Models of Influence

Social Networks Analysis and Graph Algorithms

Prof. Carlos Castillo — https://chato.cl/teach

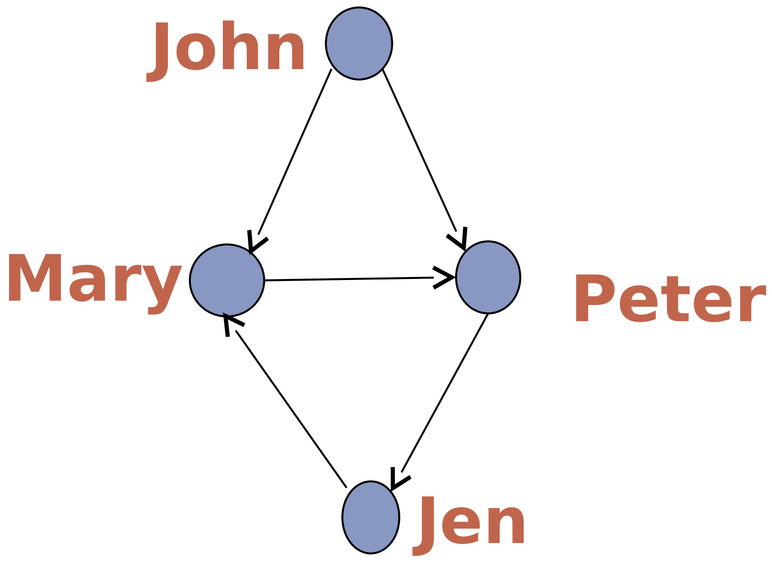
Universitat
Pompeu Fabra
Barcelona

Sources

- D. Easley and J. Kleinberg (2010). Networks, Crowds, and Markets — Chapter 19
- C. Castillo, W. Chen, L. V. S. Lakshmanan (2012). Information and Influence Spread in Social Networks, KDD Tutorial.
- URLs in the footer of slides

What are our observables?

Graph: users, links/ties



Log: user, action, time

User	Action	Time
John	Rates with 5 stars "*The Artist*"	June 3rd
Peter	Watches "*The Artist*"	June 5th
Jen	…	…

