DCS/CSCI 2350
Social & Economic Networks

How do behavior, opinion, technology, etc. propagate in a network?

“Cascading Behavior in Networks”

Reading: Ch 19 of EK

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Diffusion of innovations

- Studied in sociology since 1940s
- One’s choice influences others
- Indirect/informational effects - social learning
  - Photo/video going viral
- Direct-benefit effects
  - Technology adoption- Xbox/PS4, phone, fax, email, FB
Examples

- Adoption of hybrid seed corn in Iowa
  - Ryan and Gross, 1943
- Adoption of tetracycline by US doctors
  - Coleman, Katz, and Menzel, 1966
- Shared ingredients
  - Indirect effects
  - Adoption was high-risk, high-gain
  - Early adopters had higher socioeconomic status
  - Social structure was important - visibility of neighbors’ activity

Success factors of diffusion

*Diffusion of Innovations* - Everett Rogers (1995)

- Complexity
- Observability
- Trialability
- Compatibility
The Dress
(February 2015)

#TheDress

Chris Murphy • @ChrisMurphyCT
I know three things: 1) the ACA works; 2) climate change is real; 2) that dress is gold and white.
3 days ago • 3

Mark Takano • @RepMarkTakano
Just asked my Legislative Director at 10:30 pm to draft a House resolution tomorrow about the dress being black and blue. AMA.

Anna Kendrick • @AnnaKendrick47
If that's not White and Gold the universe is falling apart. Seriously what is happening???

Demi Lovato • @ddlovato
Hold on.... So people actually see white and gold....??!! ☹️
3 days ago • 3

Julianne Moore • @juliannemoore
@mindykaling @bjnovak what's the matter with u guys, it's white and gold.
3 days ago • 3
Next

- Modeling diffusion
- Connection with the things we know
  - Homophily
  - Clustering
  - The strength of weak ties
Threshold models for diffusion

Precursor - Granovetter's model

- Mark Granovetter's threshold model of collective behavior (1978)
  - Side note: collective behavior vs. collective action
- Model: An individual will adopt action A if at least a certain number (threshold) of other individuals adopt A
Granovetter's model

- **Example**
  - Emergence of a riot in a crowd of 100 people (complete graph)
  - Thresholds of individuals to get violent
    - 0, 1, 2, ..., 99
  - What will happen?

- **Extensions**
  - General network
  - Distribution of thresholds
    - Difference with Schelling's model: In Granovetter's model, slight change of thresholds may lead to completely different global outcome.

Contagion Model
Stephen Morris, 2000
Initial adopters

- Facilitates diffusion
- Granovetter's model: the persons with threshold = 0 are the initial adopters vs.
  We can set initial adopters without any regard for their threshold
  - Modeling assumption by Kleinberg & many others

Example: switching from B to A

- Initially everyone does B
- Payoff parameters: b = 2, a = 3
- Threshold for switching from B to A, q = 2/5
- We will set two initial adopters of A and "play out" the diffusion
Complete cascade

- **Def.** A set of initial adopters causes a "complete cascade" if everyone adopts the new action at the end of diffusion.

- Always happens?
What are the factors for a widespread diffusion?

- Initial adopters
- Network structure
- Threshold value $q$
  - Quality of product: payoff parameters $a$ and $b$
- Example: viral marketing
Diffusion vs. strength of weak ties

- Weak ties are conveyors of information
- But cannot “force” adoption of behavior

Diffusion vs. clustering

- Does clustering help diffusion?

Every node in these clusters have at most 1/3 fraction of friends outside.

Will they ever adopt the new behavior?
Diffusion vs. clustering

- Assuming a threshold of $q$, cascade will be incomplete if and only if there is a cluster of density $> 1 - q$ in the “remaining network”
  - Cluster density: Largest fraction such that no node in the cluster has lower than that fraction of neighbors within the cluster

More general models
Influence games - coming up!  
(Irfan & Ortiz, 2014)

- Thresholds are heterogeneous
- Directed, asymmetric network
- Relationships can be positive or negative  
  (gradation of "influence" is also allowed)
  - Switching back and forth two actions are allowed
- Initial adopters or seed nodes

Granovetter: seeds must have threshold 0
Kleinberg: seeds can be externally set (their thresholds don't matter)

We: seeds can be externally set as long as their threshold requirements are fulfilled at the end of diffusion

What can go wrong?