ID2220 Advanced Topics in Distributed Systems

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  - Anis Nasir (KTH/EES) (2nd part of the course)
- **Course responsible**
  - Seif Haridi (SICS/KTH)

Course Contents

- **1st period (Sep-Oct 2015):**
  - Networks
    - Intro, basic definitions
    - Network models
  - Random Walks, Spectral Graph Theory
  - Navigable Small-World Networks
  - Scalable publish/subscribe Systems
  - Gossip protocols
  - Graph partitioning, community detection (if there is time)
- **Material**
  - **Scientific papers (will be put online)**
  - **Books**
    - **"Networks, Crowds, and Markets: Reasoning About a Highly Connected World" By David Easley and Jon Kleinberg**
    - **"Networks: An Introduction" by Mark Newman**
    - **“Foundations of Data Science” by J. Hopcroft and R.Kannan**

Course Contents (cont.)

- **2^{nd} period-Reviews, Presentations, Discussions (Nov-Dec)**
  - **Presentations (list of state-of-the-art papers)**
    - ~30min per student (with questions/discussion)
    - Focus on the **Quality of presentation** and
    - Understanding/answering questions
  - Two papers to review
    - Be able to summarize the contribution/ideas
    - Identify strong/weak sides
  - Read “how to” read and review papers on the course webpage
- **Evaluation**
  - Midterm (end of Oct or Nov.)
  - Final grade: Midterm + presentation/reviews

Networks


NASDAQ
NASDAQ
NASDAQ


STOCKHOLM
T-BANA
1 Thorildsplan
2 Fridhemsplan
3 Sankt Eriksplan
4 Odenplan
5 Rådmansgatan
6 Hötorget
Akalla
11
Husby
Kista
Kymlinge
Hallonbergen
Näckrosen
Solna centrum
Västra skogen
Huvudsta
Vreten
Sundbybergs centrum
Duvbo
Rissne
Rinkeby
Tensta
Hjulsta
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Mörby centrum
14
Danderyds sjukhus
Bergshamra
Universitetet
Tekniska högskolan
Stadion
Ropsten
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Gärdet
Karlaplan
Östermalmstorg
T-centralen
Kungsträdgården
Gamla stan
Slussen
Rådhuset
Stadshagen
Hässelby gård
Johannelund
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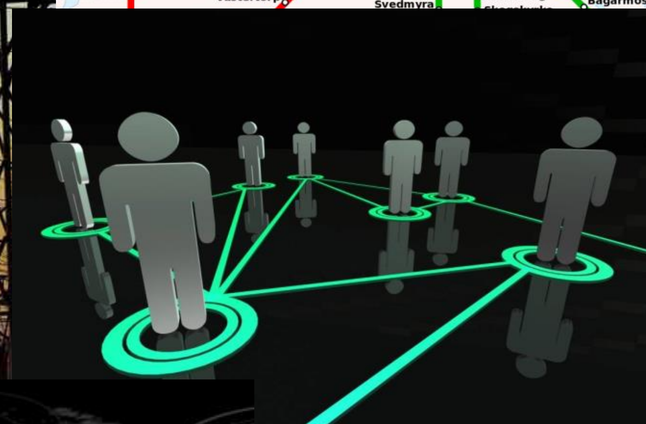
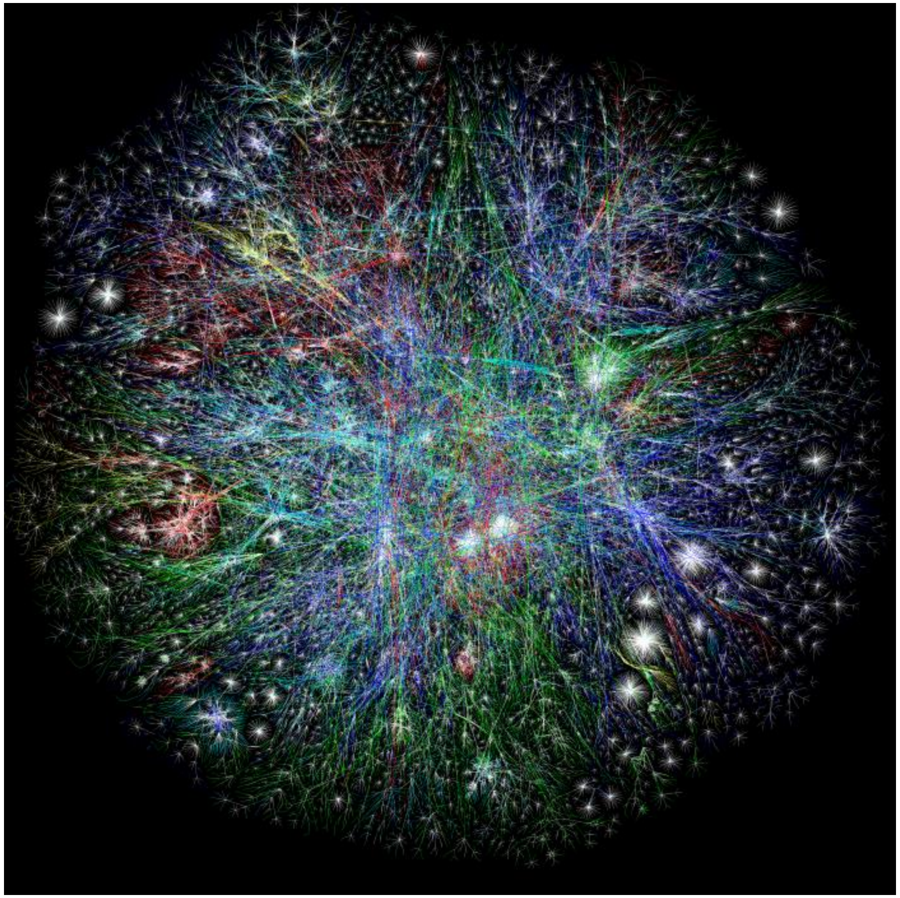
Hässelby strand
Vällingby
Råcksta
Blackeberg
Islandstorget
Ängbyplan
Åkeshov
Brommaplan
Abrahamsberg
Storamossen
Alvik
Kristineberg
Hornstull
Liljeholmen
Aspudden
Örnsberg
Bredäng
Sätra
Skärholmen
Mälarhöjden
Axelsberg
Hägerstensåsen
Västertorp
Midsommarkransen
Telefonplan
Zinkensdamm
Mariatorget
Medborgarplatsen
Skanstull
Gullmarsplan
Skärmarbrink
Hammarbyhöjden
Björkhagen
Kärrtorp
Bagarmossen
Globen
Enskede gård
Sockenplan
Svedmyra
Blåsut
Sandsborg



