CMS/CS/EE 144
Networks: Structure & Economics

Administrivia

1) QUIZ TODAY
2) Rankmaniac out today!
3) HW4 due today
   -- Solutions are up front
4) Don't forget about blog posts…
5) Be sure to think about project ideas…
6) Game theory primer on Tuesday

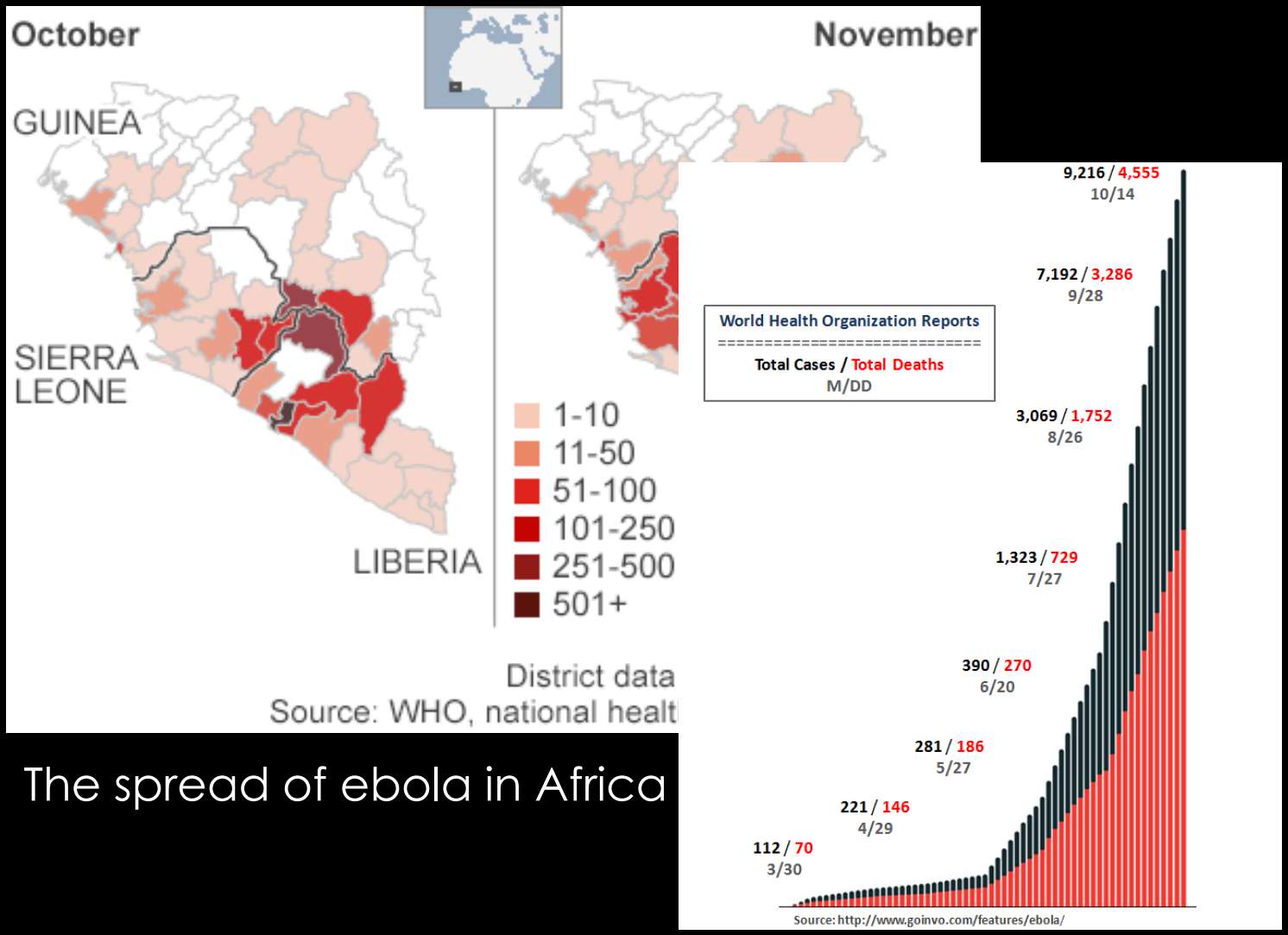
We know a lot about the **structure** of networks

…but very little about **dynamics** over networks

TODAY

Cascading behavior in networks
a.k.a. diffusion in networks
a.k.a. spread of epidemics

