

Resit exam questions (2022-07-13)

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

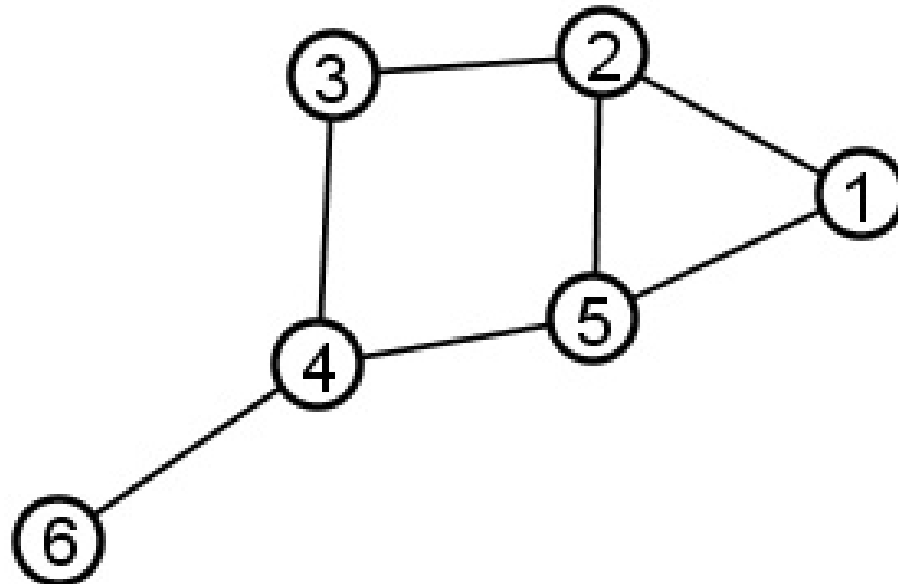
Complex networks

What is a complex system?

What is a complex network?

Graph theory basics

Draw the adjacency matrix of this graph



Graph theory basics

Draw the graph corresponding to this adjacency matrix

	0	1	2	3	4
0	0	2	3	0	0
1	2	0	15	2	0
2	3	15	0	0	13
3	0	2	0	0	9
4	0	0	13	9	0

Graph theory basics

How do you know from an adjacency matrix that a graph is undirected?

Graph theory basics

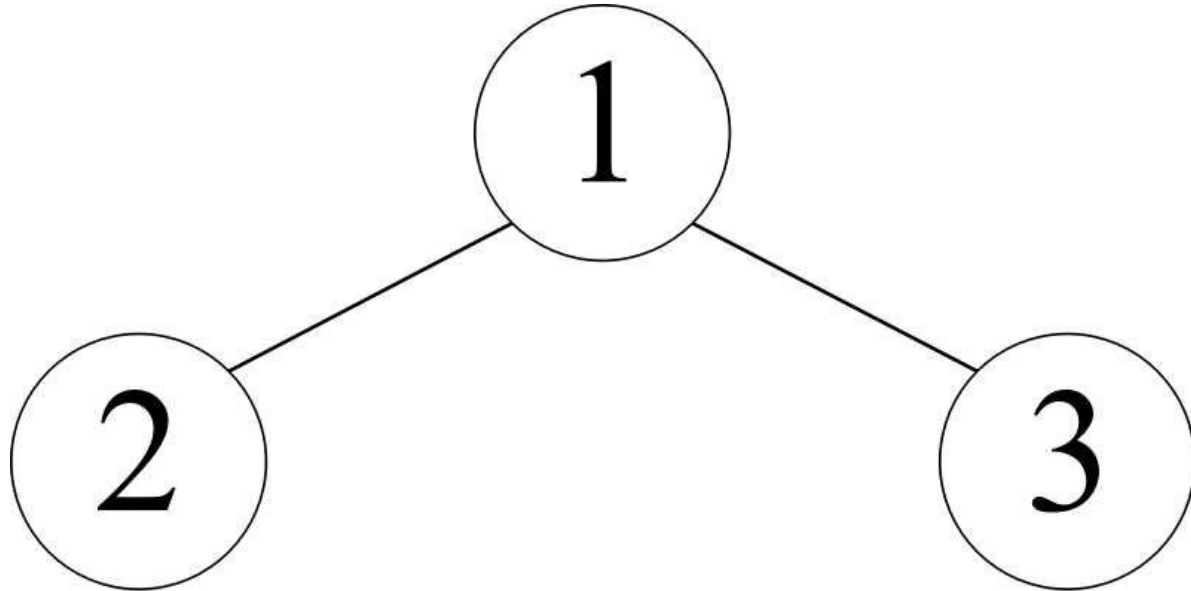
What is the maximum number of edges in an undirected graph of N nodes? Explain.