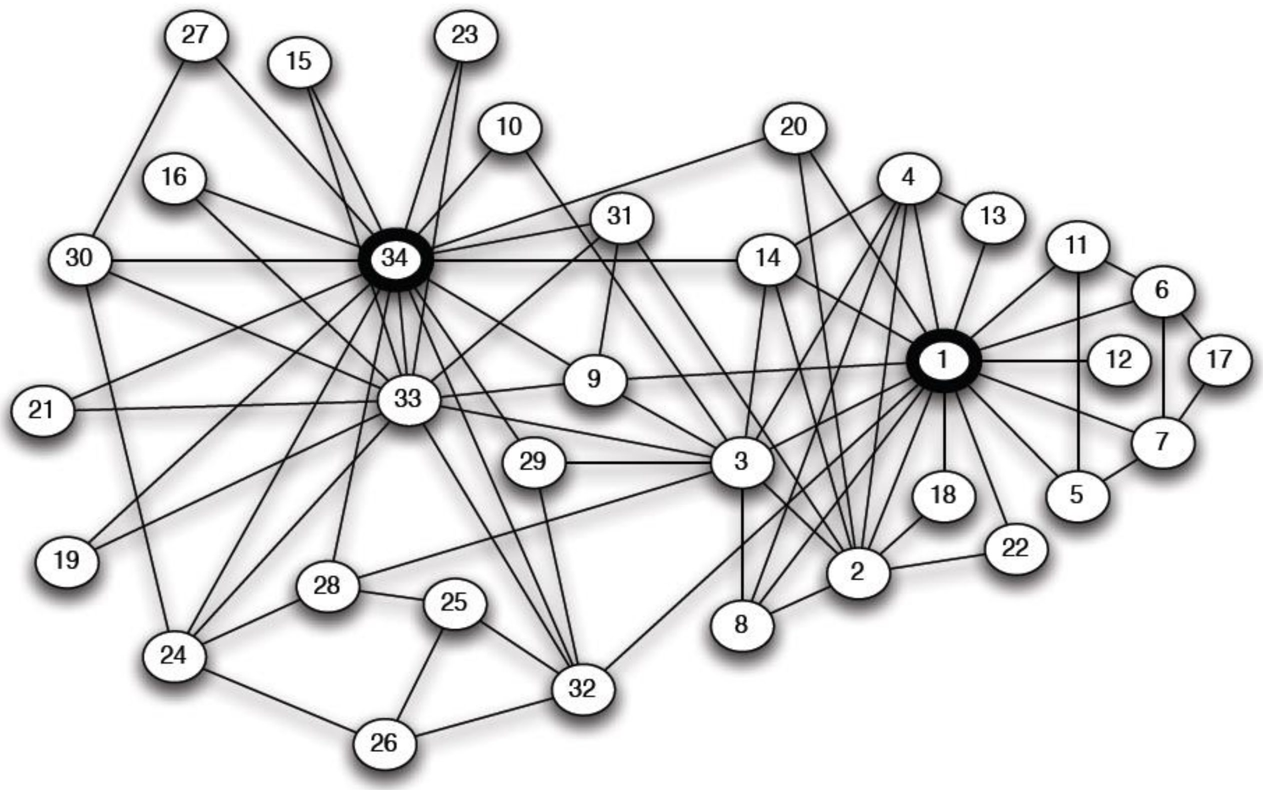
Networks are Everywhere!

- The Internet
- Social networks
- Financial Systems
- Brain
- Cell
- Roads
- Power Grids
- Information Dissemination
- Disease spreading
- Etc.



In order to understand these systems we need to understand the networks behind them!