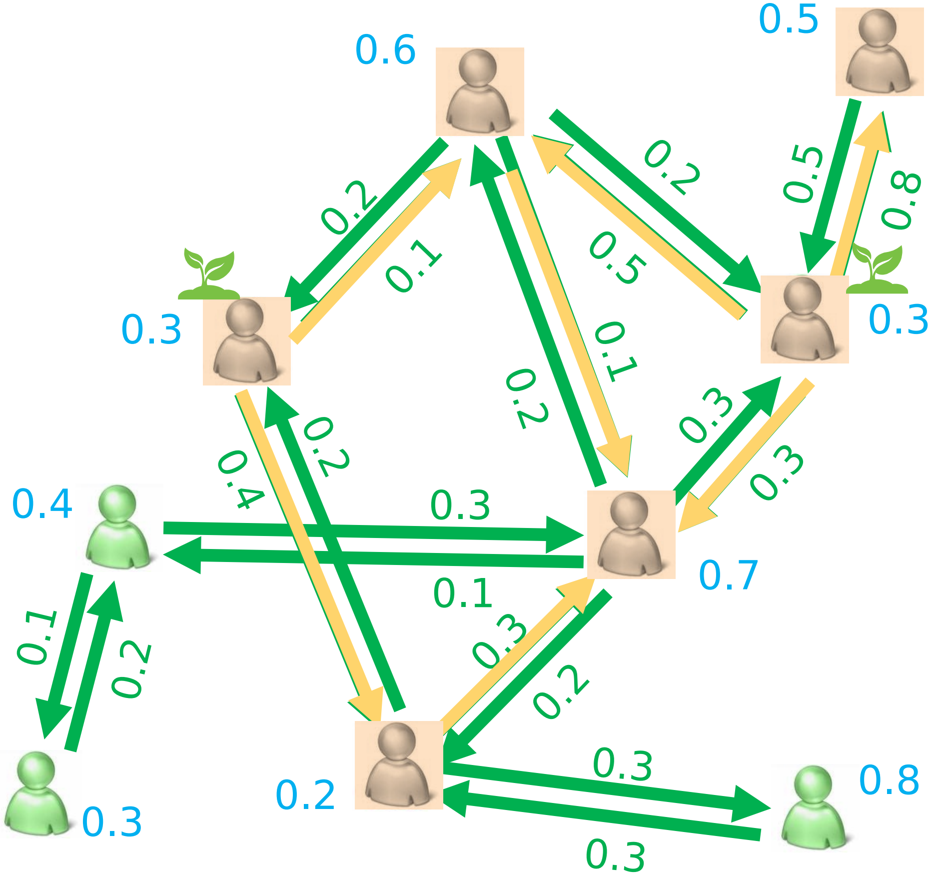
Two main models

- Linear threshold model

- Independent cascade model

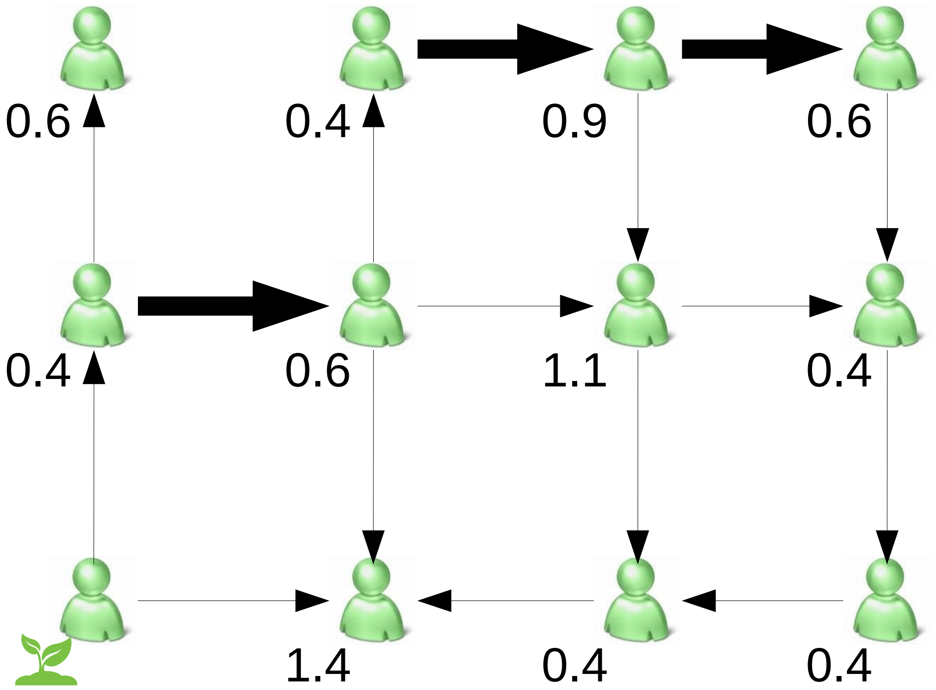
Linear threshold model

- Nodes have thresholds
- Arcs have weights
- Nodes that receive weighted influence equal or above their threshold become active



[Kempe, Kleinberg and Tardos, KDD 2003]