Sparsity and connectivity

Why do we say most real networks are sparse?

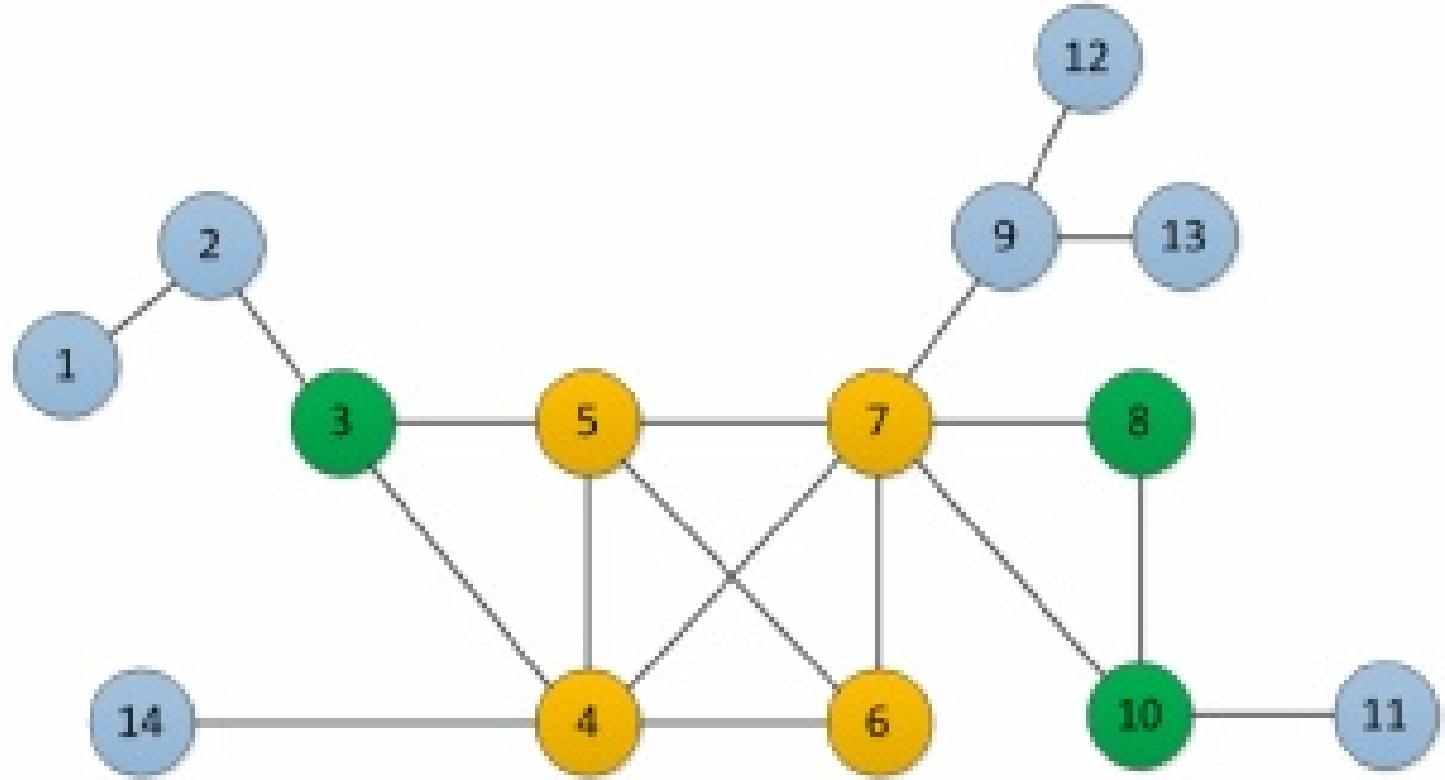
Sparsity and connectivity

What is the average distance in this graph?