The spread of disease…

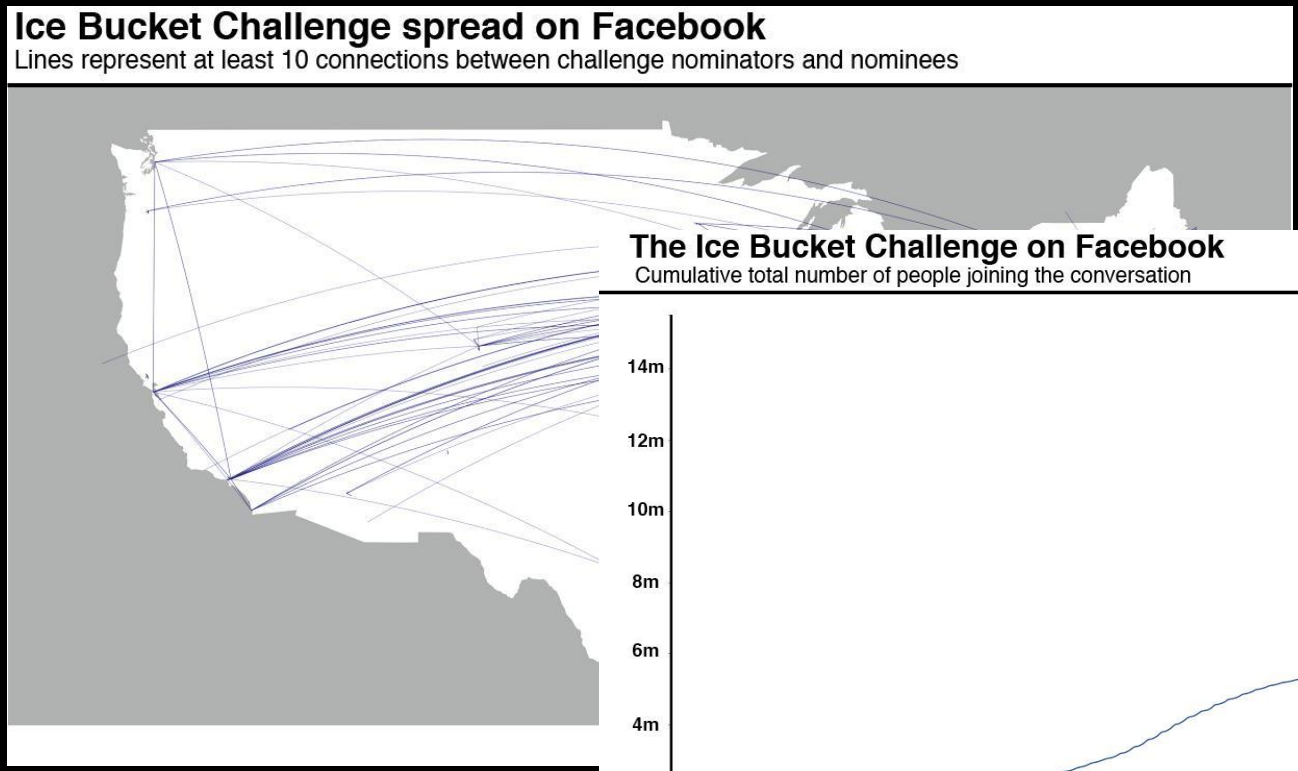


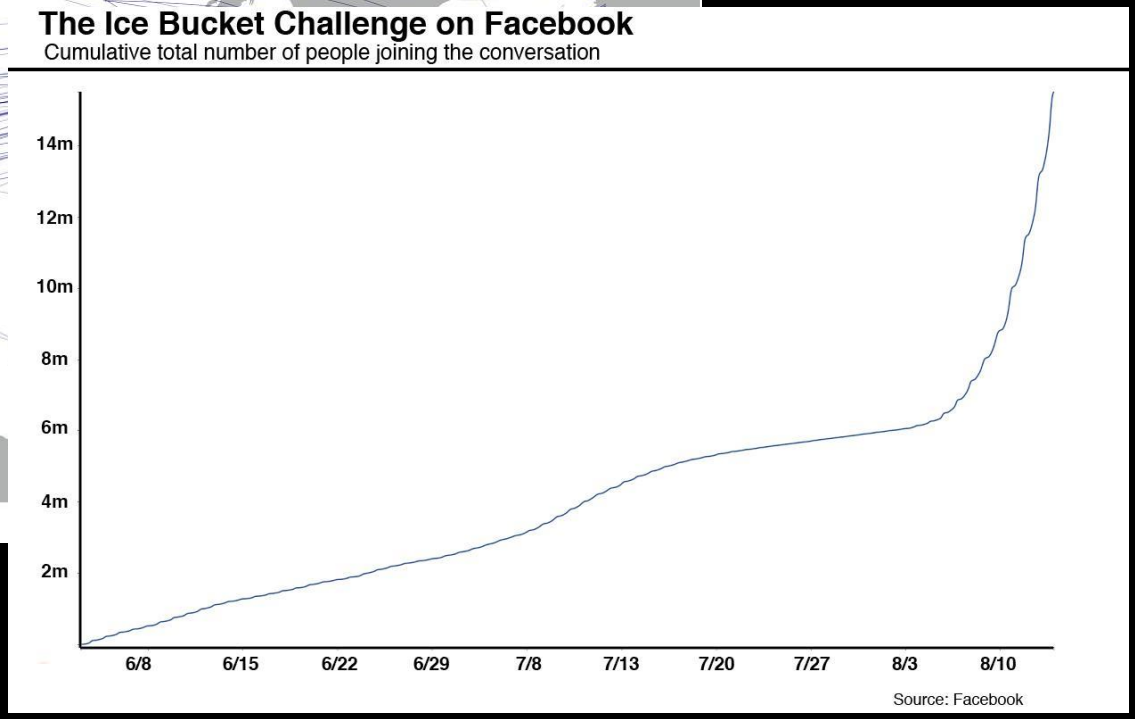
The spread of ebola in Africa

The spread of memes…

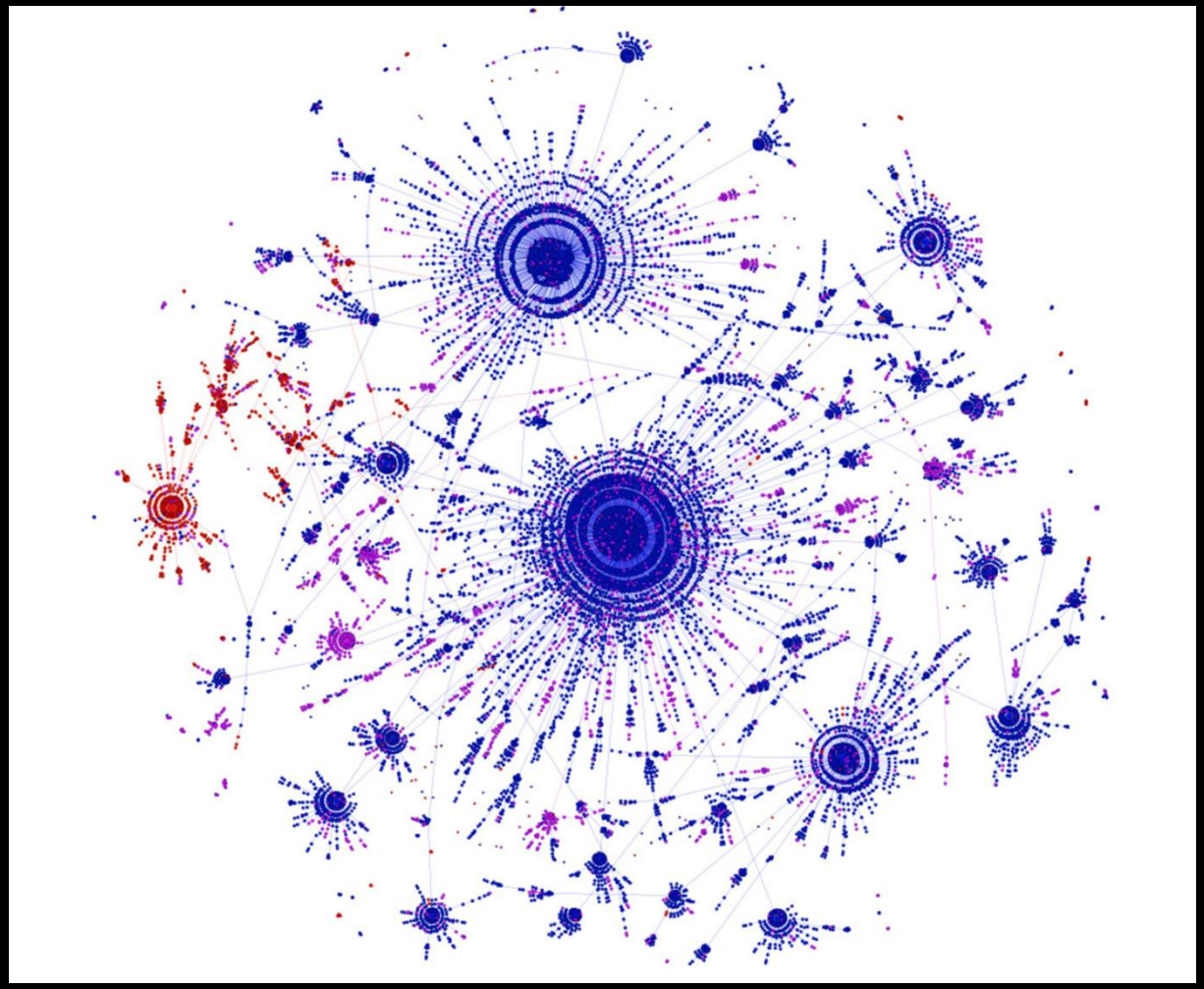
The ice bucket challenge

The spread of memes…



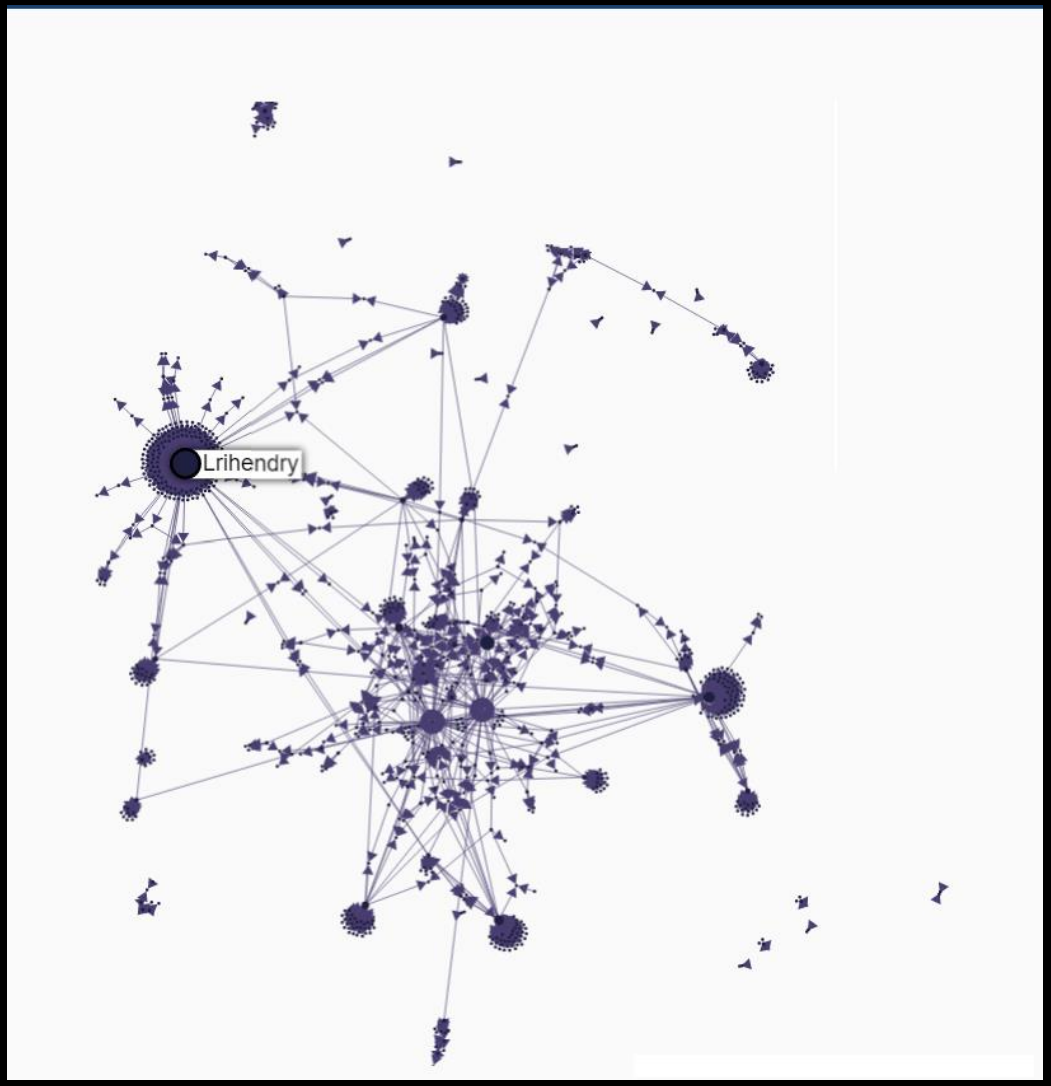


The spread of activism…



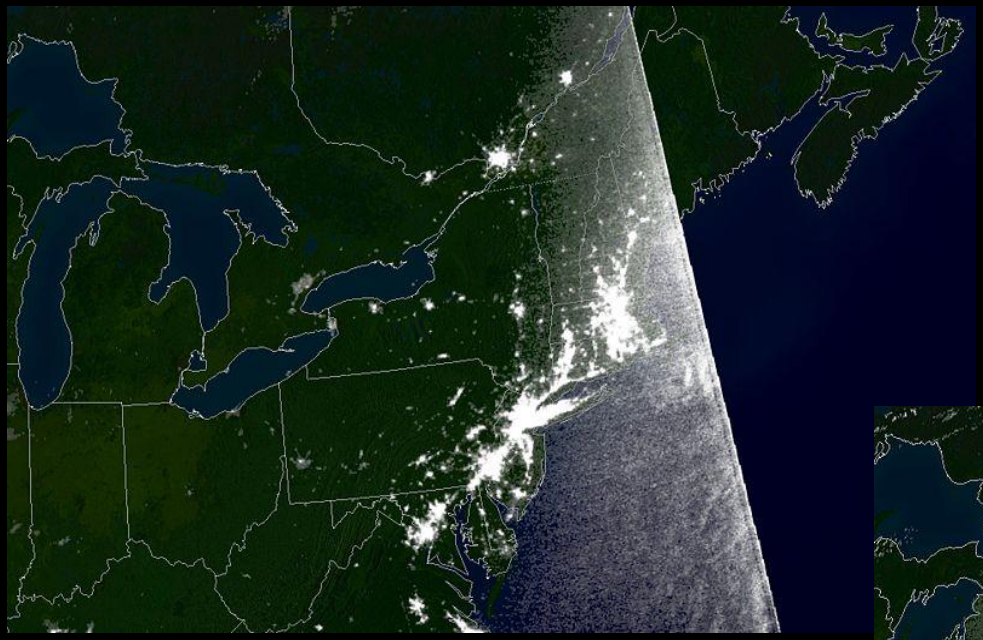
Support of health care reform

The spread of fake news…



Visualization of retweets of “Isis Leader Calls for American Muslim Voters to Support Hillary Clinton” from World Daily News Report between 10/10/16 and 12/14/16.

The spread of failures…



2003 blackout

