Resit exam questions (2020-07-16)

Exam protocol

- Choose language es/ca/en
- We are recording now, the recording will stay in the platform with access only to me, me unless the university authorities request it for some reason
- Please place your mobile in airplane mode (unless you’re using it for communicating with me)
- Please briefly show me the room where you are giving your exam
- Please briefly share with me (“present”) your entire computer screen
- We will start with a topic you think you’ve studied more, then we will go back to slide #3 and roll the dice to determine each question; if we land on a question you’ve already answered or a non-question slide, I ask you the next one; if we get to the end we restart
- I’ll ask you questions for 20 minutes starting now – pick the initial topic please

TT01 Complex networks

TT01. Complex networks

What is a complex system?

What is a complex network?

TT02 Graph theory basics

TT02. Graph theory basics

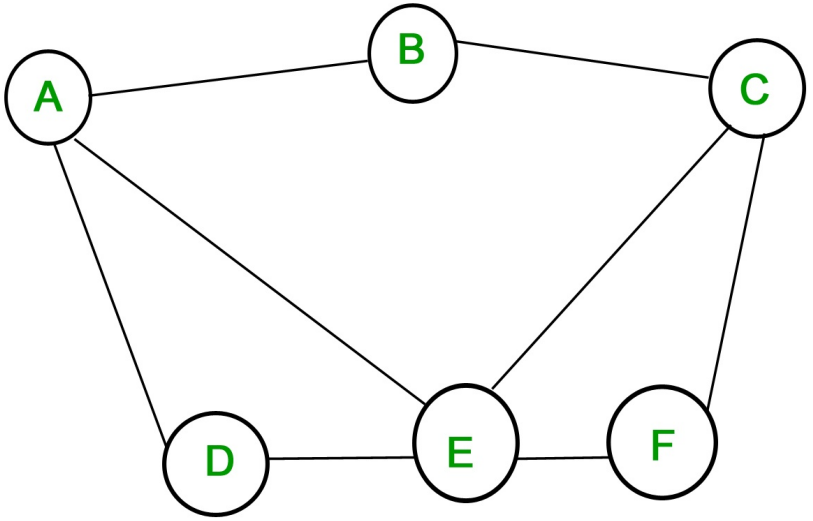
What is a **directed weighted** network?

TT02. Graph theory basics

What is an adjacency matrix?

TT02. Graph theory basics

Write the adjacency matrix of this network:



TT02. Graph theory basics

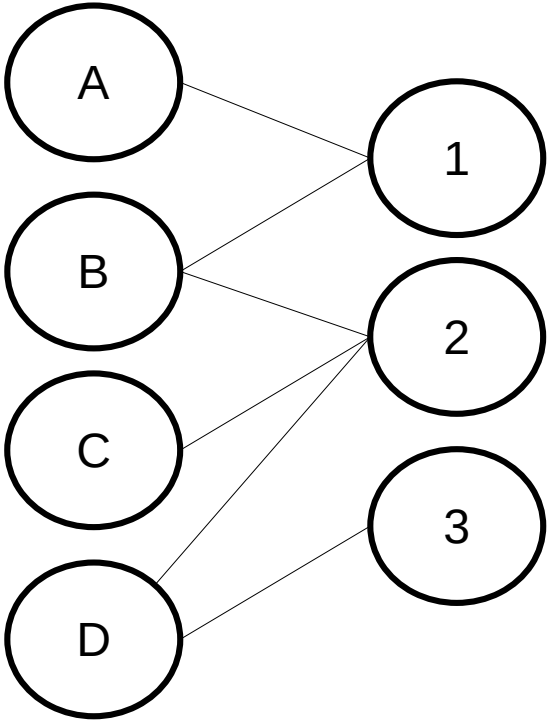
What is a bi-partite graph?

TT02. Graph theory basics

What is a **bi-partite clique**?