Exercise: linear threshold model



Thick arrows have weight 1.0

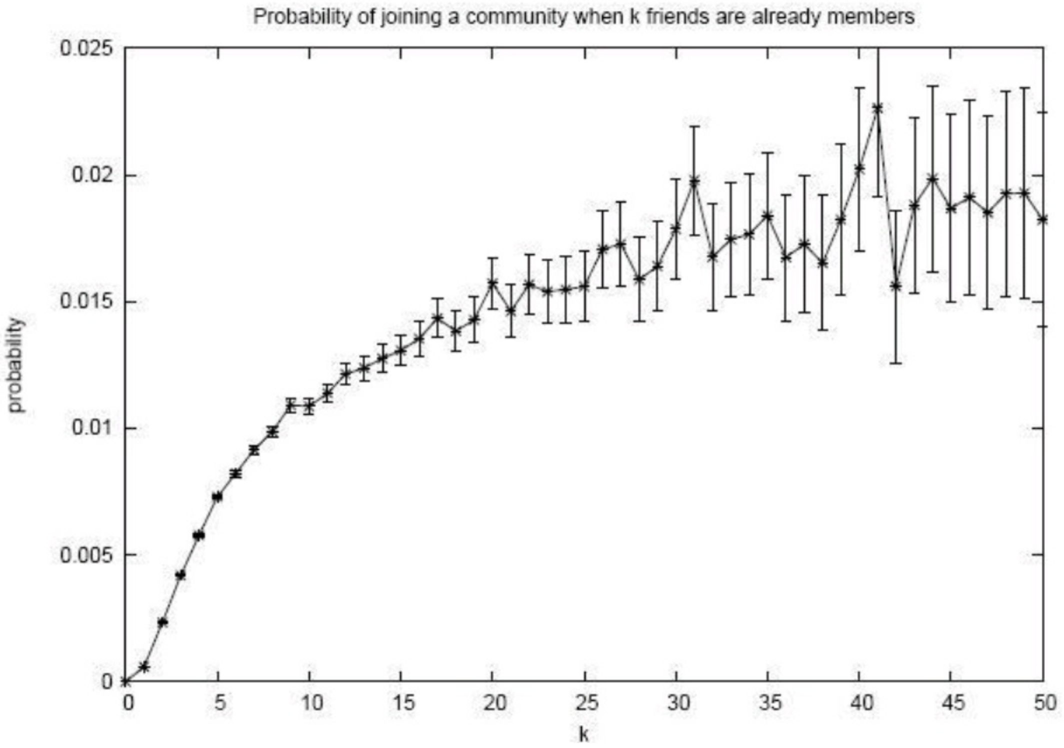
Thin arrows have weight 0.5

Execute linear threshold model starting from seed node

Spreadsheet links: https://upfbarcelona.padlet.org/chato/shyq9m6f2g2dh1bw

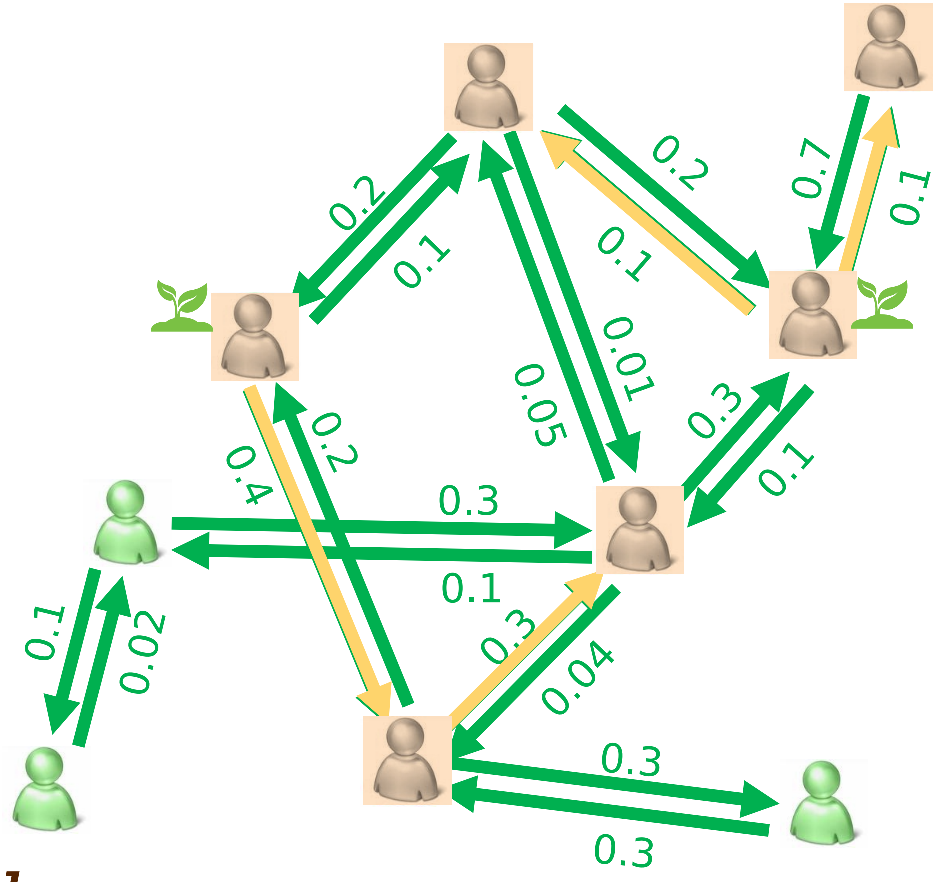
Linear threshold model

Is the linear threshold model compatible with this observation?



