BLG517E- MODELING AND PERFORMANCE ANALYSIS OF NETWORKS,

SLIDES FROM NETWORKS

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Networks: An Introduction by Newman

Content

- Introduction
- The emperical study of networks
  - *Technological network*
  - *Social networks*
  - *Networks of information*
  - *Biological networks*

Introduction

- Networks is a collection of points joined together in pairs by lines.
- Points are referred as vertices (or nodes), and the lines are referred as edges.
- The pattern of connections in a given system can be represented as a network. Components: vertices. Connections:edges.
- A network is a simpified representation that reduces a system to an abstract structure capturing only the basics of connection patterns and litle else.
- Vertices and edges in a network can be labeled with additional information such as names or strengths, to capture more detail of the system, but even so a lot of information is usually lost in the process of reducing a system to a network representation.

Introduction

- Over the years many tools are developed to analize, model, and understant networks. Using mathematical, computational, and statistical techniques.
- Some examples of networks
  - *Internet : transport data between computers, best paths to transfer data*
  - *World Wide Web : 'Web' and 'Internet' are often used interchangeably, but technically the two are very distinct.*

    The Internet is the physical network, the web on the other hand is a network of information stored on web pages. The edges are 'hyperlinks.'
- The Web also illustrates the other concept of network theory: the **directed** network.

Introduction

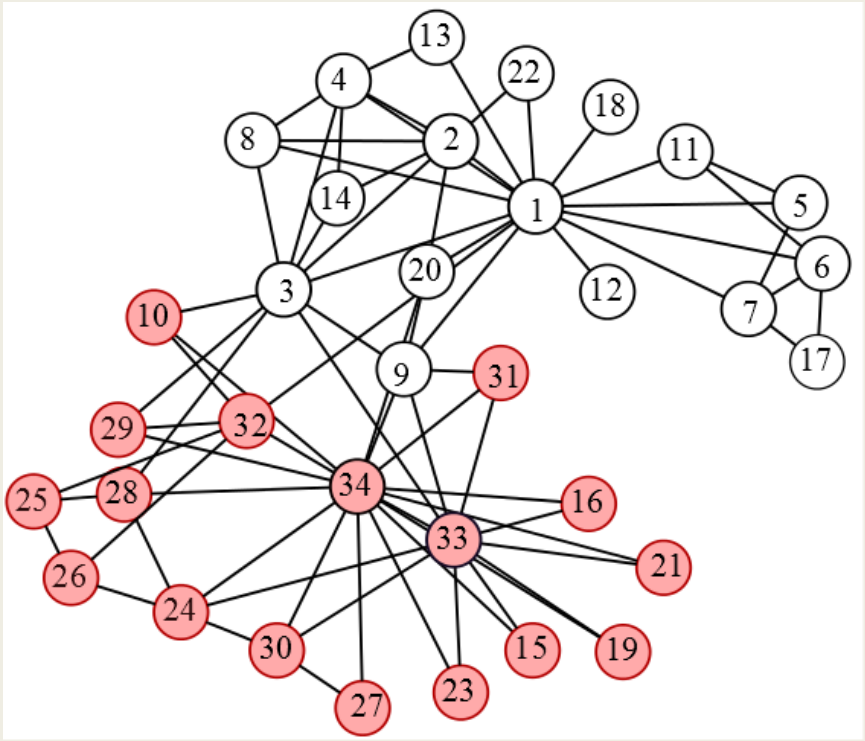
- Another type of network of scientific interest is the social network : the people or groups form the vertices of the network and the edges represent connections of some kind between them. Friendship, business relationship between companies.
- Famous Zachary's Karate Club network.

  Network shows the interaction among the club members outside (studying for 3 years).

  Node1: Instructor, Node34: administrator.

  Conflict arose between them.

  By using the min-cut-max-flow algorithm Zachary guessed the behavior of all members but Node9.



Introduction

- Another type is Biological networks: Network of neurons, food web (predator-prey relationship), biochemical networks, such as protein-protein interaction networks.

Introduction

- Properties of networks
  - *Centrality. It quantifies how important vertices are in a networked system.*
  - *Degree is a measure for it. Gives the number of edges incident with a node.*

    In-degree, out-degree. 'Hubs' are the vertices with unusually high degree.
- Small-world effect: 'six degrees of separation'
- Clusters and communities in a network: Friendship networks tend to contain cliques, circles, and gangs of friends within which connections are strong and frequent but between which they are weaker or rarer.