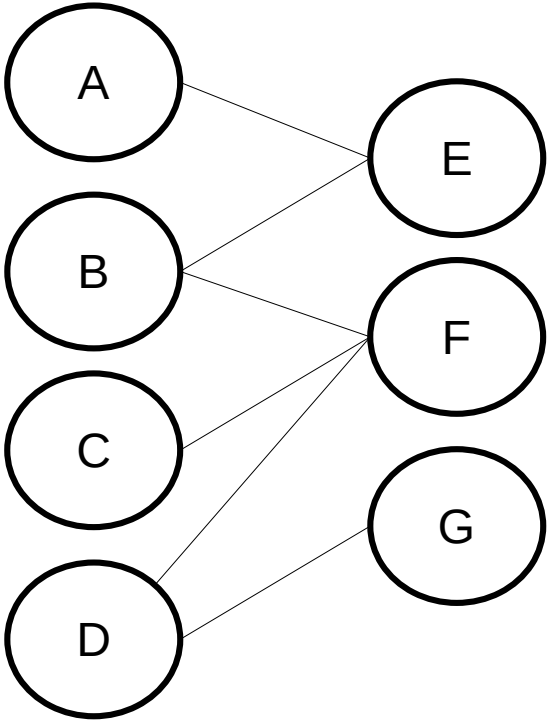
TT02. Graph theory basics

Draw the left- and right-projection of this bipartite graph



TT02. Graph theory basics

What is the **diameter** of this graph?

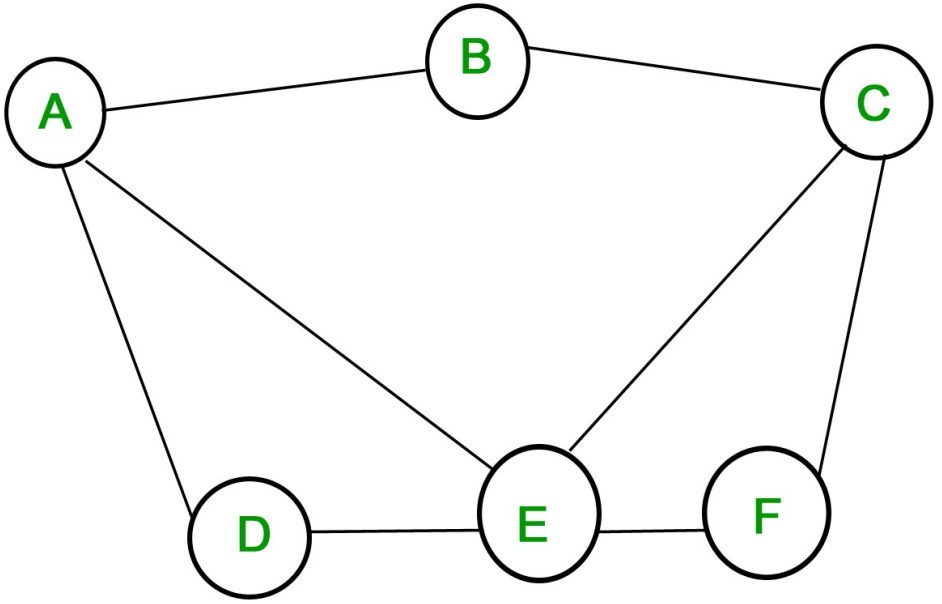


TT02. Graph theory basics

What is a the (global) clustering coefficient of a graph?

TT02. Graph theory basics

Compute the **local clustering coefficient** of each node in this graph



TT03 Random networks

TT03. Random networks

Indicate what input parameters are needed and how one creates a random (ER) graph

TT03. Random networks

What is the average degree in an ER graph of N nodes and edge probability p?

TT03. Random networks

What is the expected number of links in an ER graph of N nodes and edge probability p?

TT03. Random networks

What probability distribution follows the degree in an ER network?

TT03. Random networks

If an ER graph has average degree <k>=999 and N=1000 nodes, what is its linking probability p?

TT03. Random networks

Consider the average degree in a network ‹k›

What regime is the network in in the following cases? Explain what each regime means:

$\langle k \rangle < 1$

$\langle k \rangle > 1$

$\langle k \rangle > \log N$

TT03. Random networks

What is the average distance between two nodes
in an ER network of
N nodes and average degree ‹k›?

TT04 Scale-free networks

TT04. Scale-free networks

What is a scale-free network?