small failure in Indiana "cascaded" and affected 55 million people

3 main classes of cascading behavior in networks

The spread of "disease"

diseases like the flu, AIDS, STDs, etc,
but also computer viruses
e.g., ebolla

The spread of "information" / "memes"

news, rumors, urban legends, political messages
e.g., the ice bucket challenge

The spread of trends & tech

popularity of web sites, a new gadget, viral marketing
recycling, opinions, etc.
e.g. smartphone adoption

Cascades have been interesting to social scientists for a long time

- Spread of agricultural processes (Ryan-Gross 1943)
  → Adoption depended on social network
- Spread of medical practices (Coleman et al 1966)
  → Social power of peers caused adoption
- Many studies of the spread of disease…

…but now it's much easier to study them

THREE TYPES OF QUESTIONS ABOUT CASCADES

Measurement questions

What do cascades look like?
What drives the spread of cascades?

Modeling questions

How can we model the spread of cascades?

Optimization & Detection questions

How can we maximize/minimize the spread of cascades?
Can we detect which nodes are influential/infectious?
Can we learn network structure by observing cascades?

Outline

1) An experiment
2) A “toy” model that we can study analytically
3) Some data about real cascades
   and current research questions

AN EXPERIMENT

Each bag has 3 marbles.

{ with prob. 1/2, 1 is red and 2 are white (MW)
{ with prob. 1/2, 2 are red and 1 is white (MR)

People come up in turn. Each pulls a marble, and puts it back without showing the class and then announces a guess as to whether the bag is MR or MW.

Now, let's look at a simple cascade on a graph

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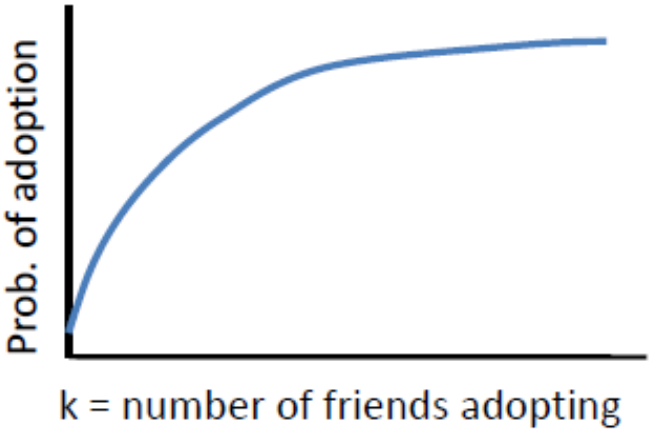
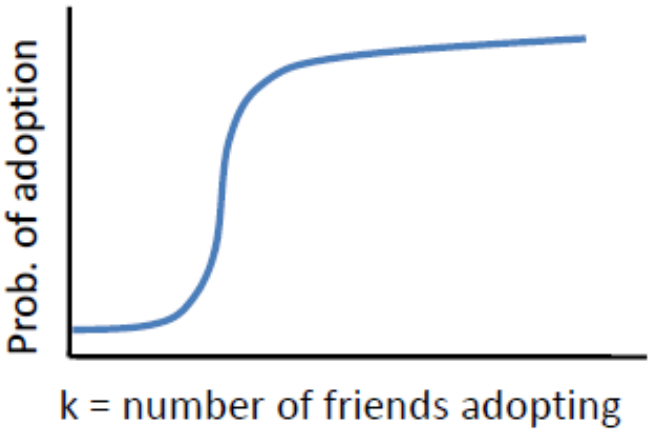
When do people adopt a new behavior?

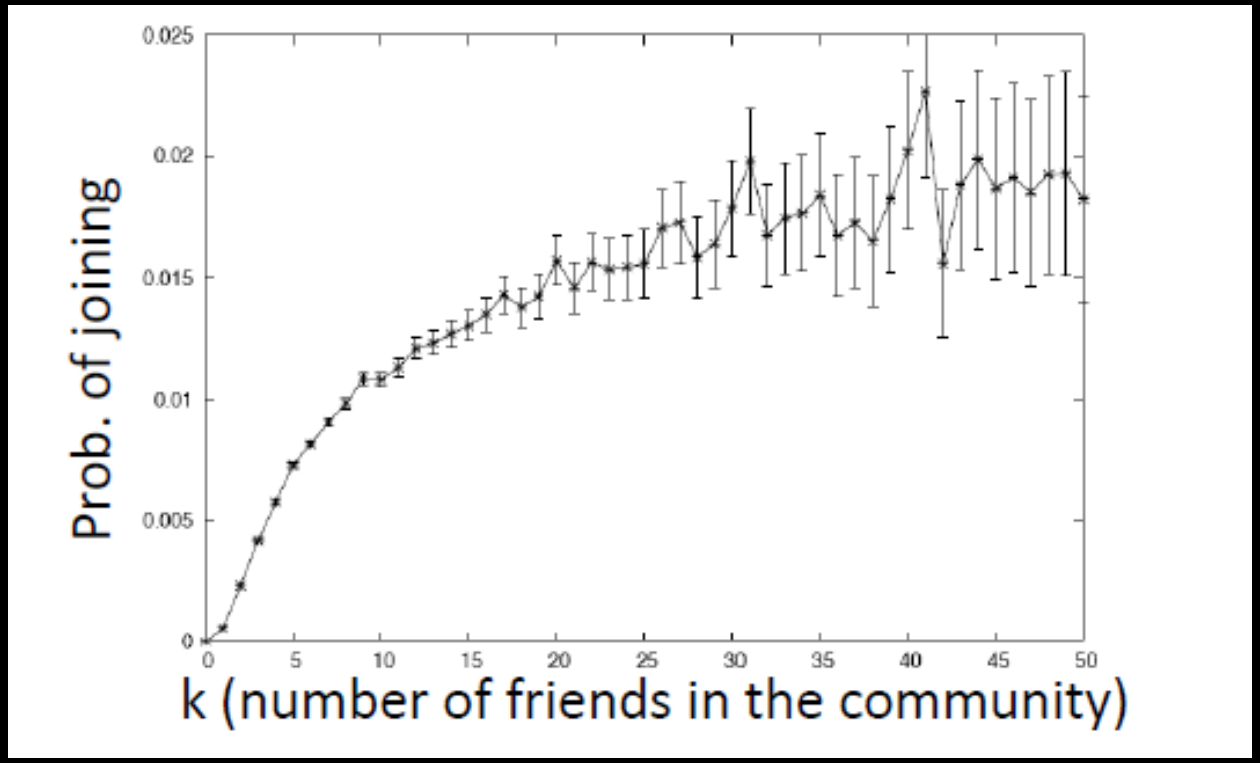


Diminishing returns?



