Networks
Spreading Phenomena

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Slides adapted from Lázló Barabási
http://www.barabaslab.com/
Why is the spreading process important?
Biological: Notable Epidemic Outbreaks

The Great Plague

HIV

SARS

1918 Spanish flu

H1N1 flu

HIV prevalence in adults, end 2001

Source: UNAIDS / WHO

Note: The map reflects the 2000 information on the global status of HIV/AIDS and is subject to further validation.

SARS - Cumulative Number of Reported Cases

Total number of cases: 8014 as of 8 April 2003, 14:35 GMT+2

Source: World Health Organization

H1N1 flu
14th Century – The Great Plague

4 years from France to Sweden
Limited by the speed of human travel

http://en.wikipedia.org/wiki/Black_Death
http://de.wikipedia.org/wiki/Schwarzer_Tod
21st Century – SARS

SARS: Cumulative Number of Reported Cases
Total number of cases: 2871 as of 8 April 2003, 14:30 GMT+2

Cumulative number of Reported Cases
(From 1 November 02 to 8 April 03)

Type of transmission

- 1
- 2 - 10
- 11 - 100
- 101 - 1000
- > 1000

Source: World Health Organization
SIR Model

S number of susceptible individuals
I number of infectious individuals
R number of removed individuals

N total population

\[ N = S + I + R \]
Compartmental Models

Assume a well mixed population, then:

\[
\frac{ds}{dt} = -\beta i(t)s(t)
\]

\[
\frac{di}{dt} = \beta i(t)s(t) - \alpha i(t)
\]

\[
\frac{dr}{dt} = \alpha i(t)
\]

\(\beta\) covers probability of infection (disease and interaction)

\(\alpha\) covers probability of recovery/removal
Do people have equal contact probability? Contact/Interaction Network is crucial in spreading...
Network SIR Model

Each time step, infected nodes have chance to **infect** susceptible neighbors with probability $\beta$

Each time step, infected nodes have chance be **removed** (recover/die), with probability $\alpha$
Importance of Networks

How does network topology impact disease spread?

Will an epidemic spread faster or slower in a scale-free network?

How important are the starting nodes of the disease?

....
Immunization?

Transmission-reducing interventions: face masks, gloves, washing hands – may reduce the transmission rate below the epidemic-causing critical rate

Contact-reducing interventions: quarantining a patient, closing schools – make the network sparser, may increase the critical transmission rate

Simulated Vaccinations: remove nodes from the network

Q. Which nodes should we vaccinate if we have a limited number of vaccines?

Q. What if we don’t have information about the network structure or node statistics?