TT04. Scale-free networks

Which **probability distribution** follows the degree of nodes in a scale-free network?

TT04. Scale-free networks

In a scale free network with power-law exponent γ, what is the **average distance** between nodes

If $2 < \gamma < 3$?

If $\gamma > 3$?

TT04. Scale-free networks

What is the **friendship paradox**?

TT05 Preferential attachment

TT05 Preferential attachment

Why do we call the BA model preferential attachment?

TT05 Preferential attachment

What are the **input parameters** to the **BA** network model?

TT05 Preferential attachment

How does one generate a BA network?

TT05 Preferential attachment

Which degree distribution have graphs generated using the BA model?

TT05 Preferential attachment

Which nodes have larger degree in a BA graph, those who are created early or those who are created late? Why?

TT05 Preferential attachment

What is the power-law exponent γ of the degree distribution in a graph generated using the BA model?

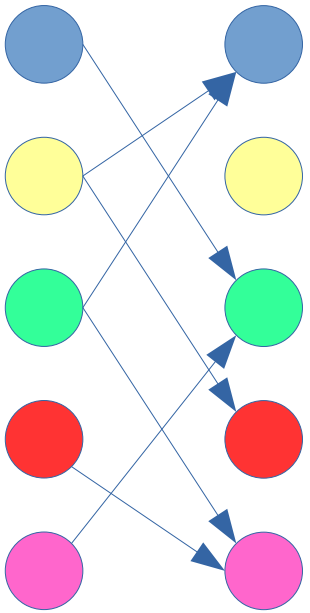
TT05 Preferential attachment

Describe how to create a graph
using the **copy model**

TT07 Hubs and authorities

TT07 Hubs and authorities

Execute some steps of HITS on this graph



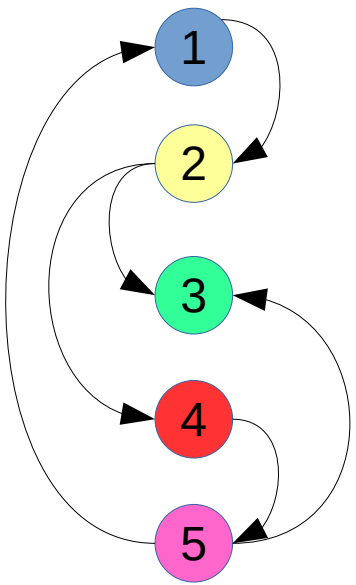
Ĥ(1)	A(1)	Â(1)	H(2)	**Ĥ(2)**	A(2)	**Â(2)**
1						
1						
1						
1						
1						

TT08 PageRank

TT08 PageRank

Execute some steps of **Simplified PageRank**

italics = normalized value



P(1)	P(2)	*P(2)*	P(3)	*P(3)*	P(4)	*P(4)*
1						
1						
1						
1						
1						

TT08 PageRank

Why do we use PageRank
instead of Simplified PageRank?

What is the problem with Simplified PageRank?

TT08 PageRank

In terms of the adjacency matrix of a graph, what is the PageRank of the nodes?

TT08 PageRank

What is personalized PageRank?

TT09 Closeness and betweenness

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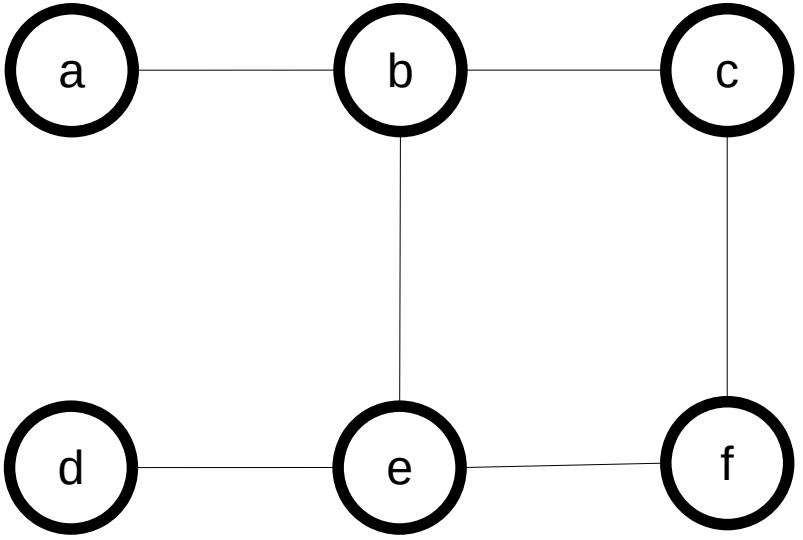
What is the closeness of a node?