Independent cascade model

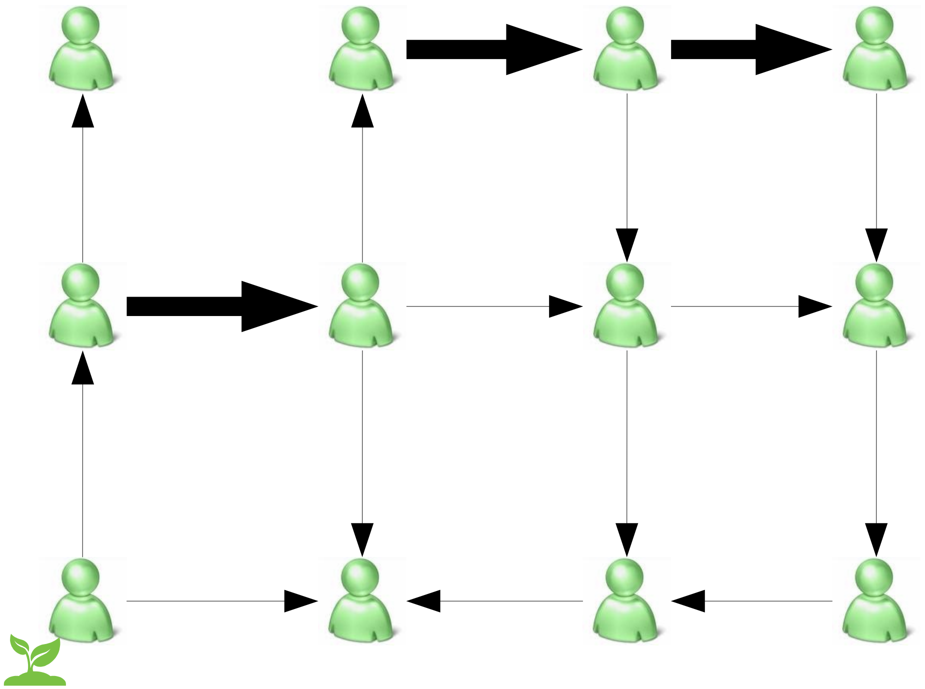
- No thresholds
- Each node, when activating, has one chance of activating each of their neighbors
- Probability of succeeding represented by arc weights



[Kempe, Kleinberg and Tardos, KDD 2003]

Exercise: independent cascade model

(you need a coin or 1d4)