Examples



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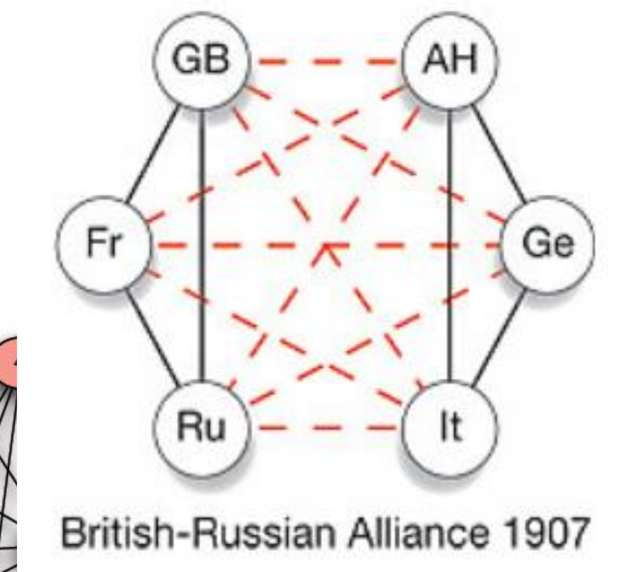
Examples



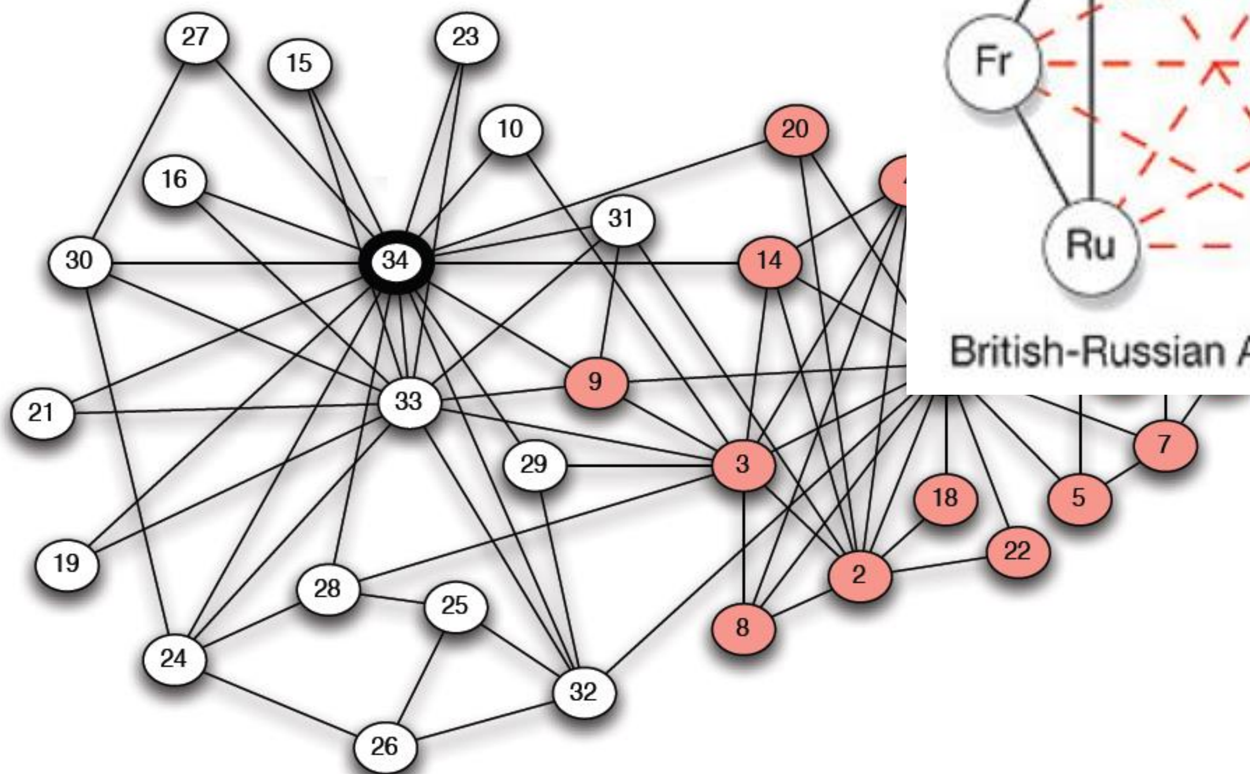
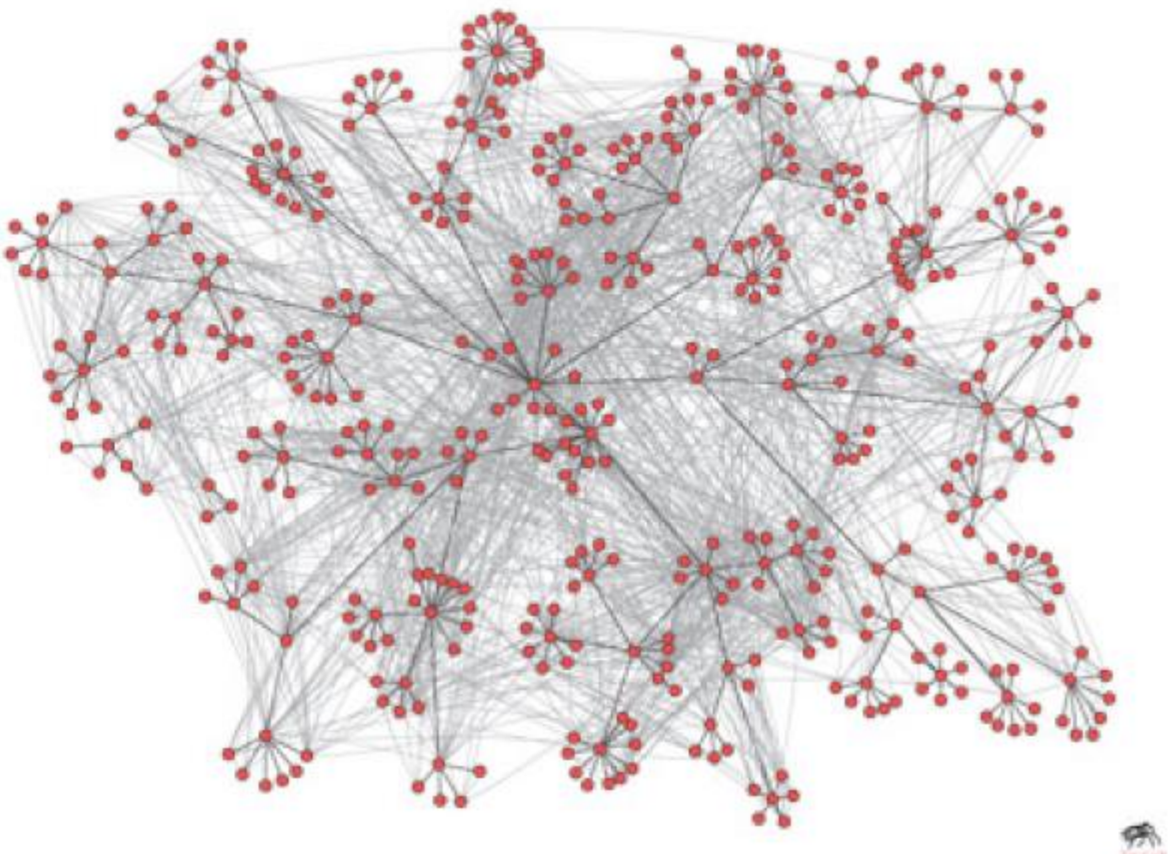