What is the harmonic closeness of a node?

TT09 Closeness and betweenness

What is the closeness of one node in this graph?

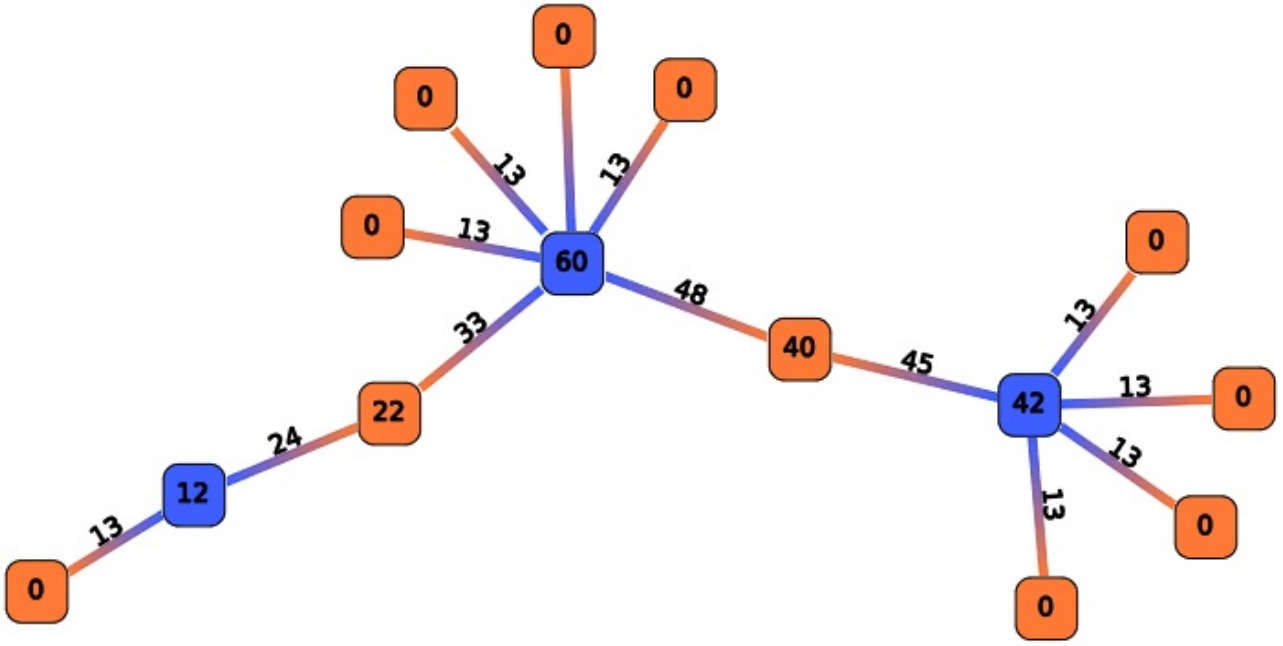


TT09 Closeness and betweenness

What is the betweenness of an edge?

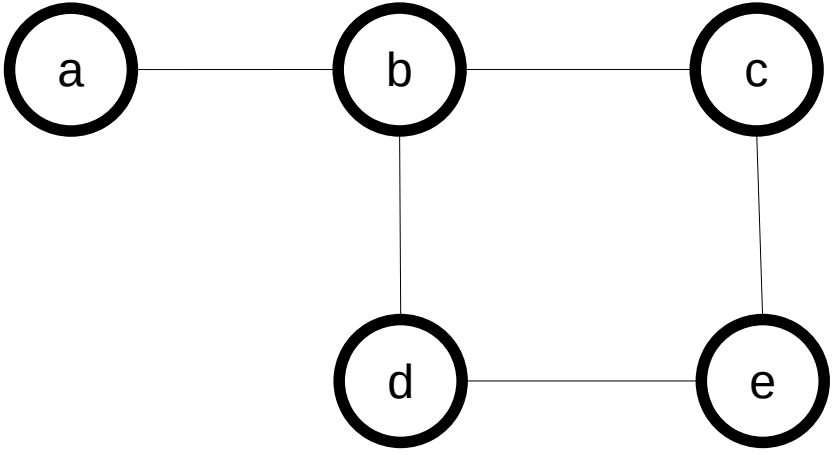
TT09 Closeness and betweenness

Why is the betweenness of the blue node on the left 12?



TT09 Closeness and betweenness

Compute betweenness using the Brandes-Newman algorithm



TT10 Network flows

TT10 Network flows

What is the max-flow problem?

TT10 Network flows

What is the min-cut problem?

TT10 Network flows

Why do we say max flow and min cut are equivalent problems?

TT10 Network flows

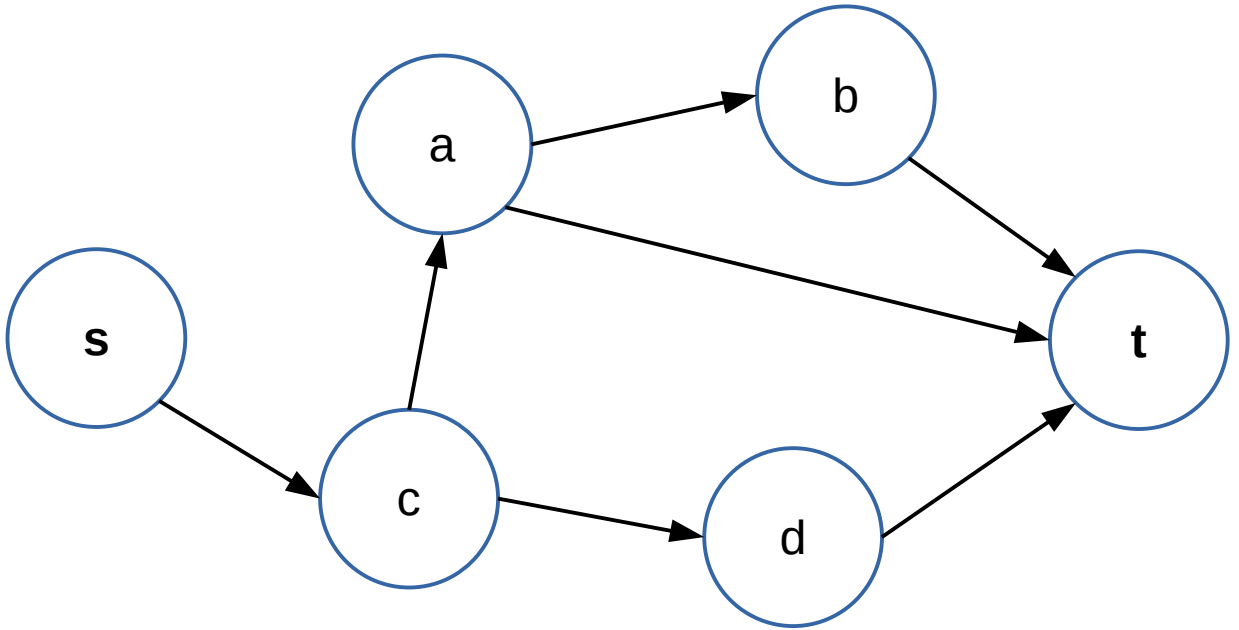
Write the formulation of max flow as a linear system

TT10 Network flows

Write the formulation of min cut
as a linear system

TT10 Network flows

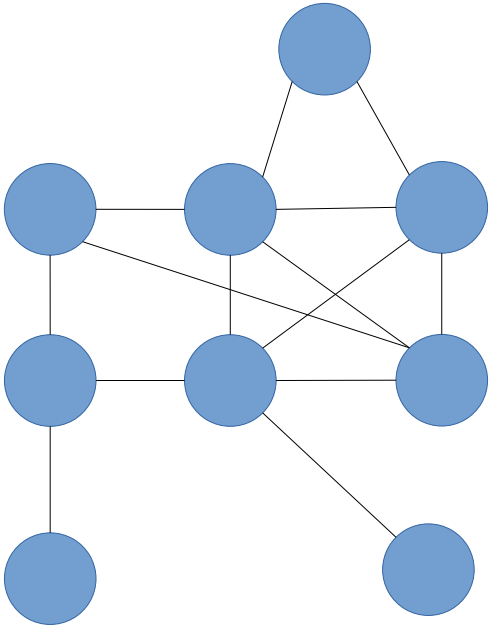
Use the randomized algorithm we saw in class to find the min cut of this graph



TT11 Dense sub-graphs

TT11 Dense sub-graphs

Perform a k-core decomposition of this graph



TT11 Dense sub-graphs

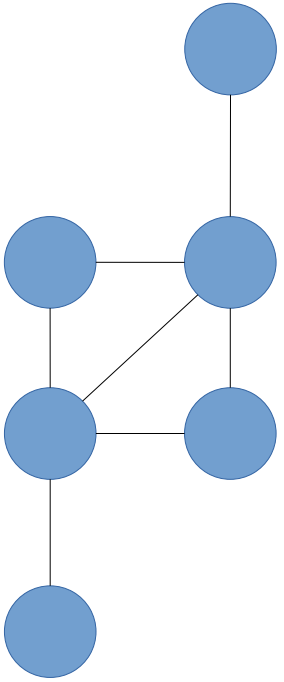
Describe two **density definitions** that are commonly used

TT11 Dense sub-graphs

What is the density definition used in Golderg’s construction?

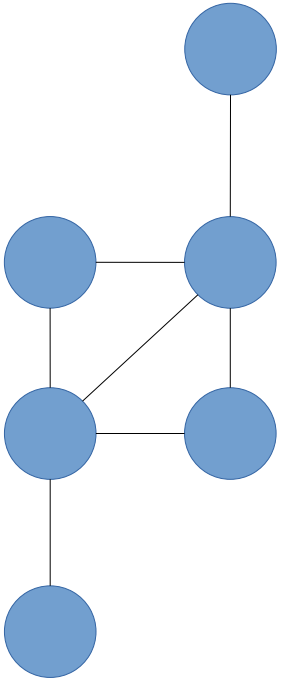
TT11 Dense sub-graphs

Draw Goldberg's construction on this graph for target density 5/2 = 2.5



TT11 Dense sub-graphs

Perform Charikar's algorithm on this graph; remember we measure density as |E|/|V|