Thick arrows have probability 0.75

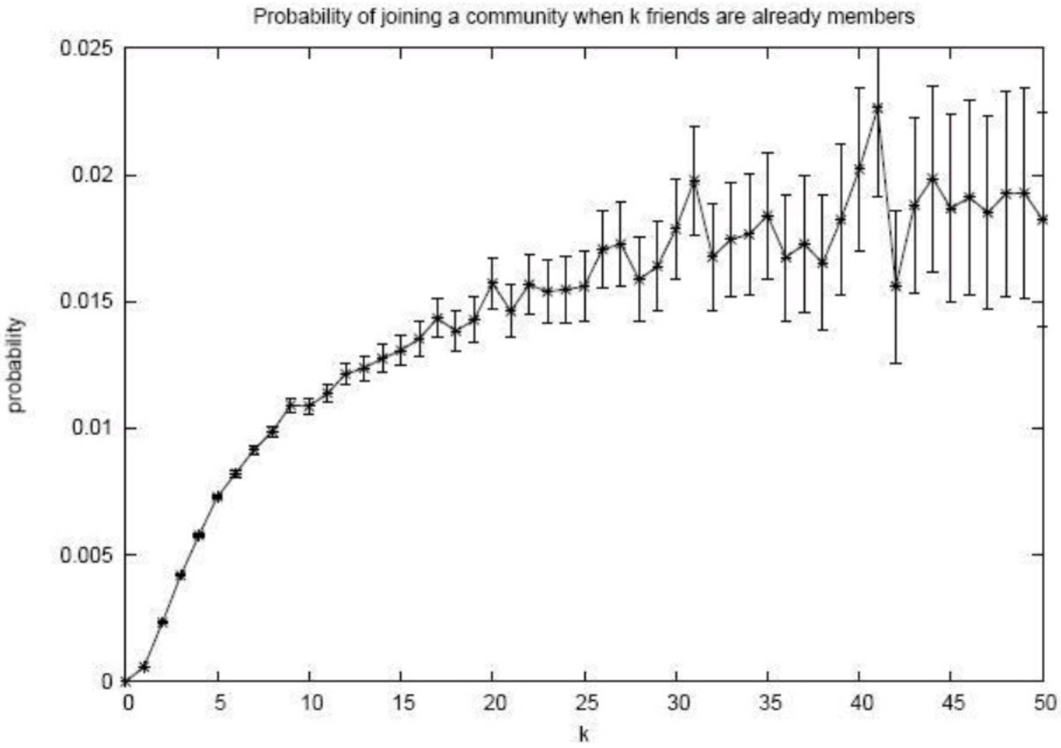
Thin arrows have probability 0.5

Execute independent cascade model starting from seed node

Spreadsheet links: https://upfbarcelona.padlet.org/chato/shyq9m6f2g2dh1bw

Independent cascade model

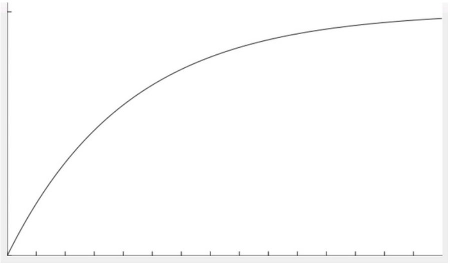
Is the independent cascade model compatible with this observation?



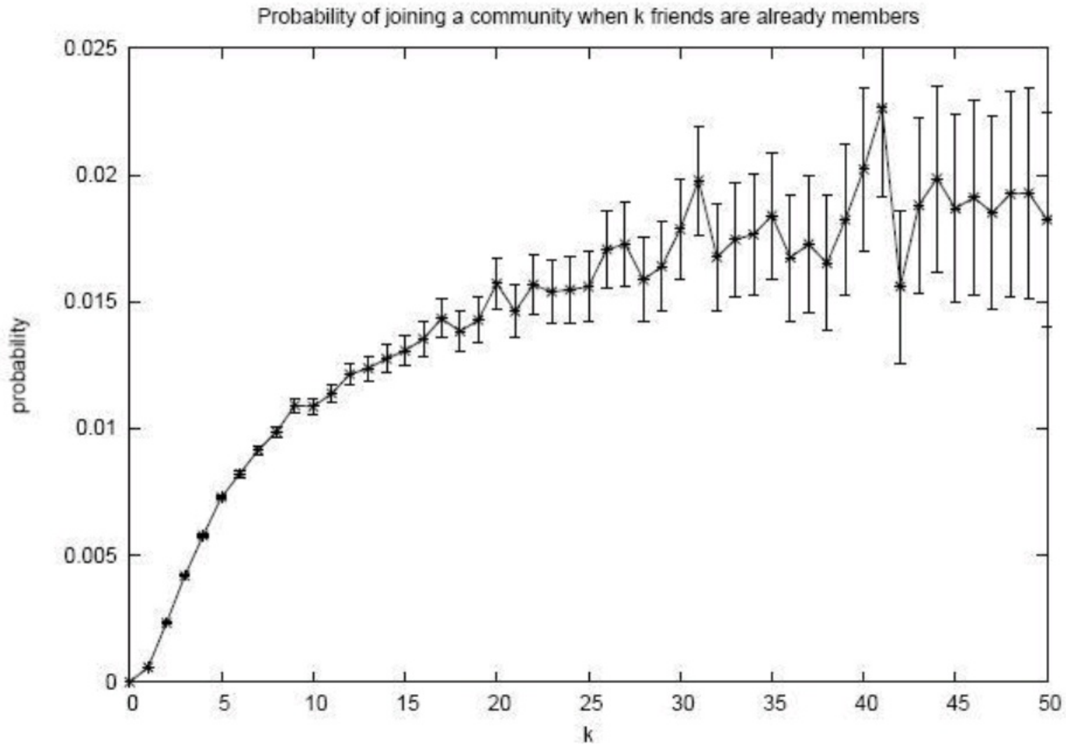
Independent cascade model

Is the independent cascade model compatible with this observation?