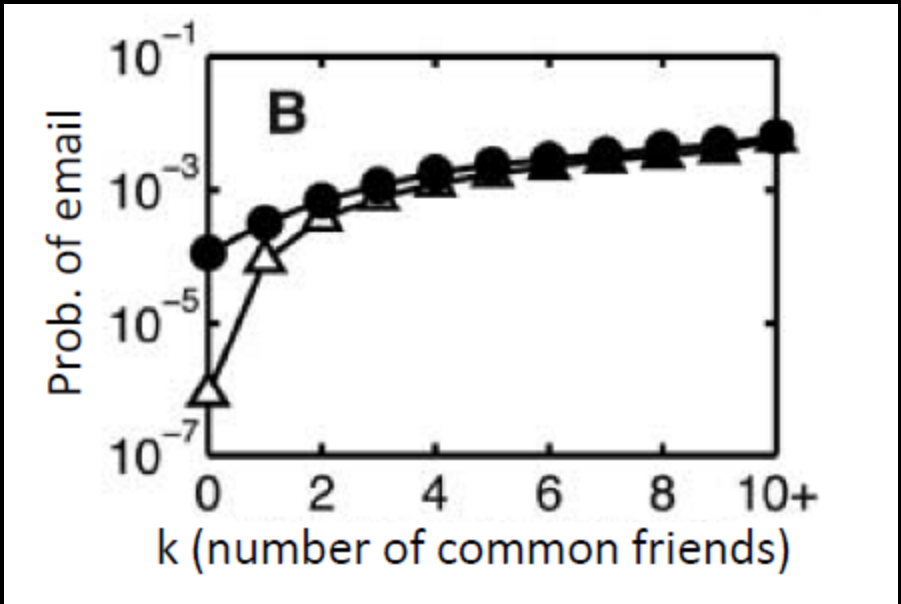
Critical mass?

LiveJournal community membership [Backstrom-Huttenlocher-Kleinberg 2006]

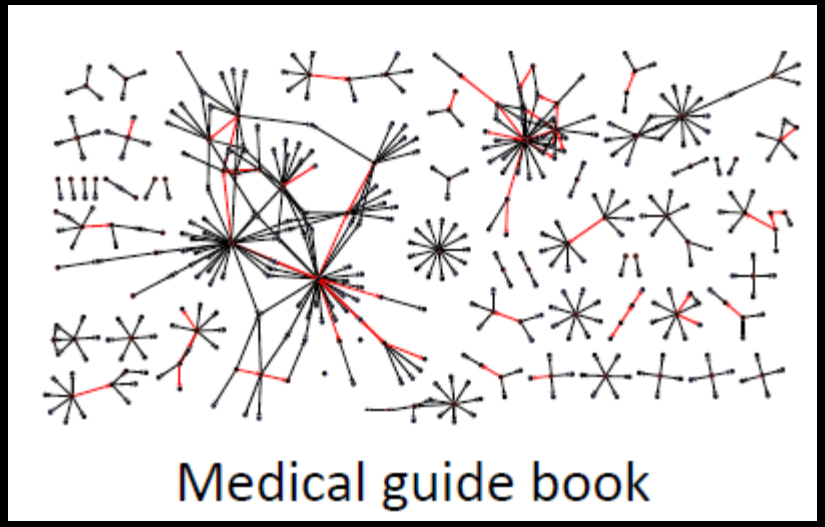


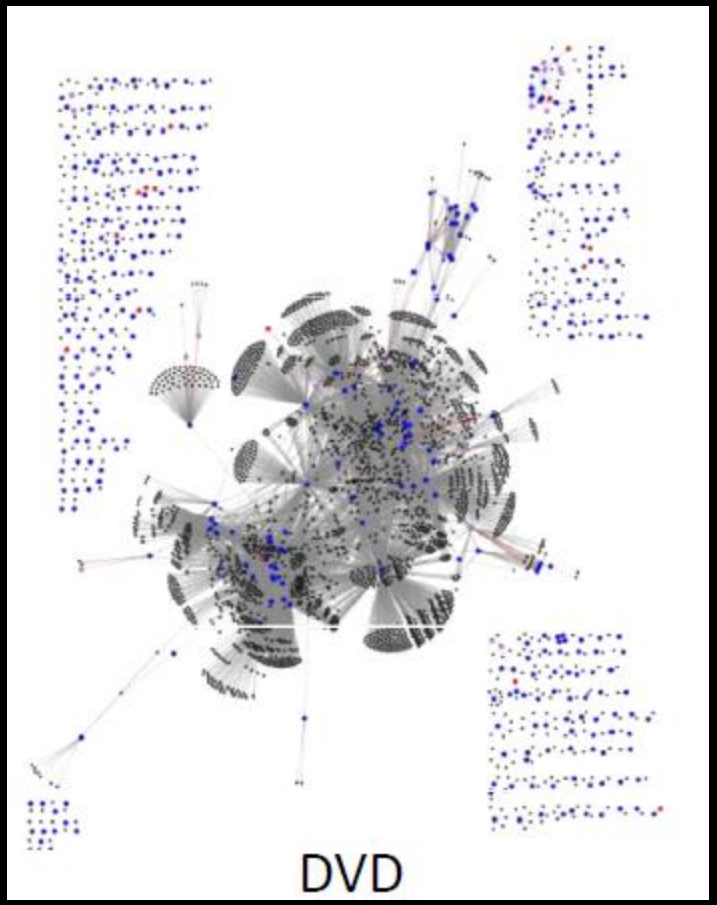
Probability of email between people as a function of number of common friends