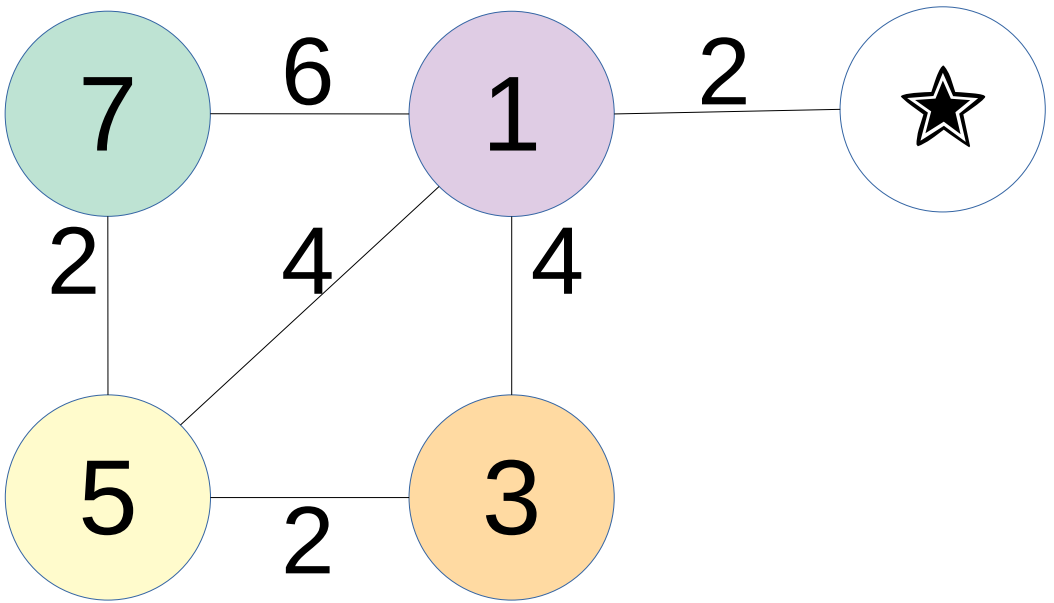
TT12 Spreading phenomena

TT12 Spreading phenomena

Describe the linear threshold propagation model

TT12 Spreading phenomena

Run the **linear threshold** model on this graph starting from the node marked ★

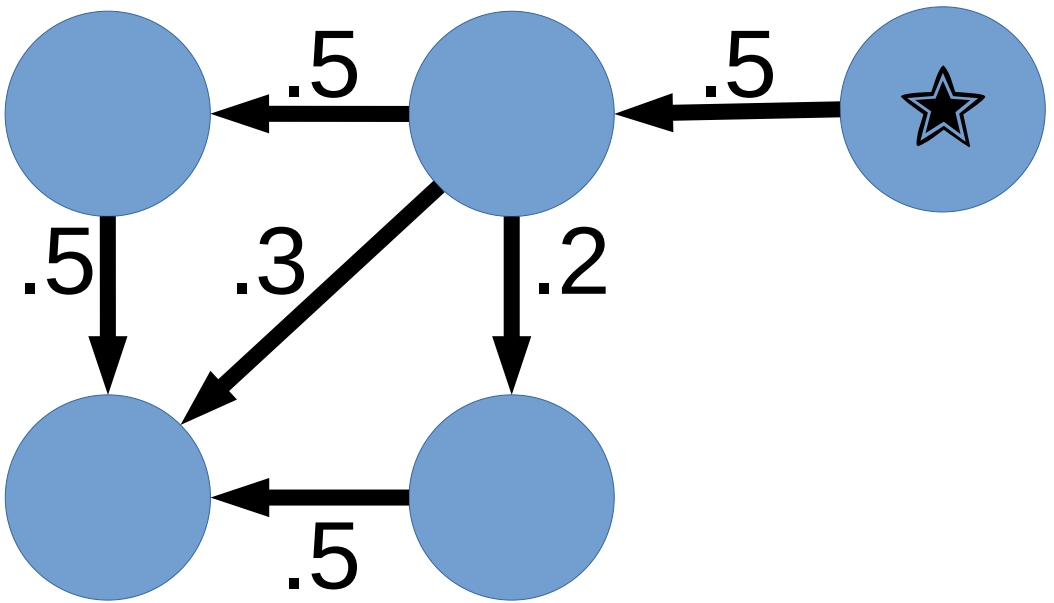


TT12 Spreading phenomena

Describe the independent cascade propagation model

TT12 Spreading phenomena

Run the independent cascade model on this graph starting from the node marked ★



TT13 Epidemics

TT13 Epidemics

Indicate what the
basic reproductive number R_0 means

Indicate its formula in a branching process

TT13 Epidemics

Describe the SI model

What fraction of the nodes are infected at the end of a SI infection process?

TT13 Epidemics

Describe the SIS model

Does the SIS model reach a steady state?
How is this steady state called?

TT13 Epidemics

Describe the meaning of different variables in the following equations, which describe changes in the number of infected under a SIS process using conventional notation:

$$\frac{di(t)}{dt} = \beta \langle k \rangle i(t)(1 - i(t)) - \mu i(t)$$

TT13 Epidemics

Describe the SIR model

What fraction of the nodes are infected at the end of a SIR infection process?

TT13 Epidemics

Describe the meaning of different variables in the following equations, which describe a SIR process using conventional notation:

$$\frac{di(t)}{dt} = \beta \langle k \rangle i(t)(1 - r(t) - i(t)) - \mu i(t)$$
$$\frac{dr(t)}{dt} = \mu i(t)$$
$$\frac{ds(t)}{dt} = -\beta \langle k \rangle i(t)(1 - r(t) - i(t))$$