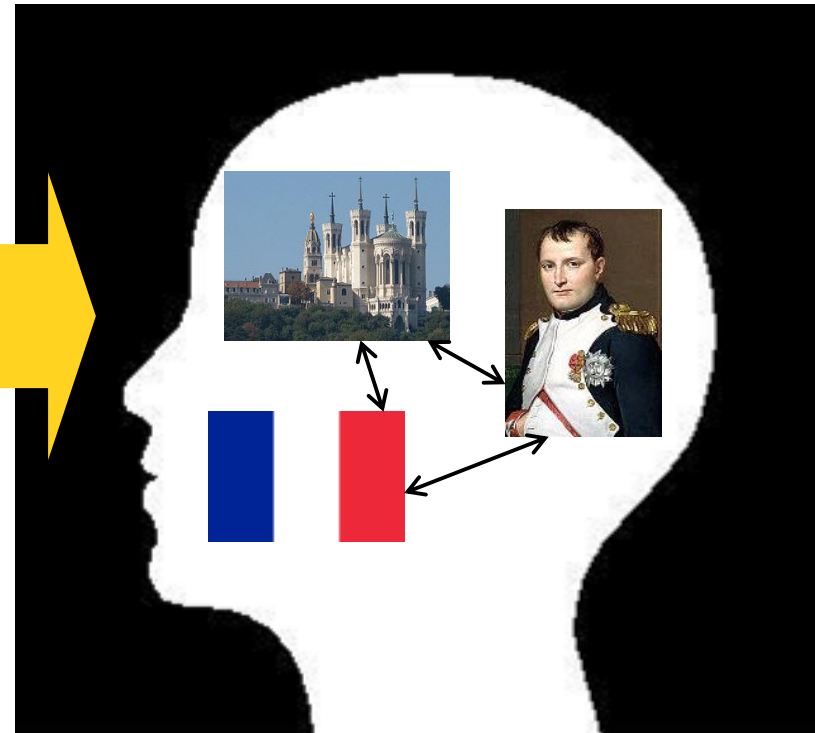
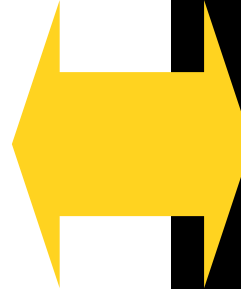
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Citation networks and Maps of science
[Börner et al., 2012]