[Kossinets-Watts 2006]



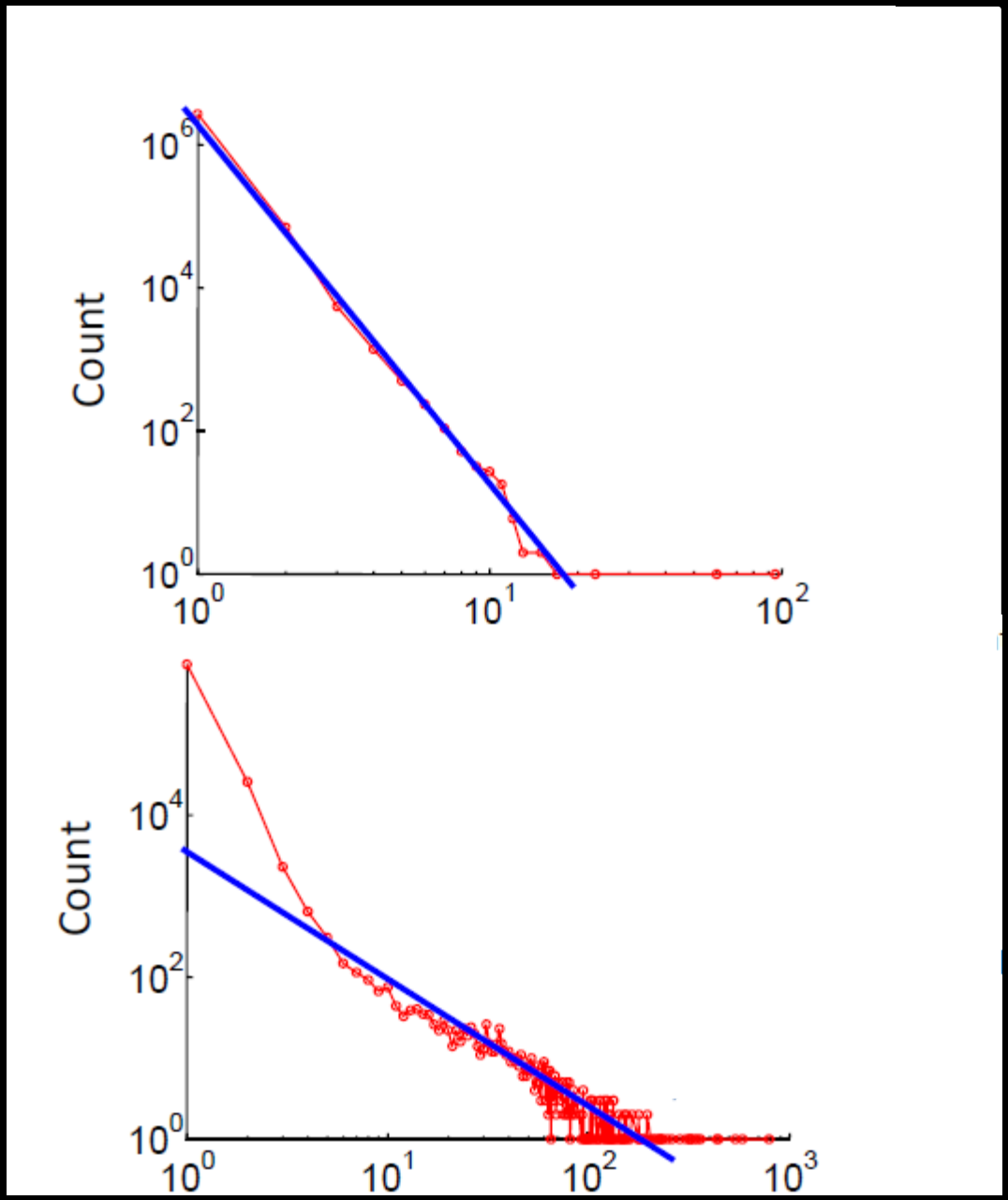
What do cascades look like?





Books

DVDs



Cascade size

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At this point, there are a huge number of models,
but few are "realistic" … most are toys …

-- Adoption propagates if >t neighbors have adopted
-- Disease spreads to each neighbor with prob. p

(of course, there are many generalizations of both)

The reason is that people want to solve
the optimization/detection problems….
so the model needs to be simple

Key current research questions (and good project ideas)

What are the "cascade thresholds" for various networks?

Can network structure be learned by observing cascades?

Which product/fad will "win"?

What is the cheapest way to create/stop a cascade?

…these are all great project ideas!