Figure 1.7: From the social network of friendships in the karate club from Figure 1.1, we can find clues to the latent schism that eventually split the group into two separate clubs (indicated by the two different shadings of individuals in the picture).

Email communication of HP Research Labs

- What can we see from this network?



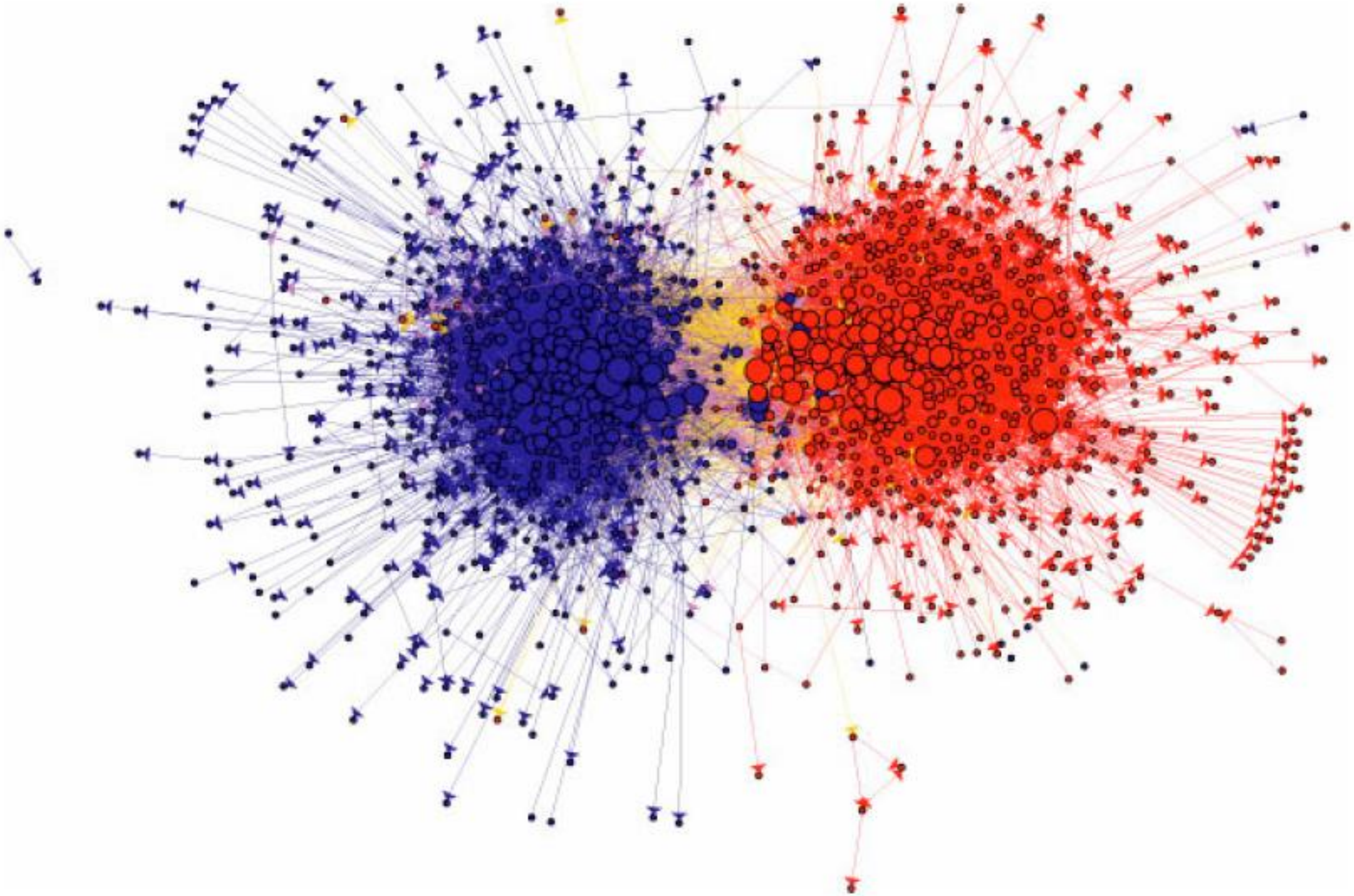


Figure 1.4: The links among Web pages can reveal densely-knit communities and prominent sites. In this case, the network structure of political blogs prior to the 2004 U.S. Presidential election reveals two natural and well-separated clusters [5]. (Image from http://www-personal.umich.edu/ ladamic/img/politicalblogs.jpg)

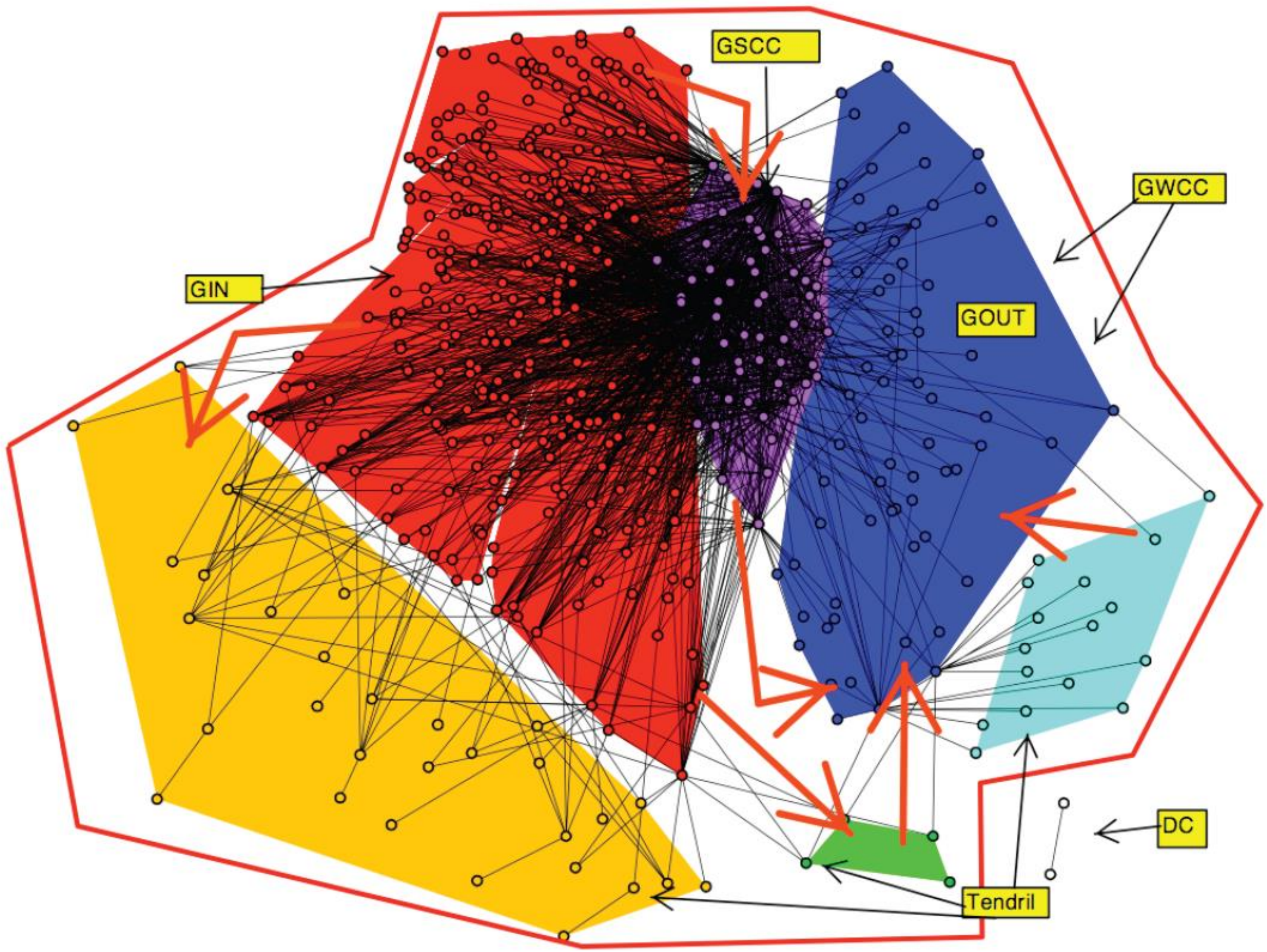


Figure 1.3: The network of loans among financial institutions can be used to analyze the roles that different participants play in the financial system, and how the interactions among these roles affect the health of individual participants and the system as a whole The network here is annotated in a way that reveals its dense core, according to a scheme we will encounter in Chapter 13. (Image from Bech and Atalay [50].)

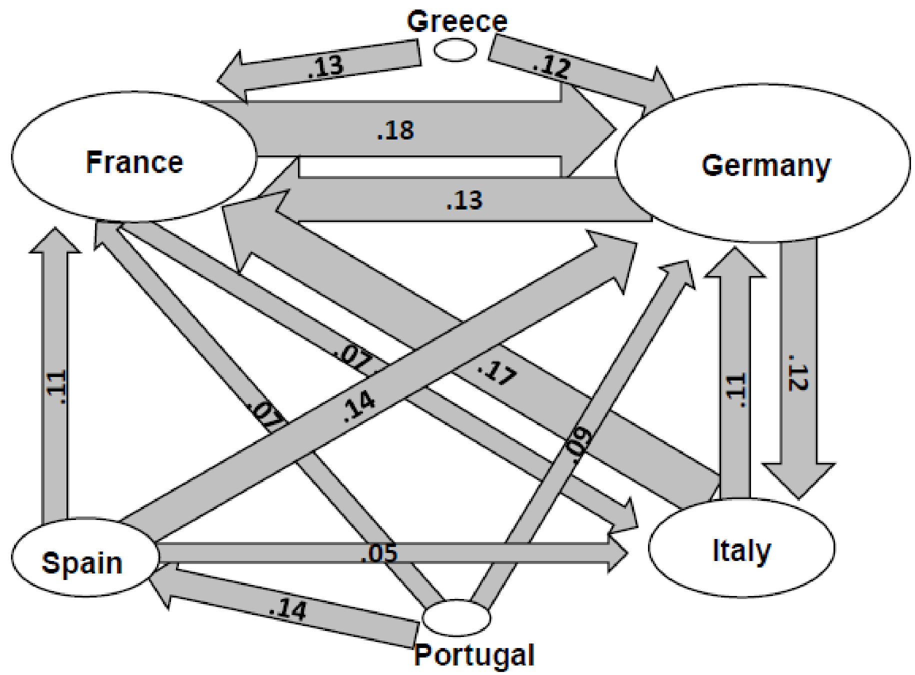


Figure 9: Interdependencies in Europe: The matrix **A**, describing how much each country ultimately depends on the value of others' debt. The widths of the arrows are proportional to the sizes of the dependencies; the area of the oval for each country is proportional to its underlying asset values.

Financial Networks and Contagion*

Matthew Elliott† Benjamin Golub‡ Matthew O. Jackson§

Revision: January 2013

Behavior and Dynamics

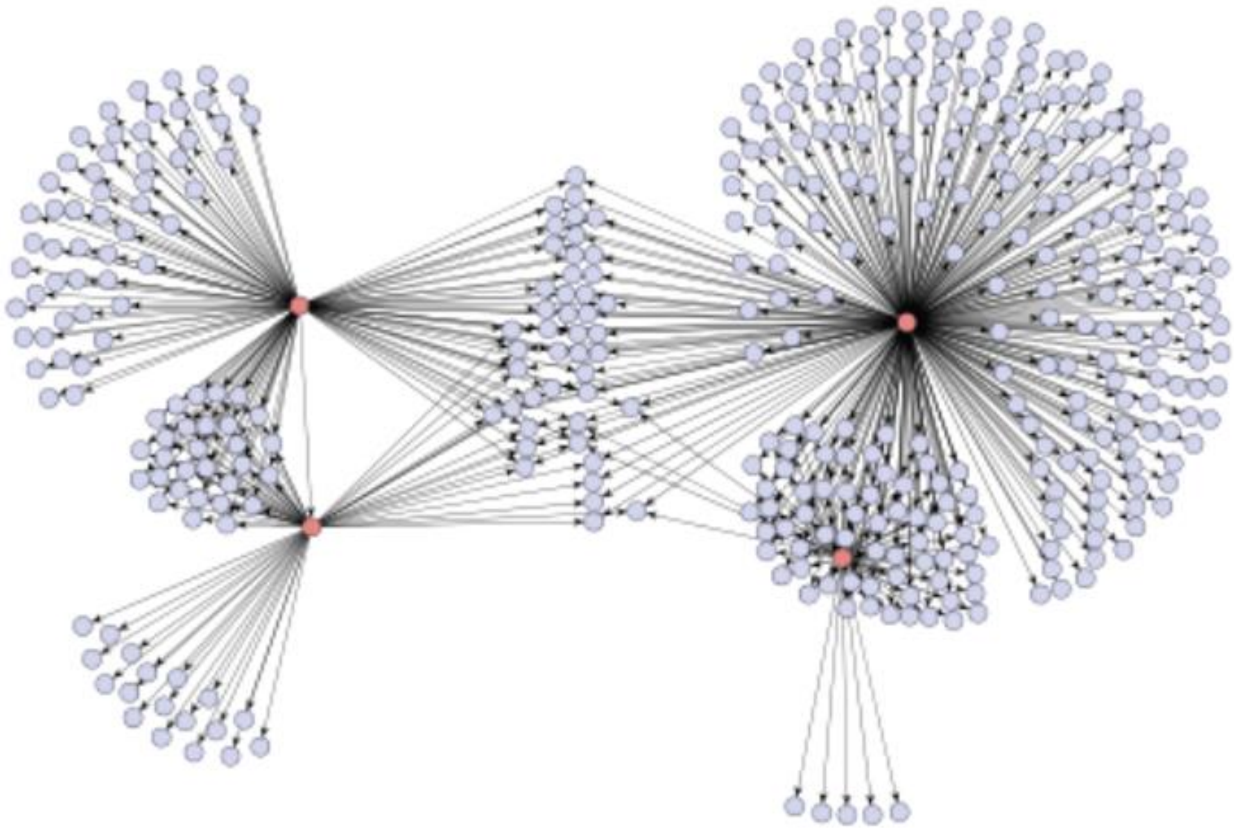


Figure 1.11: When people are influenced by the behaviors their neighbors in the network, the adoption of a new product or innovation can cascade through the network structure. Here, e-mail recommendations for a Japanese graphic novel spread in a kind of informational or social contagion. (Image from Leskovec et al. [271].)

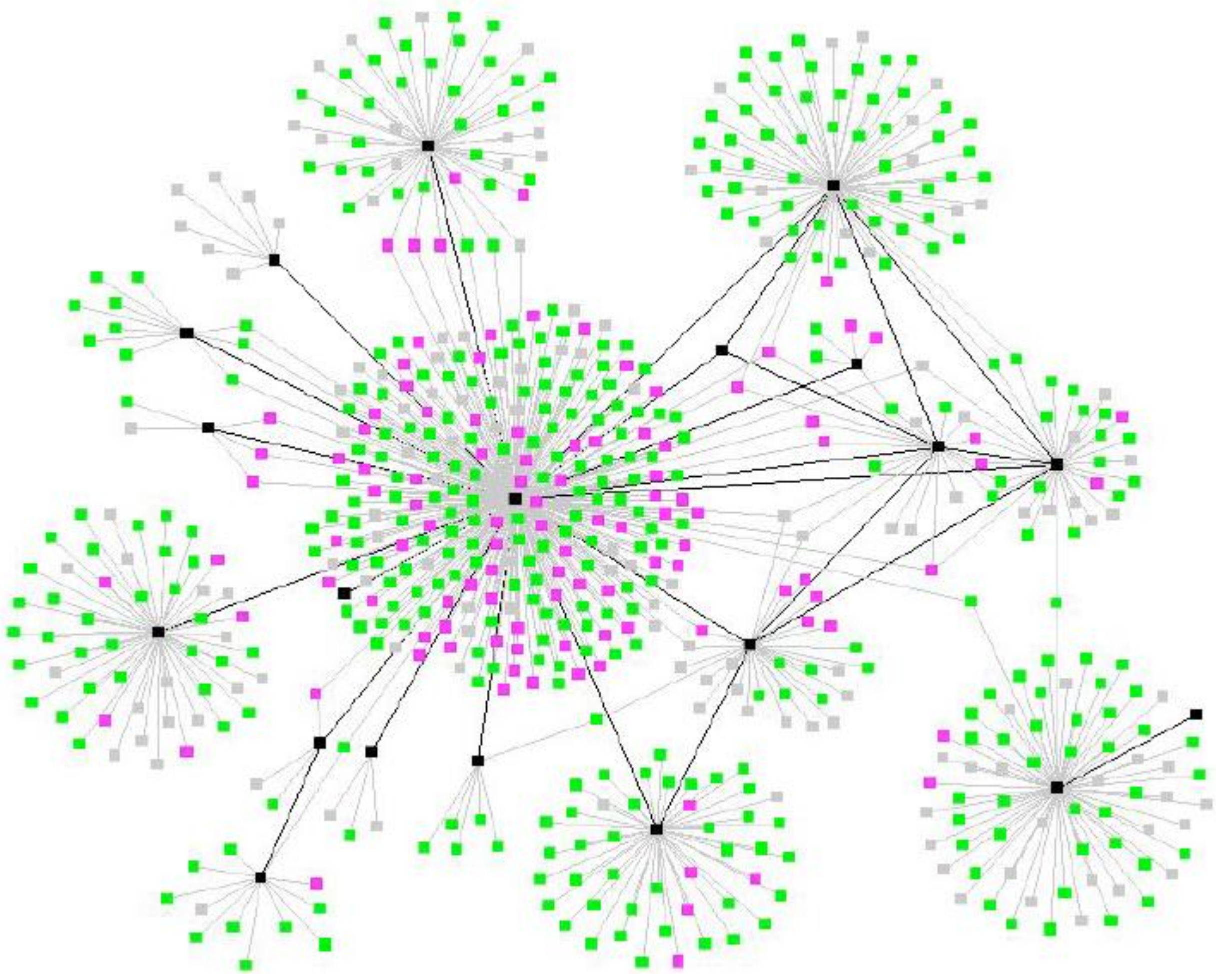
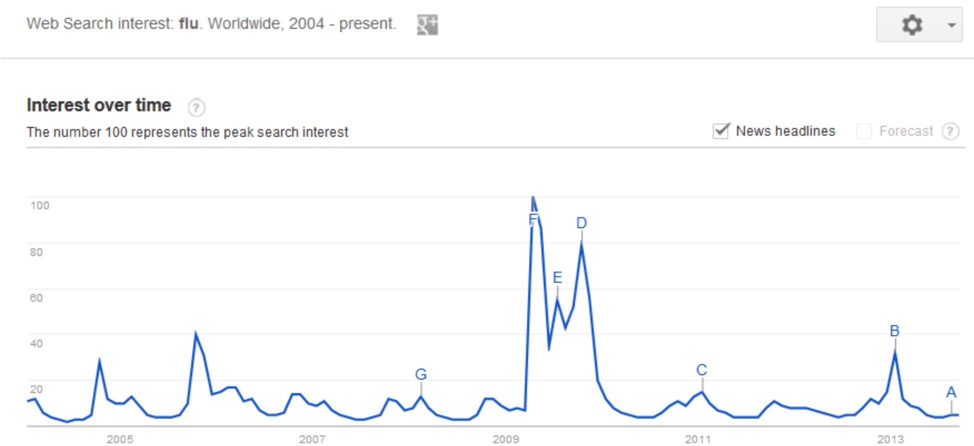