Networks: Knowledge

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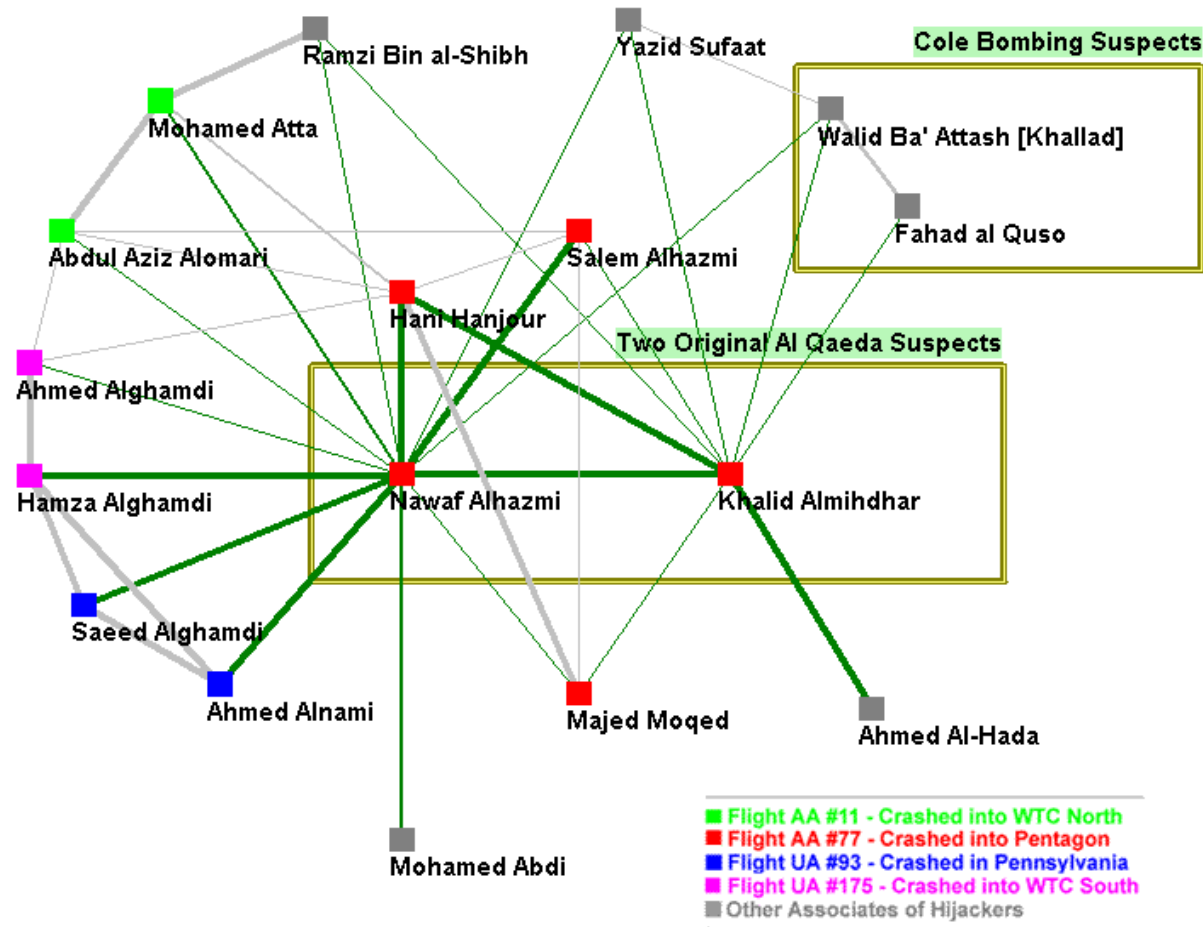
Understand how humans
navigate Wikipedia

Get an idea of how
people connect concepts

[West-Leskovec, 2012]

Networks: Organizations

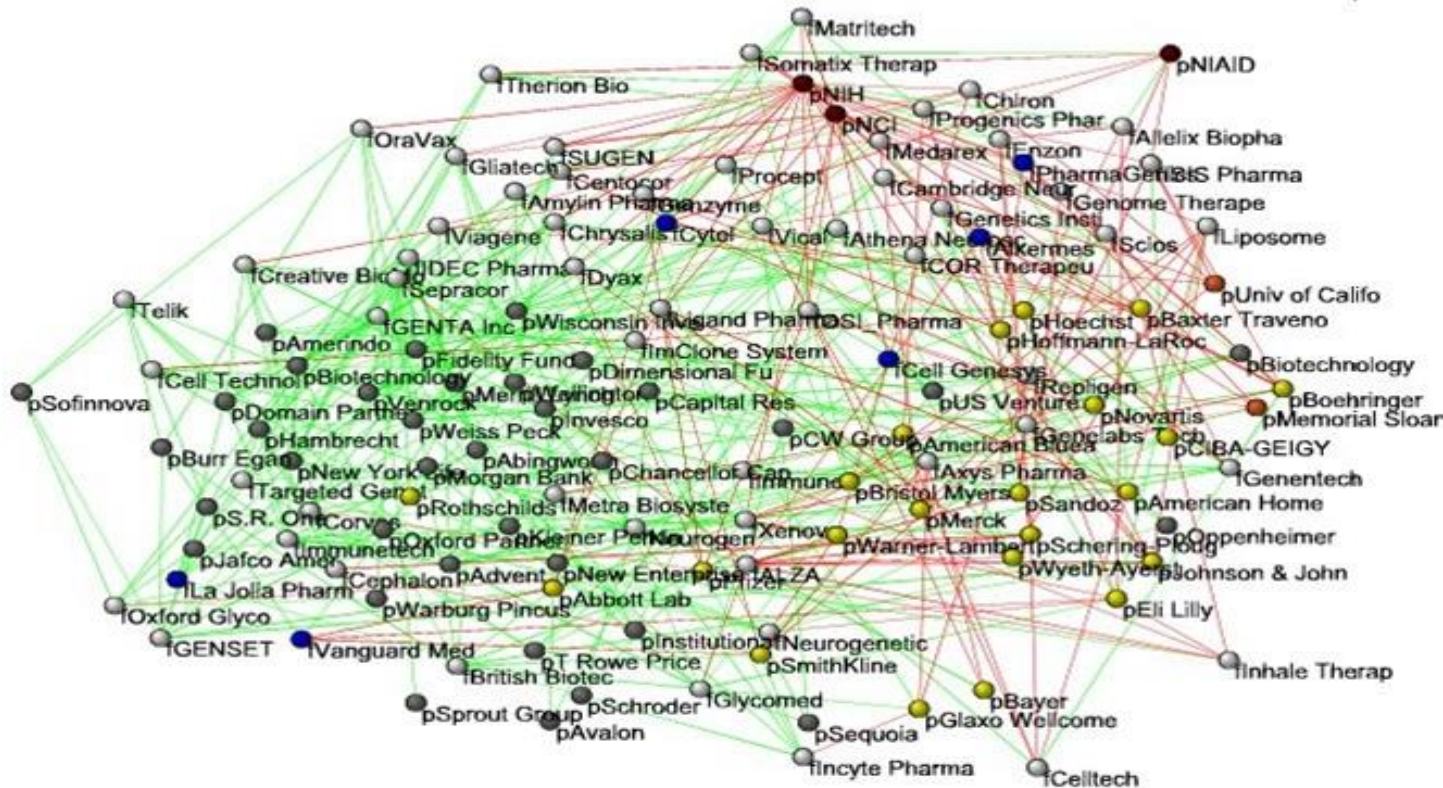
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9/11 terrorist network
[Krebs, 2002]

Networks: Economy

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Nodes:

Companies

Investment

Pharma

Research Labs

Public

Biotechnology

Links:

Collaborations

Financial

R&D

Bio-tech companies
[Powell-White-Koput, 2002]

Networks: Brain

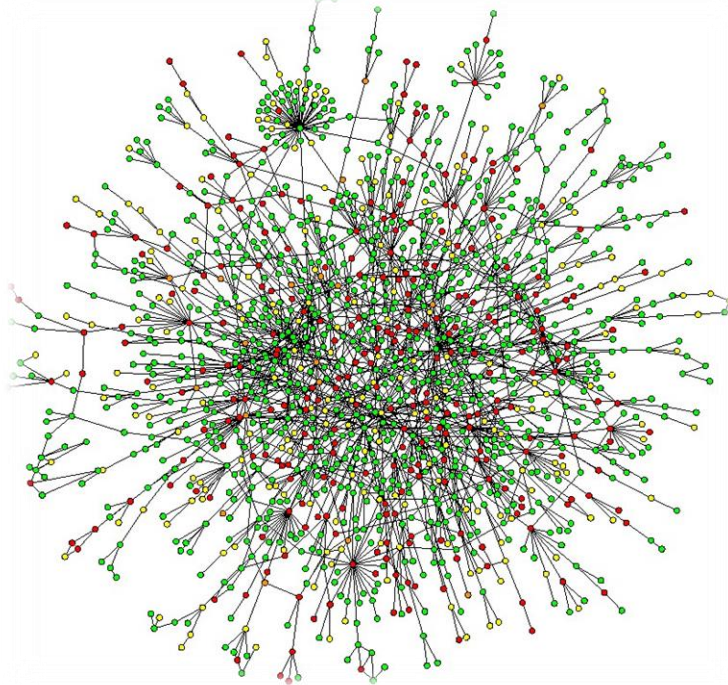
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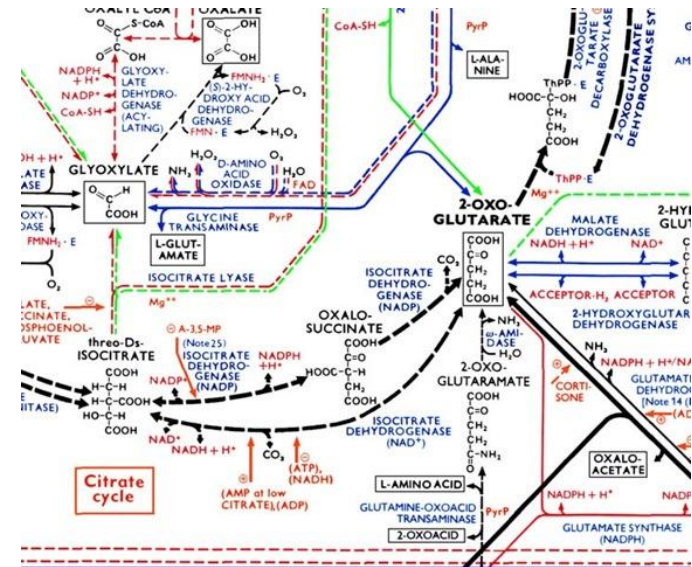
**Human brain has between
10-100 billion neurons**
[Sporns, 2011]

Networks: Biology

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Protein-Protein Interaction Networks:
Nodes: Proteins
Edges: 'physical' interactions



Metabolic networks:
Nodes: Metabolites and enzymes
Edges: Chemical reactions

Reasoning about Networks

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□ How do we reason about networks?

- **Empirical:** Study network data to find organizational principles
- **Mathematical models:** Probabilistic, graph theory
- **Algorithms** for analyzing graphs

□ What do we hope to achieve from studying networks?

- Patterns and statistical **properties** of network data
- **Design principles** and **models**
- **Understand** why networks are organized the way they are (Predict behavior of networked systems)

Networks: Structure & Process

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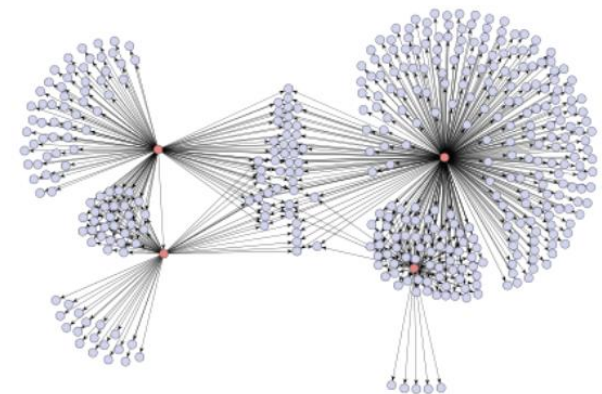
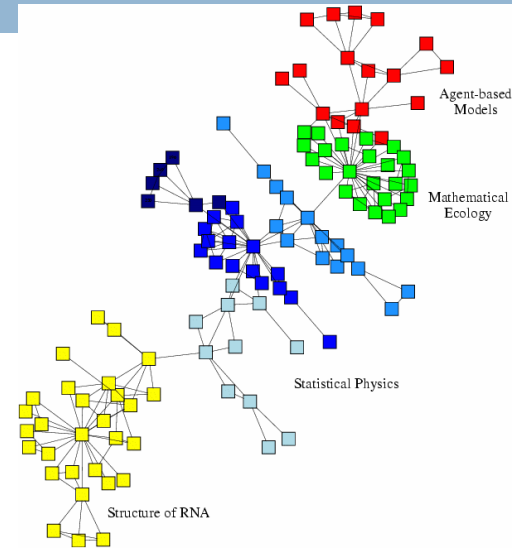
What do we study in networks?

□ Structure and evolution:

- What is the structure of a network?
- Why and how did it become to have such structure?

□ Processes and dynamics:

- Networks provide “skeleton” for spreading of information, behavior, diseases
- How do information and diseases spread?



Why Networks? Why Now?

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Why is the role of networks expanding?

□ **Data availability**

- Rise of Mobile, Web 2.0 and Social media

□ **Universality**

- Networks from science, nature, and technology are more similar than one would expect

□ **Shared vocabulary between fields**

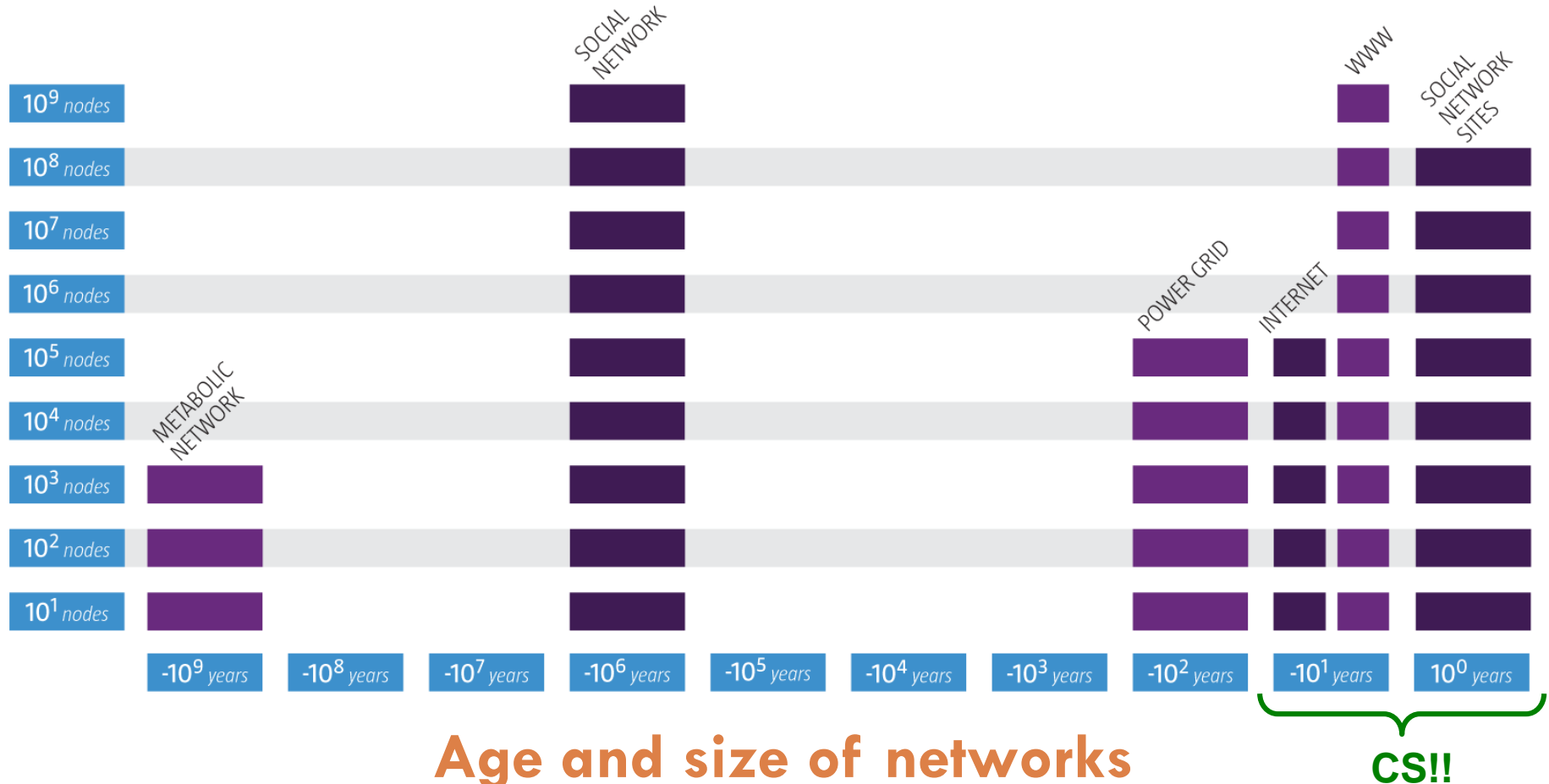
- Computer Science, Social science, Physics, Economics, Statistics, Biology

□ **Impact!**

- Social networking, Social media, Drug design

Networks: Why Now?

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Networks: Size Matters

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□ Network data: Orders of magnitude

- **436-node** network of email exchange at a corporate research lab [Adamic-Adar, SocNets '03]
- **43,553-node** network of email exchange at an university [Kossinets-Watts, Science '06]
- **4.4-million-node** network of declared friendships on a blogging community [Liben-Nowell et al., PNAS '05]
- **240-million-node** network of communication on Microsoft Messenger [Leskovec-Horvitz, WWW '08]
- **800-million-node** Facebook network [Backstrom et al. '11]

Web – The Lab for Humanity

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Networks: Impact

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- **Google**
Market cap:
\$250 billion
- **Cisco**
Market cap:
\$100 billion
- **Facebook**
Market cap:
\$50 billion

Networks Really Matter

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- If you were to understand the spread of diseases, **can you do it without social networks?**
- If you were to understand the WWW structure and information, **hopeless without invoking the Web's topology.**
- If you want to understand dissemination of news or evolution of science, **it is hopeless without considering the information networks**

Social Computing

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- The next generation could be the one with access to an unprecedented amount of **behavioral** data
- This can solve **real** problems
 - ... not just finding a movie or a restaurant
 - ▣ ensuring energy efficiency
 - ▣ monitoring our environment
 - ▣ reduce inequality
 - ▣ informing social decision



Only convinced by numbers?

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+40% □ How much data production grows / year
□ Enough to double every 24 months
(72h of videos upload on YouTube in 1 min).

€260b □ How much data can save on health care
□ In Europe [McKinsey] (U.S. save \$300b)

+300-1000% □ How much lifts improve when ads are using
behavioral targeting

What are Social Networks?

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- Large set of *personal information* about users
 - ▣ History of Browsing, Purchasing, Rating
 - ▣ Sociological profile (age, gender, location, income)
 - ▣ Community of interests
- Large set of *relational information* about users
 - ▣ Connections (friendship, collaboration, schoolmate)
 - ▣ Contacts (email IM phone calls etc., meeting)

A key principle

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- What *primarily* matters is your social environment!
 - ▣ For Business: how to best advertise a product?
 - ▣ For Media: how to find most relevant information?
 - ▣ For Engineers-CS: how to best design an application?
 - ▣ For Science and Society at large: how to understand human behavior? Take advantage of it?
 - ...
- ... 4 (classical) questions, being reinvented *today*

COURSE LOGISTICS

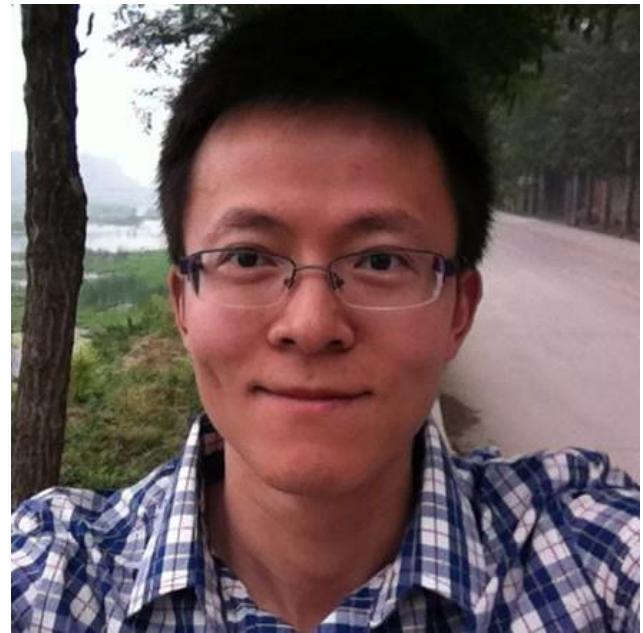


Logistics: Teaching Assistants

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Yaofeng Zhang



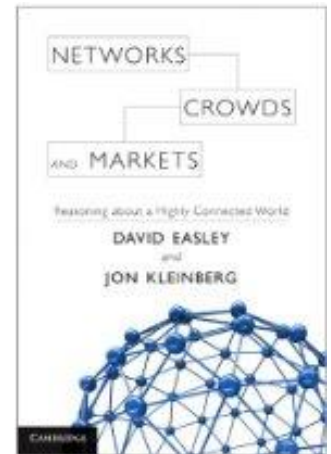
Rui Zheng

See course website for office hour schedule!

Logistics: Website

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- <http://course.cs.ust.hk/comp4641/>
- Slides posted at least 30 min before the class
- **Readings:**
 - Many chapters from Easley&Kleinberg
 - Papers
- **Optional readings:**
 - Papers and pointers to additional literature
 - **This will be very useful for project proposals**



Logistics: Communication

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- For e-mailing your course instructor
 - panhui@cse.ust.hk
- For e-mailing your TA
 - yzhangak@ust.hk & rzhengac@ust.hk
- We will post course announcements to course website (make sure you check it regularly)

Work for the Course & Grading

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- **Final grade will (tentatively) be composed of:**
 - ▣ **Homeworks: 20%**
 - Homework 0: 2%
 - Homeworks 1,2,3: 6% each
 - ▣ **Midterm: 30%**
 - ▣ **Substantial class project: 50%**
 - Proposal: 20%
 - Project milestone: 15%
 - Final report: 50%
 - Poster presentation: 15%
- ▣ Extra credit for class participation

Course Schedule (tentative)

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Week	Assignment	Due on THU
2	Homework 0	March 6
3	Homework 1	March 13
4	Project proposal	March 18
5	Homework 2	March 25
	Work on the project	
7	Homework 3	April 10
8	Project milestone	April 17
	Project presentation	May 8
	Final report	May 10 (no late days!)

Homeworks, Write-ups

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- **Assignments take time. Start early!**
- **How to submit?**
 - ▣ **Paper** (Print code!): In class
 - ▣ **In addition**, write-ups (proposal, milestone, final report) have to **also** be submitted electronically
 - Email PDF to hkust.comp4941@gmail.com
- **2 late days for the semester:**
 - ▣ Max 1 late day per assignment

Course Projects

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- **Substantial course project:**
 - **Experimental evaluation** of algorithms and models on an interesting network dataset
 - A **system project** that involve software implementation of social information services or applications
 - A **theoretical project** that considers a model, an algorithm and derives a rigorous result about it
 - Develop **scalable algorithms** for massive graphs or large scale social information systems
- **Performed in groups of 3 students**
- Project is the **main work** for the class

Prerequisites

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- **Basic background in:**

- Algorithms
- Graph theory
- Probability and Statistics
- Linear algebra

- **Programming:**

- You should be able to write non-trivial programs

- **Lab and tutorial sessions:**

- Review programming tools (SNAP, NetworkX)
- Review basic mathematical concepts
- Review social networking services

Course Syllabus

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Introduce **properties, models and tools** for

- Large real-world networks
- Processes taking place on networks

through **real applications and case studies**

- **Goal:** find **patterns, rules, clusters, outliers, ...**
 - ... in large static and evolving graphs
 - ... in processes spreading over the networks
 - ... in scalable computer networking system design

Course Syllabus

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- Covers a wide range of **network analysis techniques**
– from basic to state-of-the-art
- **You will learn about things you heard about:**

Six degrees of separation, small-world, page rank, network effects, P2P networks, network evolution, virus propagation, link prediction, power-laws, scale free networks, core-periphery, network communities, hubs and authorities, bipartite cores, information cascades, influence maximization, tipping points, social engineering, altruism, malicious behaviors, mobile social networks ...
- **Covers algorithms, theory, system and applications**
- **It's going to be fun** 😊