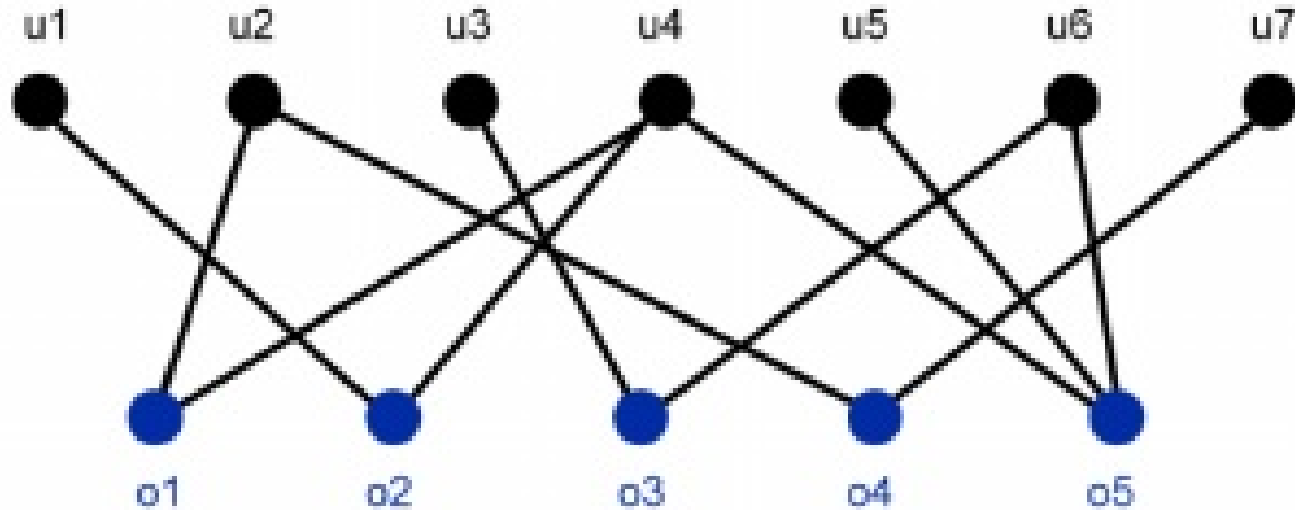
Clustering coefficient

Compute the **local clustering coefficient** of nodes 4, 5, 6, and 7.



Projections

Draw the left-projection (“u” side) and right-projection (“o” side) of this graph.



Random networks

Consider an ER graph with 1,000 nodes.

What is the probability that a node in this graph has 0 links? Explain.

Random networks

Consider an ER graph with 1,000 nodes.

What is the expected distance $\langle d \rangle$ in this graph
Explain.

Scale-free networks

What does it mean to be scale-free in a scale-free network?

Scale-free networks

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

Scale-free networks

Consider a scale-free network of $N=500,000$ nodes and $\gamma=2.2$.

$$\text{Riemann's } Z(2.2) = 1.4905$$

What is the maximum degree x for which you would expect to find at least one node with degree x ?

Preferential attachment

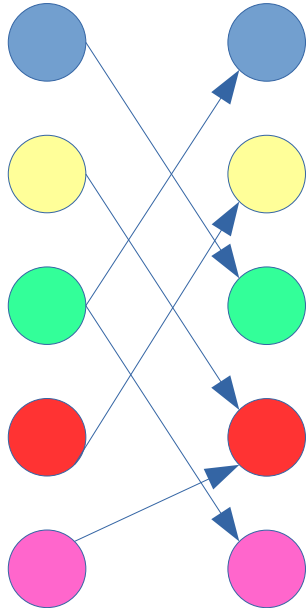
How is the exponent of the degree distribution in a graph generated using the Barabasi-Albert model (BA) affected by the number of nodes of the generated graph?

Preferential attachment

How is the exponent of the degree distribution in a graph generated using the Barabasi-Albert model (BA) affected by the number of edges (“ m ”) that are added to the graph at each step?

Hubs and authorities

Execute some steps of HITS on this graph

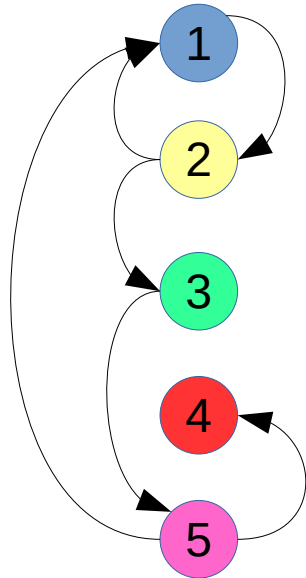


$\hat{H}(1)$	$A(1)$	$\hat{A}(1)$	$H(2)$	$\hat{H}(2)$	$A(2)$	$\hat{A}(2)$
1						
1						
1						
1						
1						

PageRank

Execute some steps of **Simplified PageRank**

underlined italics = normalized value



P(1)	P(2)	<u><i>P(2)</i></u>	P(3)	<u><i>P(3)</i></u>	P(4)	<u><i>P(4)</i></u>
1						
1						
1						
1						
1						

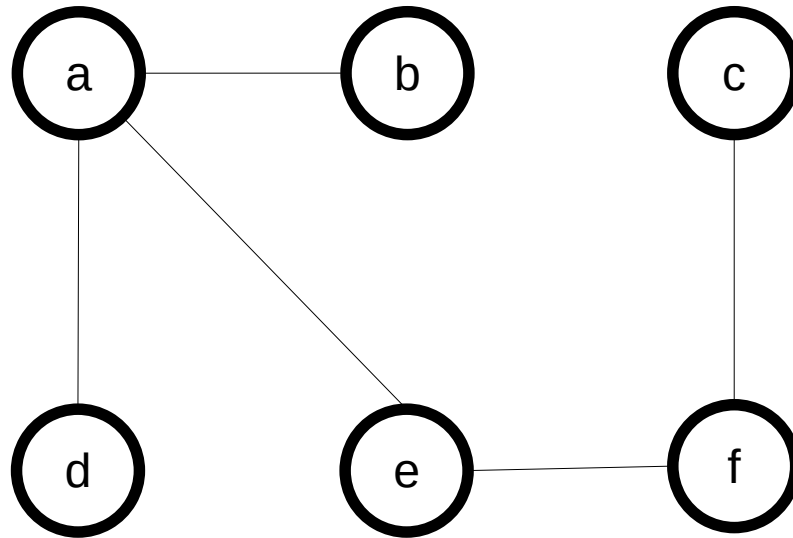
Closeness

What is the closeness of a node?

What is the harmonic closeness of a node?

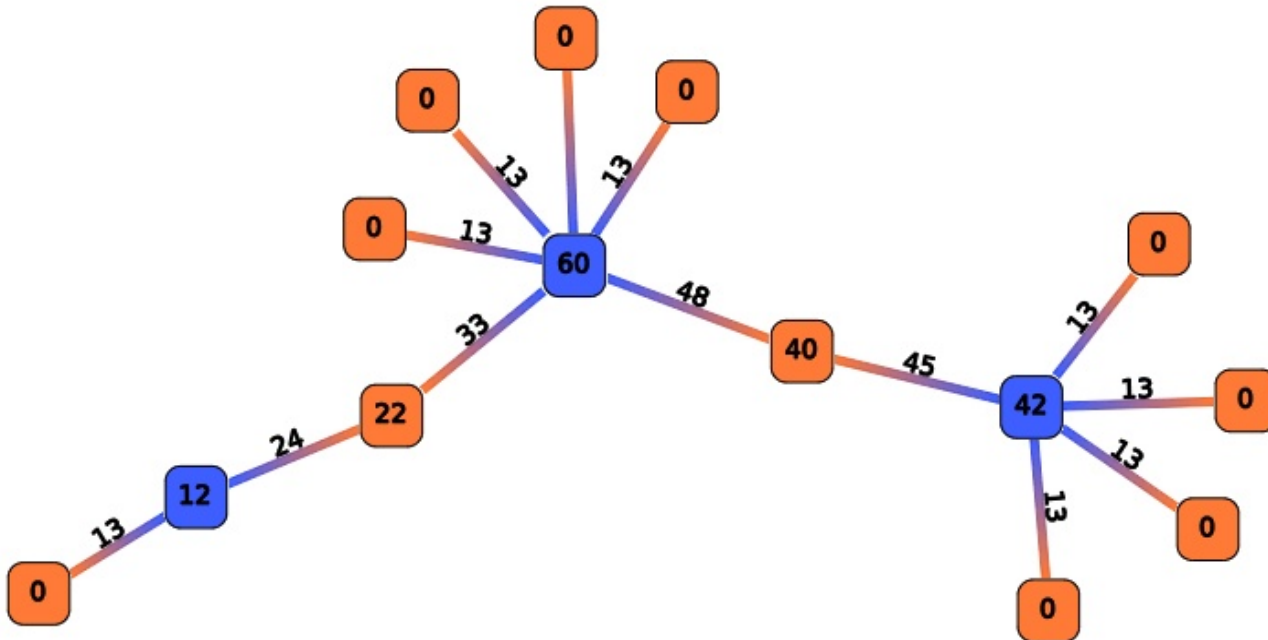
Closeness

What is the closeness of node “b” in this graph?



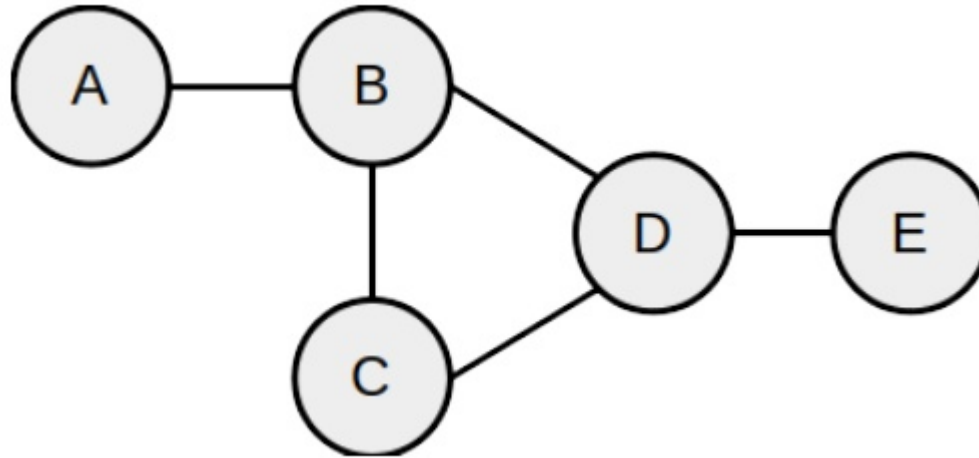
Betweenness

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



Betweenness

Compute betweenness using the Brandes-Newman algorithm



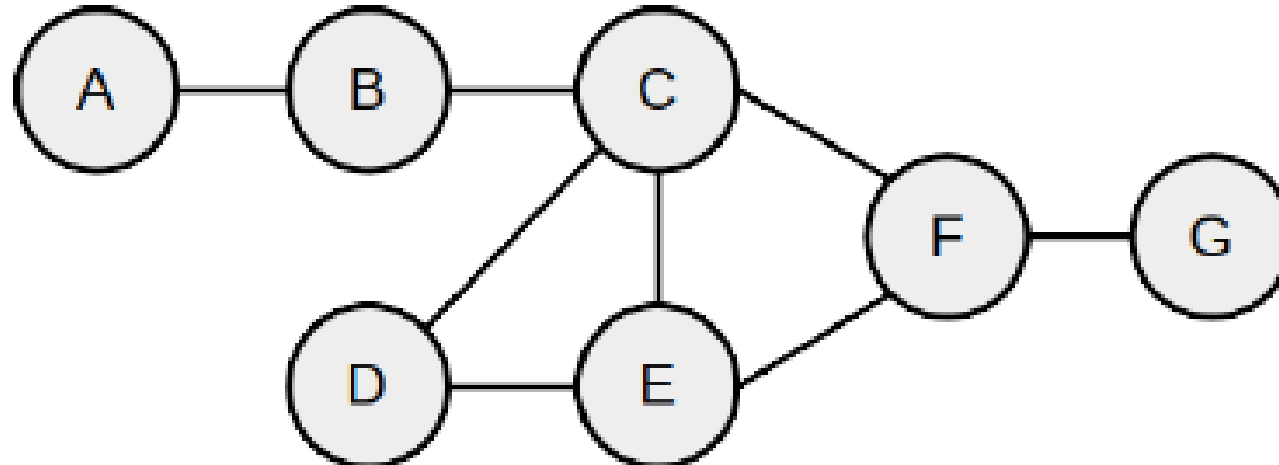
Network flows

What are the min-cut and max-flow problems?

Dense sub-graphs

Dense sub-graphs

What is the k-core value for each node in this graph?

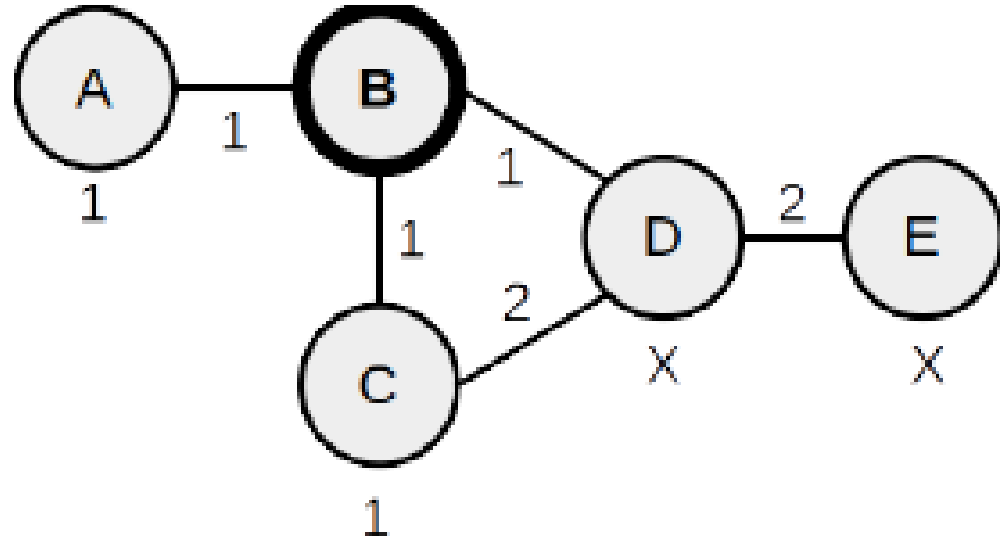


Dense sub-graphs

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

Spreading phenomena

Under the linear threshold model:



(a) what value of X makes D and E infected?

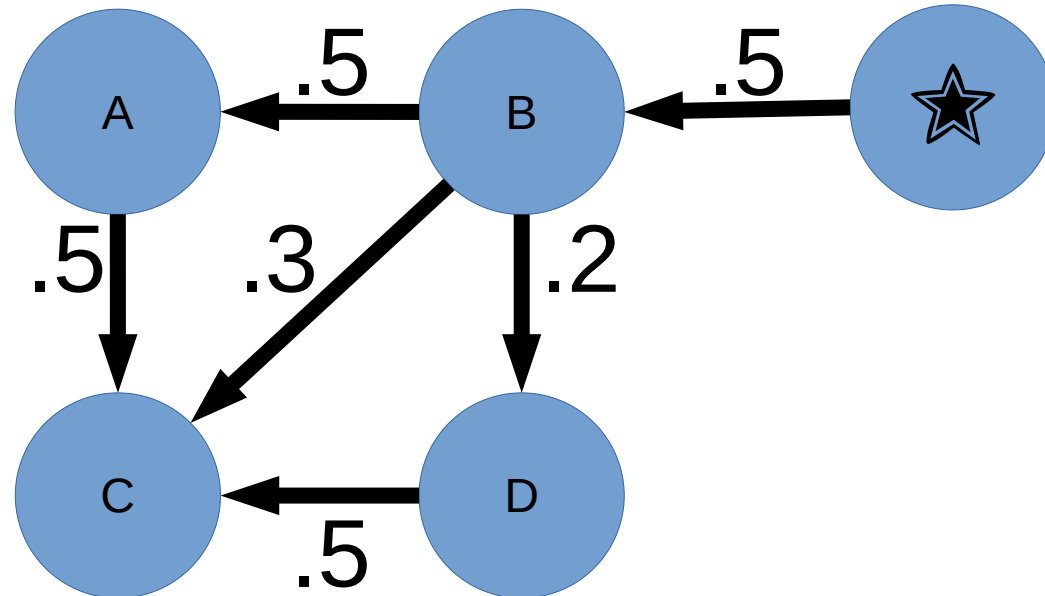
(b) what value of X makes D infected but E not infected?

Spreading phenomena

Describe the independent cascade propagation model

Spreading phenomena

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



Spreading phenomena

Describe a method to compute the influence $f(S)$ of a node subset S of nodes of a graph, where $f(S)$ is the number of nodes that will be infected, on expectation, if an infection starts simultaneously in all nodes of set S and follows the independent cascade model

Spreading phenomena

Again considering $f(S)$ as the influence function, indicate the relationship ($<$, \leq , $=$, \geq , $>$) between

$f(A \cup B)$



?

$f(A) + f(B)$

Epidemics

Indicate what the
basic reproductive number R_0 means

Indicate its formula in a branching process

Epidemics

Describe the SIR model

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

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:

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

Epidemics

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

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

$$\frac{dr(t)}{dt} = \mu i(t)$$

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