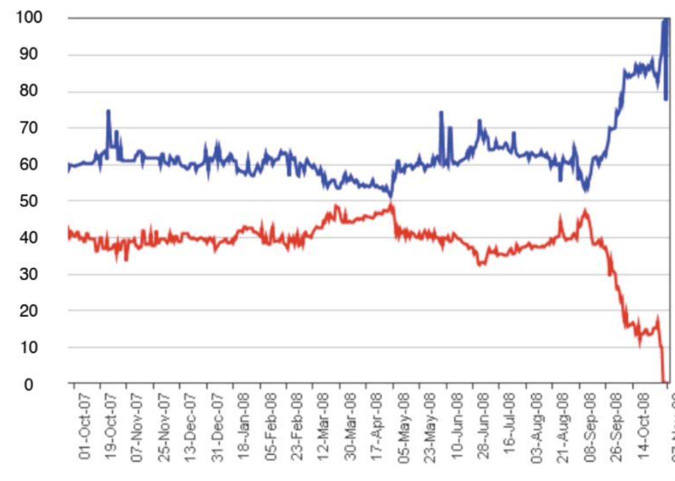
Figure 1.12: The spread of an epidemic disease (such as the tuberculosis outbreak shown here) is another form of cascading behavior in a network. The similarities and contrasts between biological and social contagion lead to interesting research questions. (Image from Andre et al. [16].)

Network dynamics

- **Structure**
  - What is network structure, how it evolves over time?
- **Behavior**
  - Information Flow/Cascades (social contagion)
  - Social *practices* that people can choose to adopt or not
    - Should I join Facebook? Should I buy iPhone? Should I go to this restaurant? Should I join the revolution?
  - Road Traffic Behavior
  - Etc.

Aggregate Behavior





- Why things go viral?
- How to start a movement
- http://www.ted.com/talks/derek_sivers_how_to_start_a_movement.html

Analysis of Networks

- Why?
- To understand the **structure of the network** (topology)
  - Can we **model** the networks?
  - Why networks are the way they are? Can we find the **underlying rules** that build these networks?
  - How does the structure **evolve** over time?
- To understand network **behavior and dynamics**
  - Small-World Effect
    - Decentralized Search/Routing
  - Epidemics (gossip protocols)
    - E.g., disease spread, why/how things go viral?
  - Aggregate behavior

Networks vs. Graphs

- **Network** refers to a **real system**, while **Graph** to a **mathematical representation** of a network
  - **Node** vs. **vertex**, **link** vs. **edge**
  - We will use the terms interchangeably

What graphs represent?

- It is important to chose **proper graph representation** of a real system
  - Connecting all the actors that co-appeared in the same move together will result in a co-appearance graph (e.g, Kevin Bacon graph)
  - Connecting all the actors that share the same consonants in their first names will result in what?
- The way **nodes and links are assigned** determines the type of questions we can study

Complexity of the Networks

- How many different networks can we produce if we have N nodes?
  - How many possible links in your class?
  - M=0,5*N*(N-1), i.e., N choose 2
    - If N=10, we have M=45
    - If N= 30, we have M=435
    - If N=100 we have M=4950
  - The number of possible networks 2^M
    - Wikipedia says that number of atoms in the observable universe is 2^{80}

Complexity of the Networks (cont.)

- Party problem: what is the minimum number of guests *R* that must be invited so that at least *r* will know each other OR at least *s* will not know each other.
- Take an social network of 6 people
  - Claim: “I would able to find either 3 mutual friends or 3 mutual strangers (or both) on any instance of a social network of size 6”.
  - Can you prove it?
- What if we have 7 people?
- What if we have 5 people? Am I guaranteed to find 3 mutual friends or strangers?
  - Can you show a counter example?
- **Ramsey’s** number R(3,3)=6
- Can be extended to R(r,s)
- R(4,4)= ?
  - R(4,4)= 18
- R(5,5)= ?
  - R(5,5)= we don
- **Why don’t we so**
  - How many netw
  - 2^{946}

> "Erdős asks us to imagine an alien force, vastly more powerful than us, landing on Earth and demanding the value of R(5,5) or they will destroy our planet. In that case, he claims, we should marshal all our computers and all our mathematicians and attempt to find the value. But suppose, instead, that they ask for R(6,6). In that case, he believes, we should attempt to destroy the aliens.”