Ideas and Terminology

Big Questions

How does the individual behavior aggregate to the collective behavior?

How can systems generate greater complexity (or less complexity) than their individual elements display?

How can we assess the reliability of models and simulations?

Tragedy of the Commons. Can we be trusted to act in a manner that is in our collective best interests (putting our self-interest aside)?

How can understanding of the network structure aid in understanding the global phenomena (history, organization, social)?

Ideas

We live in a connected age.

Science provides simple explanations of complex phenomena. Network science provides explanations of our connectedness. In this class we are users of these explanations.

Six Degrees of Separation– Milgram’s experiment exposes a paradox of social networks – in spite of the fact that the network of the world’s population is highly clustered (many of an individual’s friends are themselves friends) it is still possible to reach anyone in that population through a short acquaintance chain.

Phase transitions can occur as a network develops:
Erdos and Renyi – critical point for random graphs is one link per node on average.
Anatole Rappaport – between the extremes of population density in disease propagation.
From Physics: – interaction length is a measure of the average range of nodes adjacent to a single node (nearest neighbors); correlation length is the average range of the largest connected component; when the correlation length reaches the network size a transition occurs.

There is a strength in weak ties.

Small world networks arise from a compromise between order and randomness.

The rich get richer. 80/20 rule – Pareto distribution (income distribution)

Think globally, act locally.

People follow the crowd. Solomon Asch’s experiments.
To gain a non-linear view of history, we should examine the network surrounding events.

Models are simple representations of complex phenomena and can simulate reality and provide a means of studying phenomena.

Complex, connected systems (like New York City) can be robust in some ways and fragile in others. Network structure can add stability and aid in the recovery from disaster.

**Terminology**

**About Systems**
emergence
synchrony
centrality
universality – diverse systems have similar characteristics; classes of systems where details can be ignored.

tunable parameters
modeling and simulation

**About Graphs or Networks**

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<tr>
<th>Nodes or vertices</th>
<th>search on networks</th>
<th>sexually transmitted</th>
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<td>links or edges</td>
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<td>logistic growth</td>
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<td>adjacent nodes</td>
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<td>disease front</td>
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**Social networks**
strong and weak ties
acquaintance chain

**Disease Propagation**
Susceptible
Infected
Removed (Immune)
host
level of contagion
duration of infection
Influenza
Ebola
HIV

**Business**
/Organization
thresholds
financial bubbles
cascades
externalities
information
coercive
market
Industrial Divide
economy of scale
economy of scope
Names of contributors to Network Science
Leonard Euler (1707-1783)  Mark Granovetter
Frigye Karinthy (1887 – 1938)  Harrison White
Paul Erdös (1913-1996)  Duncan Watts
Alfred Renyi (1921-1970)  Stephen Strogatz
Anatoli Rappaport  Albert-László Barabási
Stanley Milgram  John Guare
Marshall MacLuhan

Some Types of Networks

Biological
- food chains
- molecules in a cell connected by chemical reactions
- neural networks

Physical
Communication
- telephone
- cell phone

Social
- Relatives (genealogical)
- friends
- collaborators
- political party

Distribution
- gas, water, electricity
- of goods and services
- food distribution

Semantic
- synonyms
- chains of common usage

Business
- ceo’s, board of directors,
- supply chains
- internet business

Some Degrees of Separation
Species in a food web are 2 links away from each other
Molecules in a cell are separated by 3 chemical reactions
Scientists in different fields are separated by 4 – 6 coauthorships
neurons in brain of C, elegans are separated by 14 synapses
WWW 19 degrees of separation