THE EMPIRICAL STUDY OF NETWORKS

Technological Networks: Internet

- The Internet is a packet switched data networks
- The format of the packets follows a standard known as IP (Internet Protocol) and Includes an IP address.
- An alternative to a packet switched network is a circuit switched network.
- Packet vs circuit switching
- A software protocol called TPC (Trasport Control Protocol) runs on tp of IP and performs the necessary error checking and retransmission automatically.
- UDP (User Datagram Protocol) is another protocol on top of IP.

Technological Networks: Internet

- How to represent the Internet? Data, nodes, routers, lines, core of the network (backbone), network backbone providers, ISPs, regional ISPs

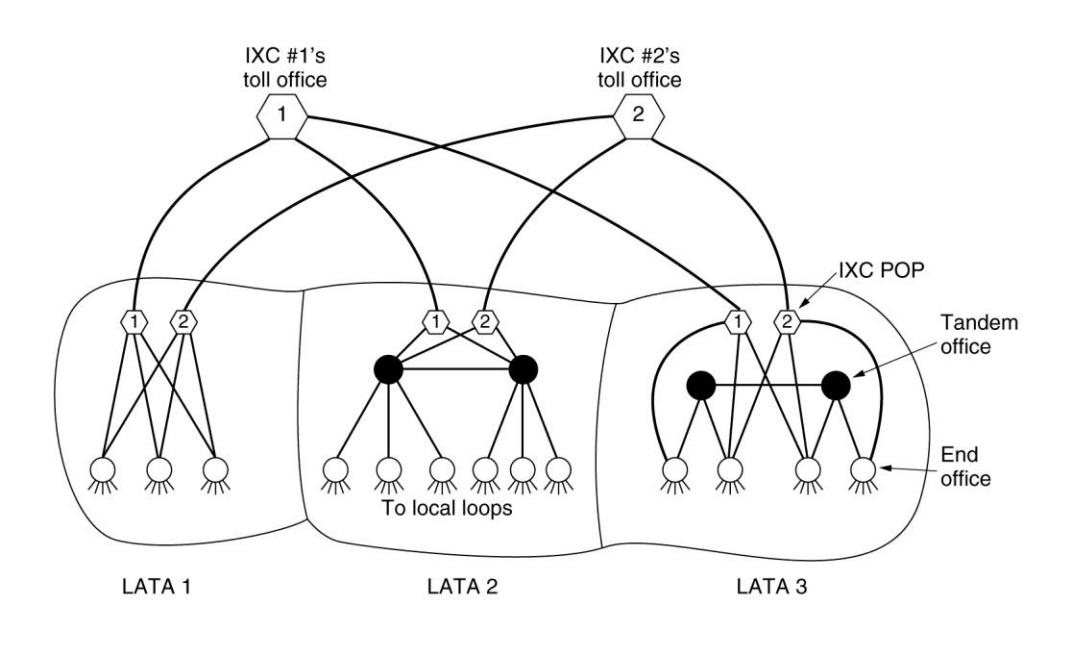
  Figure

- Border Gateway Protocol (BGP)
- How to construct the map of the network?
- Measuring Internet structure using Traceroute (It uses the TTL field)
- Figure 2.2

Technological Networks: Internet

- Three ways to group addresses:
  - *Subnet*
  - *Domain name (itu.edu.tr ..)*
  - *Autonomous system (similar to domain. A group of computers under single administrative control)*
- Measuring Internet Structure Using Routing Tables
  - *Routing within and Autonomous System (AS) and between ASes*
  - *BGP is used to route between ASes*

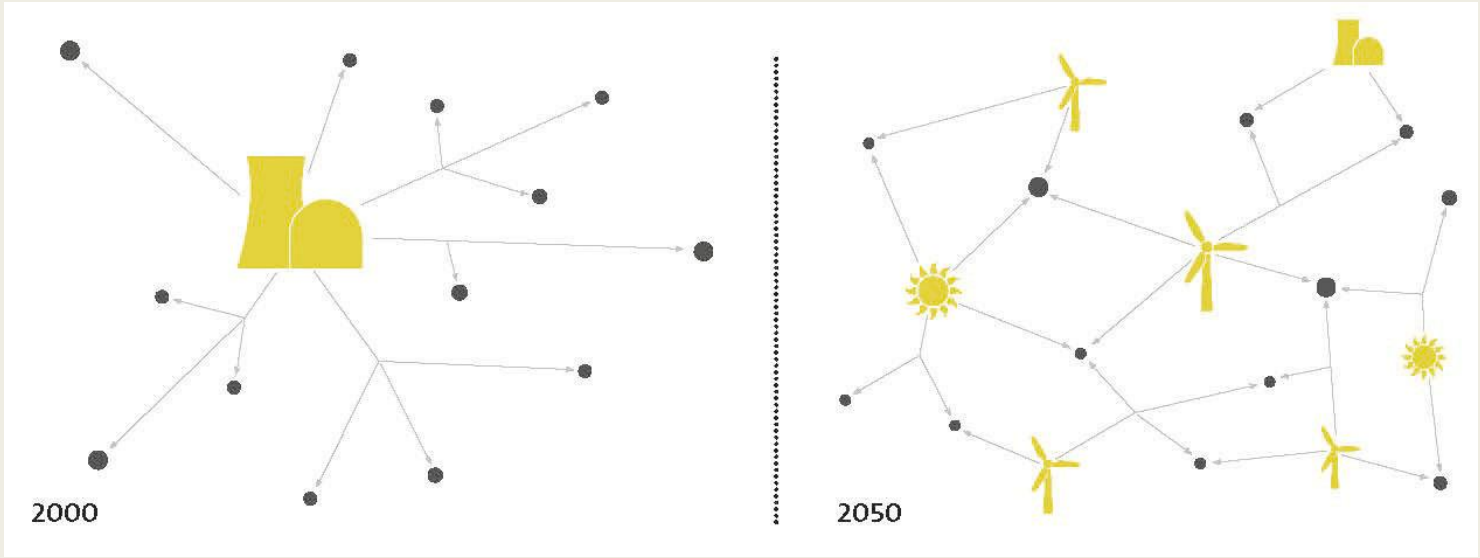
Technological Networks: The Telephone Network



From Computer Networks by Tanenbaum

Technological Networks: Power Grids

- Vertices here corresponds consumers and the generators



Technological Networks: Transportation Networks, Delivery and Distribution Networks

- Airline networks an be constructed based on the time tables
- A study made in India showed that people care about changing the train but not the length of a line when deciding about their travel. They do not want to change train even though it makes the journey shorter.
- Power grids are also distribution networks

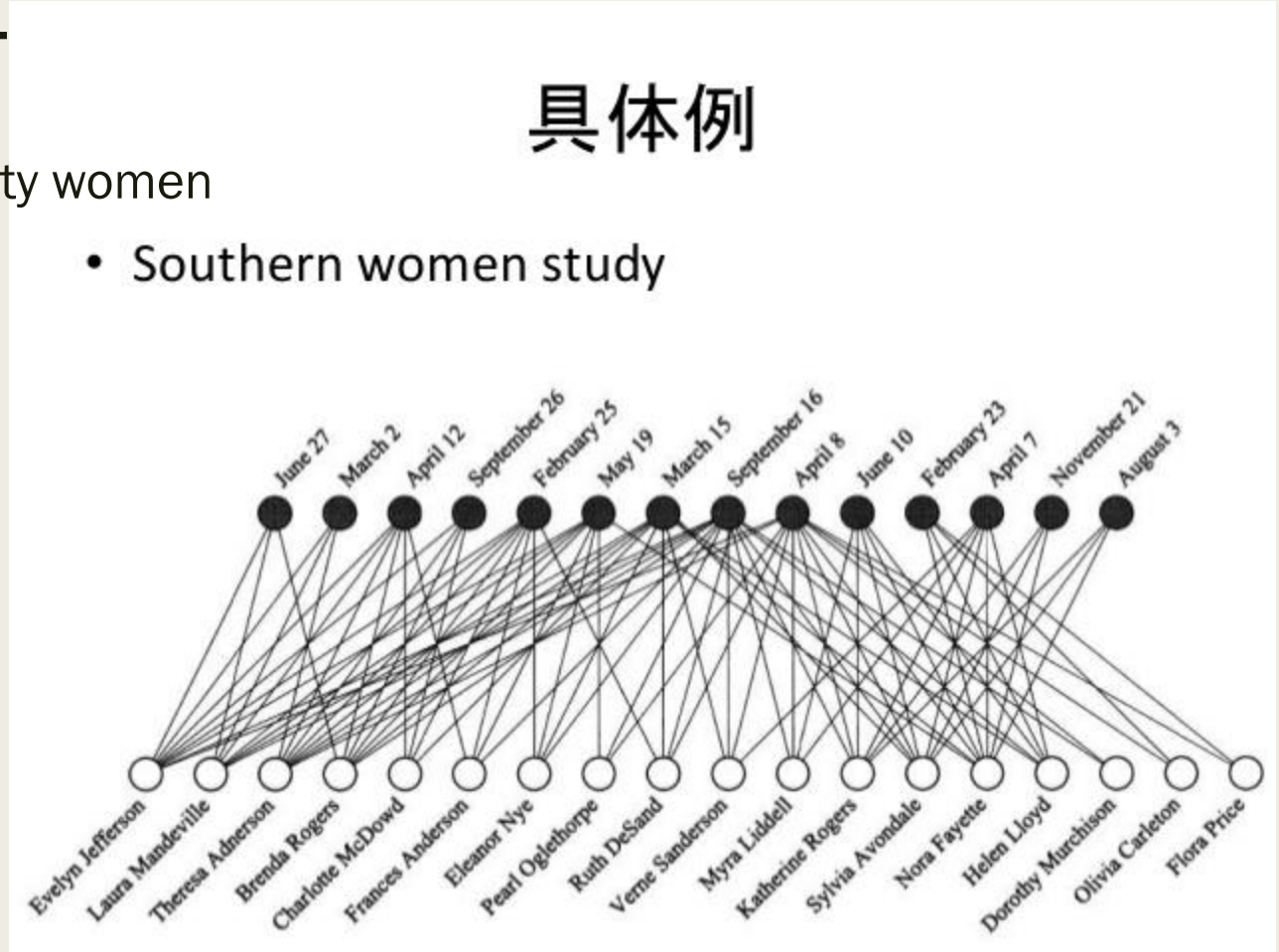
SOCIAL NETWOKS

Social Networks

- Social networks are networks in which the vertices are people (or group of people), and the edges represent some form of interaction between them, such as friendship. Vertices and edges are represented as actors and ties
- Social network analysis is called sociometry.
- In such network there are many different possible definitions of an edge, relationship, exchange of money, communication pattern etc.

Social Networks: ‘Southern Women Study’ in 1941

- Public appearances of society women
- Two types of vertices
- A bipartite graph



Social Networks: Interviews and Questionaries

- Most common method of accumulating data
- Are the answers correct? Limit the number of responses
- Studies in which all or nearly all of the individuals in a community are surveyed are called sociometric studies. Personal networks (or egocentered networks) are the others.
- The indivudials surveyed is referred as **ego** and the contacts as **alters**.

Social Networks: Obtaining Data

- Direct observation. By watching interactions
  - *One arena in which direct observation is essential is the experiments related to social networks of animals*
- Data from archival or thid-party records
  - *Network of intermariages between families*
  - *Email networks. Emails can be examined. Those can be helpful when studying spread of viruses. Email address books can be used.*
  - *Social networks of services such as Facebook, LinkedIn*

Social Networks: Affiliation Networks

- An affiliation network is a network in which actors are connected via comembership of groups of some kind.
- Ex. Southern Women Study
- Bipartite network or ‘two-mode network’
- CEO-Club network, 1970 in Chicago
- Actor-movie network
- Co-authorship network

Social Networks: Small-World Experiment

- **Geodesic distance** between two vertices is the minimum number of edges that must be traversed to travel from one vertex to the other through the network.
- Milgram conducted a small-world experiment as
  - *96 packages are sent recipients randomly chosen from the telephone directory in US town Omaha, Nebraska.*
  - *The package contained an official looking booklet or 'passport' emblozened with the crest of Miligram's home institution, Harvard Univ.*
  - *The written instructions were asking the recipients to get the passport to the specified target individual (a friend of Miligram in Boston, Massachusetts) over a thousand miles away. The only information provided about the target was his name.*
  - *The recipients are not allowed to send the letter to the given address but someone who they know and stant the best chance of getting the passport to the intended target.*

Social Networks: Small-World Experiment

- Of the 96 passports sent out 18 found their way to the target
- Recepients are asked to record the path taken (in order to find the length of each path taken)
- The mean length of the completed paths was 5.9 steps
- This results was only approximate since there was a single target. The target was in the same country.
- No guarantee that those were the shortest paths.

Social Networks: Snowball sampling, Contact tracing, and Random Walks

- Techniques for sampling hidden populations?
- Studies of some populations like drug users, illegal immigrants present problems to the investigators
- The most widely used such technique is called **snowball sampling**
- You start like a ego-centered survey and interview about themselves. Upon gaining their confidence invite them to name other members of the target population.
- Pretty soon the process ‘snowballs’.
- Some diseases like tuberculosis and HIV are considered very serious and when some one discovered to be carrying them an effort must be made in order totrack down all those who might also have been infected. In this manner samples are decided.

Social Networks: Snowball sampling, Contact tracing, and Random Walks

- Random walk sampling is a type of contact tracing. Only a contact is selected randomly
- Respondent-driven sampling (unethical to get participants to give the names of their contacts. So they are given tickets. Participants are paid for taking part)

NETWORKS OF INFORMATION

This subsection should be read!

END OF CH3

The Chapters below are covered in this course

- Chapter 6: Mathematics of Networks (Up to Section 6.13)
- Chapter 7: Measures and Metrics (Up to Section 7.10)
- Chapter 12: Random Graphs (All)