Hint:



$1 - q^k$ for $0<q<1$



Exercise

List model assumptions

- What are these models assuming?

  (List as many assumptions as you can)

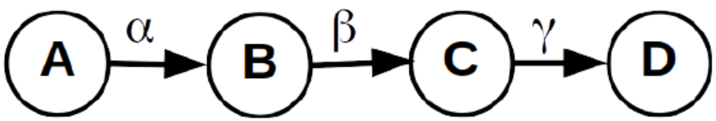
Pin board: https://upfbarcelona.padlet.org/chato/3d6ed4wppqkbmin0

Summary

Things to remember

- Linear threshold model
- Independent cascade model
- Practice executing these models in small graphs by hand
- Practice writing code implementing them

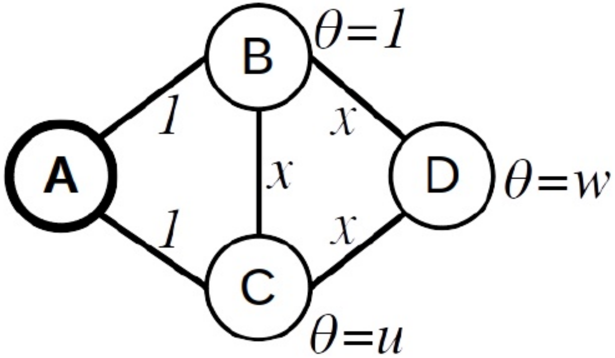
Practice on your own



- Consider the graph on the top-right, including the infection probabilities indicated in the edges: α, β and γ. Let X_i be the expected number of nodes infected under the Independent Cascade Model for an infection starting at node i, including the node initially infected.
- For instance, if an infection starts from node B, the probability that the number of nodes infected is 2 is $P(X_B = 2) = \beta \cdot (1 - \gamma)$. This is because for the infected to be 2 we need the infection from B to C to succeed and the infection from C to D to fail.
- Remember that the expectation of a variable X is $E[X] = x \cdot P(X = x)$, where the summation is done over the possible values x that the variable can take.
- 1. What is $E[X_C]$ as a function of γ?
- 2. What is $E[X_A]$ as a function of α, β, γ?

Practice on your own (cont.)

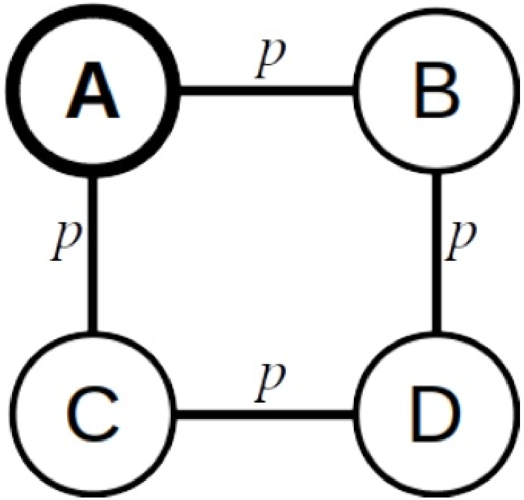
- Consider this graph and the Linear Threshold model executed on it, starting from seed node A.
- The influence weights are written next to the edges, and the thresholds θ are written next to the nodes.
- Indicate what is the range of values of x for node C to be infected, but not node D. Justify briefly your answer.



1. ____≤ x< ______
2. Justification:

Practice on your own (cont.)

- Consider the graph on the right an the Independent Cascade model executed on it, starting from seed node A.
- The contagion probability of all edges is p
- Indicate what is the probability that at the end of the process:



1. Only node A is infected:
2. Only nodes A, B are infected:
3. Only nodes A, B, C are infected:
4. Only nodes A, B, D are infected: