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

COMP4641: Social Information Network Analysis and Engineering
Wednesday February 4th 2015

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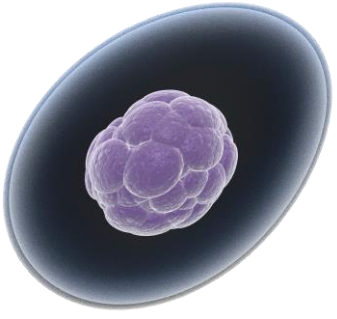
What do the following things have in common?

2

World economy

3



Human cell

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Roads

5

Brain

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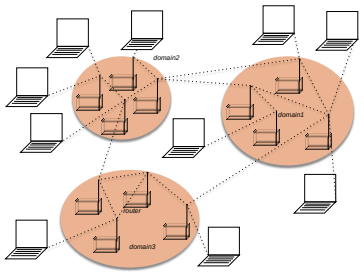

Internet

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Friends & Family

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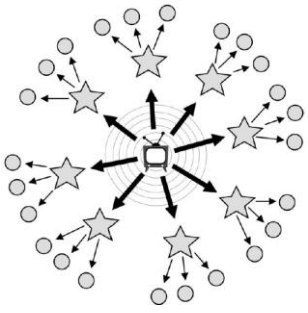

Media & Information

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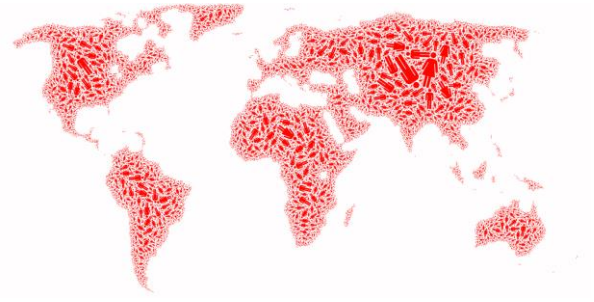

Society

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Networks & Complex Systems

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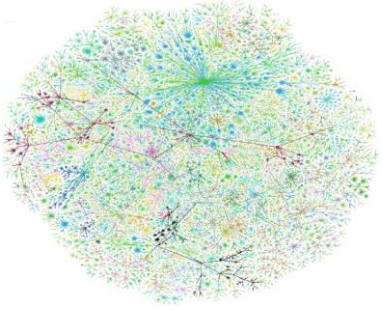
- **Hopelessly complex systems are around us:**
  - **Society** is a collection of six billion individuals
  - **Communication systems** link electronic devices
  - **Information** and **knowledge** is organized and linked
  - Thousands of **genes** in our cells work together in a seamless fashion
  - 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!

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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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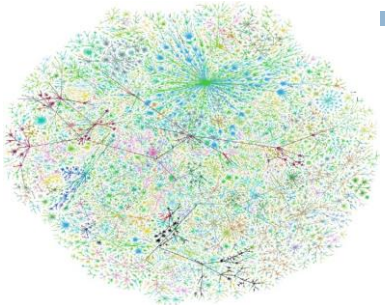

Graph of the Internet (Autonomous Systems)
Power-law degrees [Faloutsos-Faloutsos-Faloutsos, 1999]
Robustness [Doyle-Willinger, 2005]

Networks: Media

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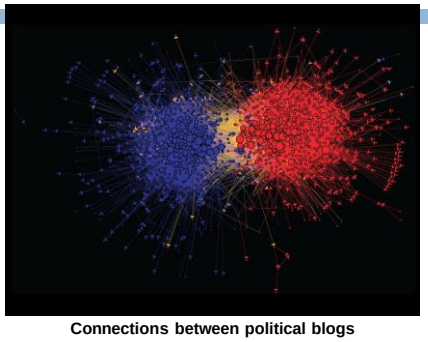

Connections between political blogs
Polarization of the network [Adamic-Glance, 2005]

Networks: Technology

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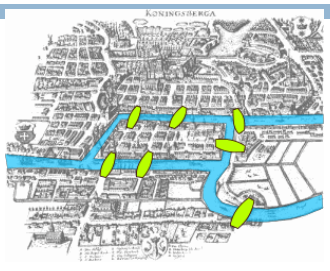
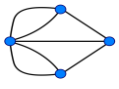


Seven Bridges of Königsberg
[Euler, 1735]
Return to the starting point by traveling each link of the graph once and only once.



Networks: Information

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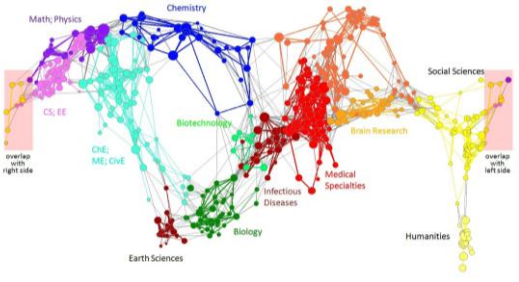

Citation networks and Maps of science
[Börner et al., 2012]

Networks: Knowledge

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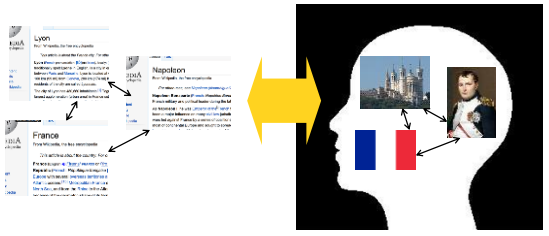

Understand how humans navigate Wikipedia

Get an idea of how people connect concepts

[West-Leskovec, 2012]

Networks: Organizations

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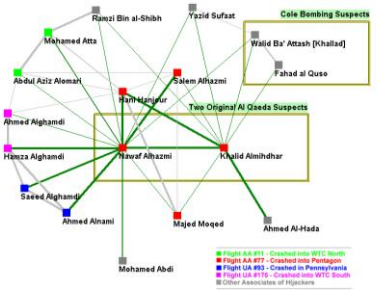

9/11 terrorist network

[Krebs, 2002]

Networks: Economy

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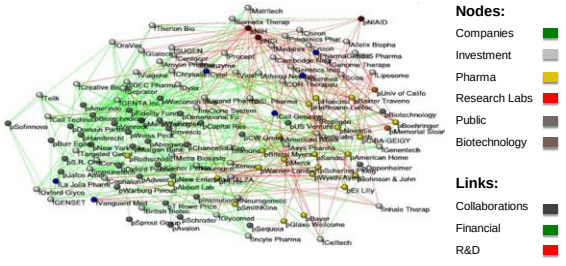

Bio-tech companies

[Powell-White-Koput, 2002]

Networks: Brain

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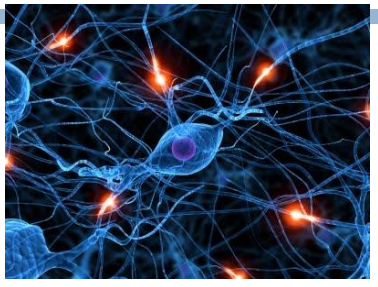

Human brain has between 10-100 billion neurons

[Sporns, 2011]

Networks: Biology

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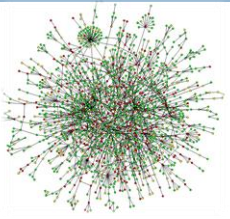
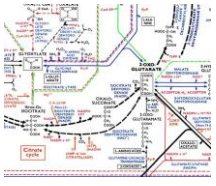


Protein-Protein Interaction Networks:
Nodes: Proteins
Edges: 'physical' interactions



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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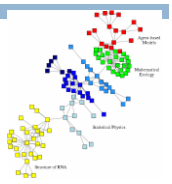
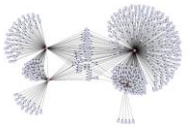
What do we study in networks?

- **Structure and evolution:**
  - What is the structure of a network?
  - Why and how did it became 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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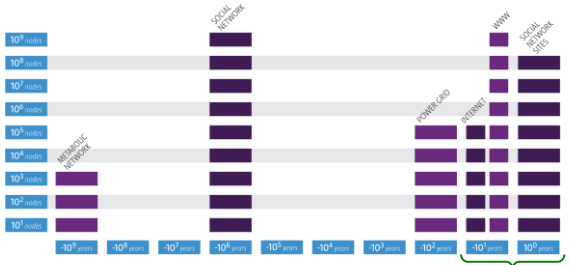

Networks: Size Matters

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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 24months

(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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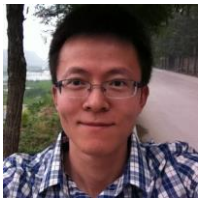
Yaofeng Zhang



Rui Zheng

See course website for office hour schedule!

Logistics: Website

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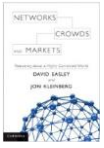
- http://course.cs.ust.hk/comp4641/
- Slides posted at least 30 min before the class
- **Readings:**
  - Many chapters from Easley&Kleinberg
  - Papers
- **Optional readings:**
  - Papers and pointers to additional literature
  - **This will be very useful for project proposals**



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	February 27
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.comp4641@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 ☺**