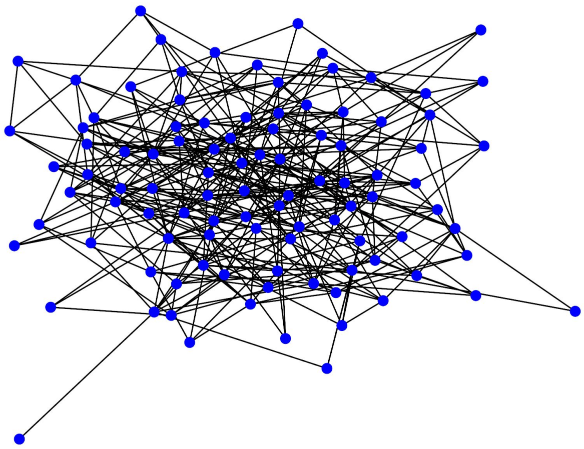
Giacomo Usai - S4390761 giacomo.usai.iic97@gmail.com UniGe

3rd Assignment: Social contagion

Implemented a Social Contagion on a Realistic Graph in Python.

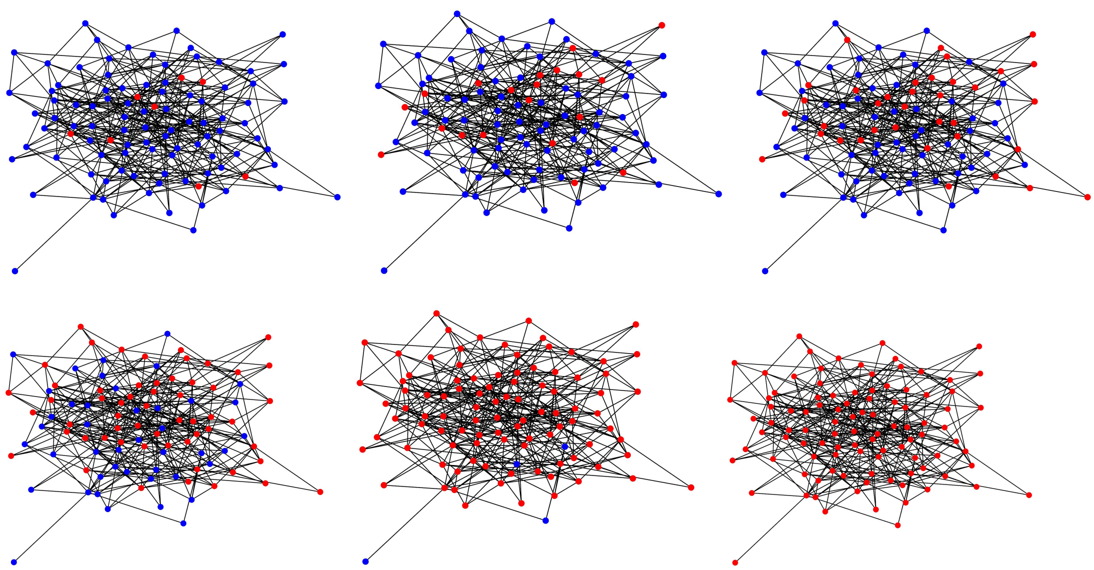
Using this script you will be able to reproduce a Social Contagion on your Graph. First of all, the Graph will be printed, day zero, everyone is healthy, noone is contagious :



(In this example I used a scale free network with 100 nodes.)

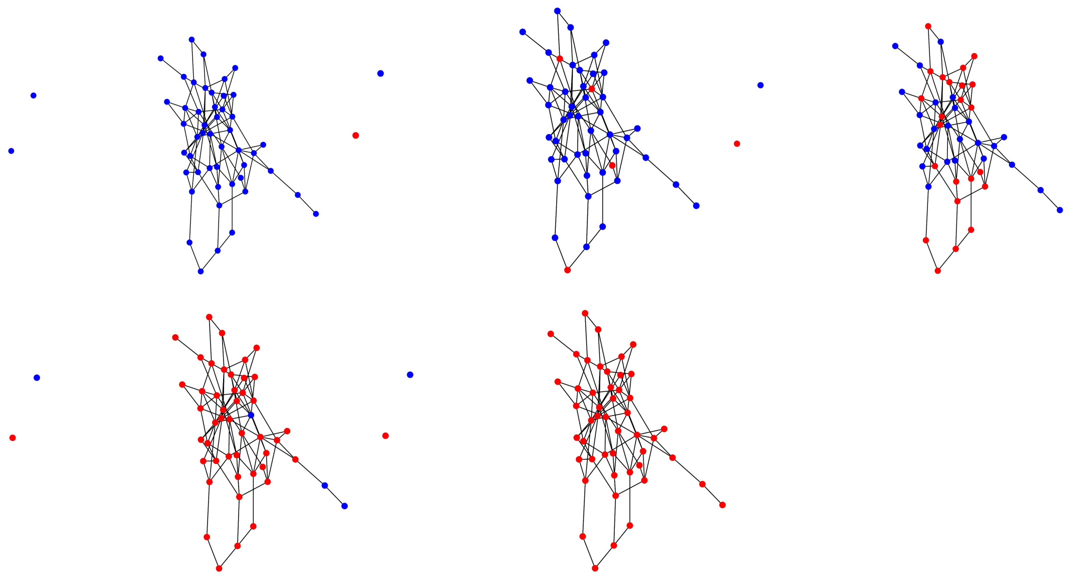
The png images will be numbered from 1 (the first) to the last one and they represent the days of the contagion.

The red nodes represent the infected ones. At the end, if every node is red, the whole graph is infected.



(parameters used: a= 1, b= 2)

Note that in some cases the graph is too big, so you cannot visualize all the nodes and maybe there are blue nodes hidden behind the reds. Anytime (and anydays) you can check on terminal the list of healthy nodes (not infected). Naturally, if the list is empty, it means that the whole graph is infected.



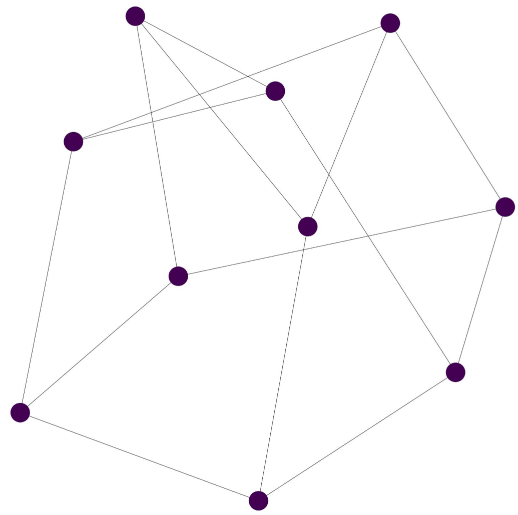
(I used a random graph generator, we can see day0 on top left to day4 on the bottom right)

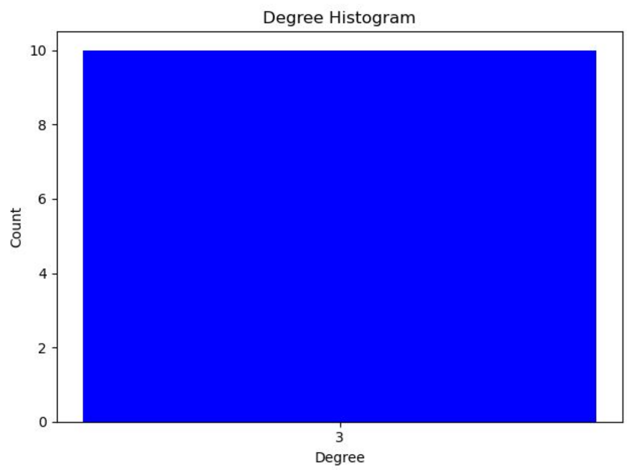
In this scenario, we can see that there are nodes without edges, so it cannot be infected because it cannot be reached! In addition, if initially infected, they cannot contact (and transmit) nobody.

Here you can find some examples about how to set the parameters (a,b) based on the network that you want to infect. In some examples I extended the number of days in order to see what happen.

The script selects the random nodes to start the contagion; then computes the payoff matrix for each nodes (at each day that we want) and finally, based on neighbors' data that influence the payoff, decides if a node become contagious or not.

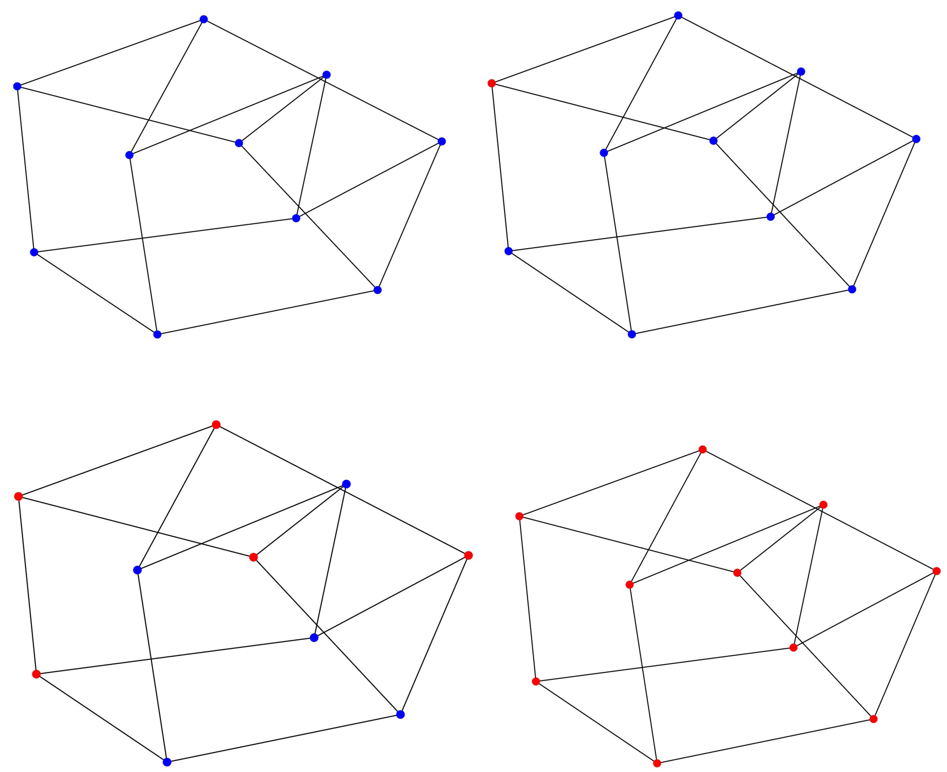
Synthetic graphs: Petersen Graph





Number of nodes: 10
Number of edges: 15
Average degree: 3.0000; Diameter (it is the maximum eccentricity): 2

Using b> 2.1 (a=1), the % of contagion is positive 4 times on 10 (=total number of nodes), so all the nodes die in only three days (see the pictures below):



(Day0=no infected(top left); Day1(top right); Day2; Day3=end game.)

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Social networks : online social networks, edges represent interactions between people

My real Network Analysis

Name: Facebook **Type**: Graph

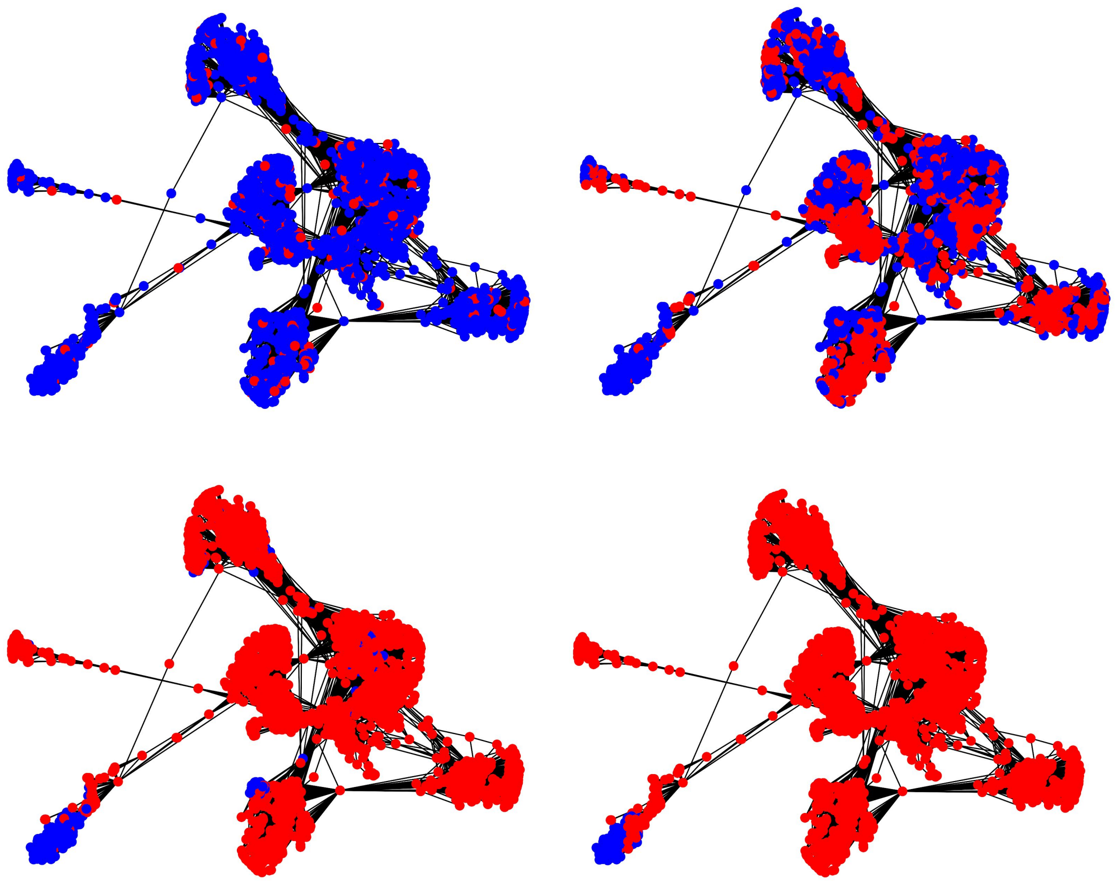
Number of nodes: 4039 (named from 0 to 4038) **Number of edges:** 88234

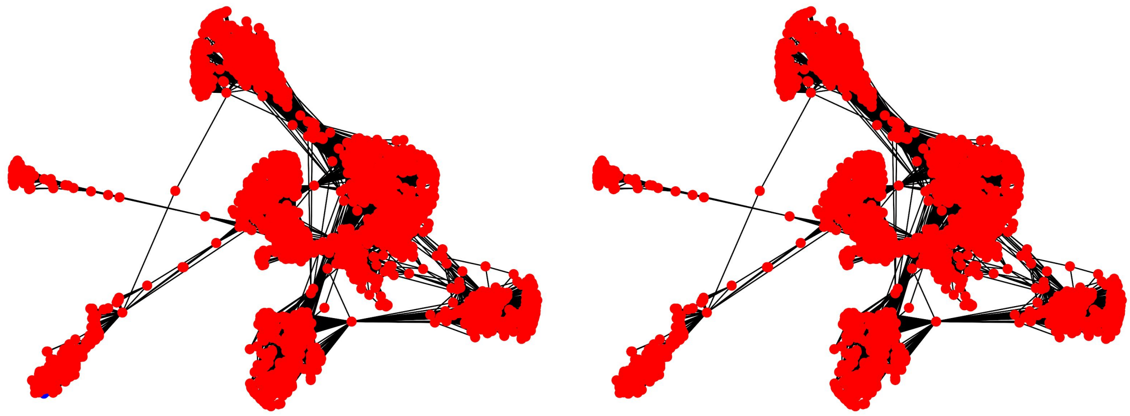
Average degree: 43.6910

Density: 0.010820, so we can see that our graph is not dense: it's **sparse** because $\rho \rightarrow 0$.

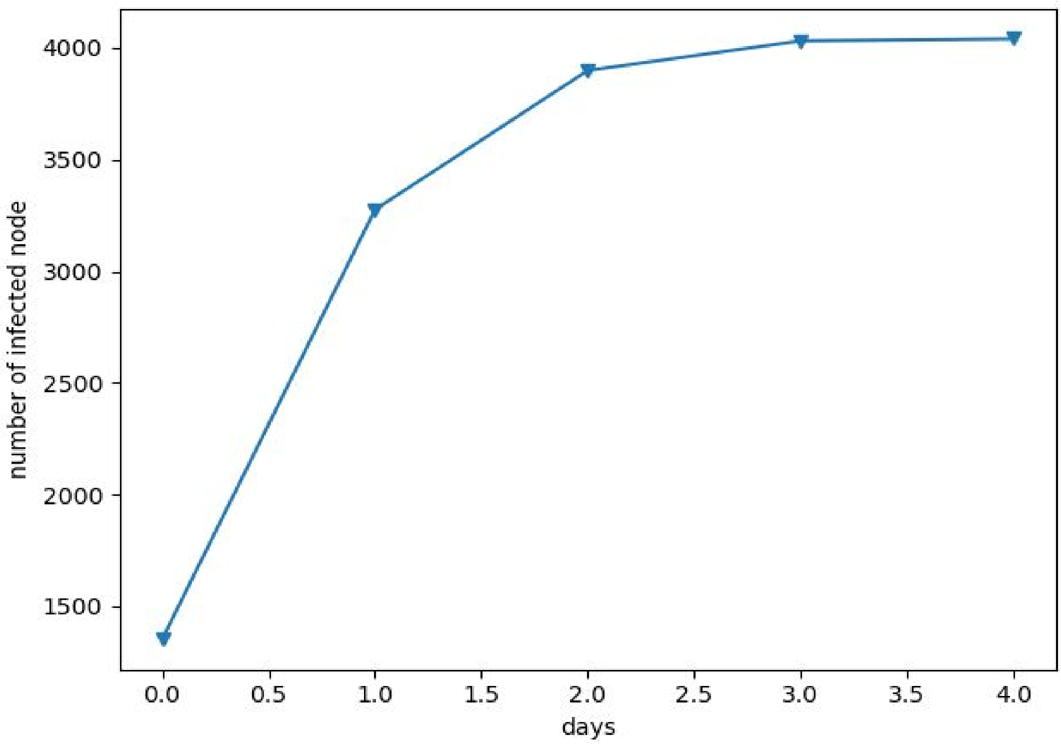
is directed: False **is complete**: False

Diameter (it is the maximum eccentricity): 8

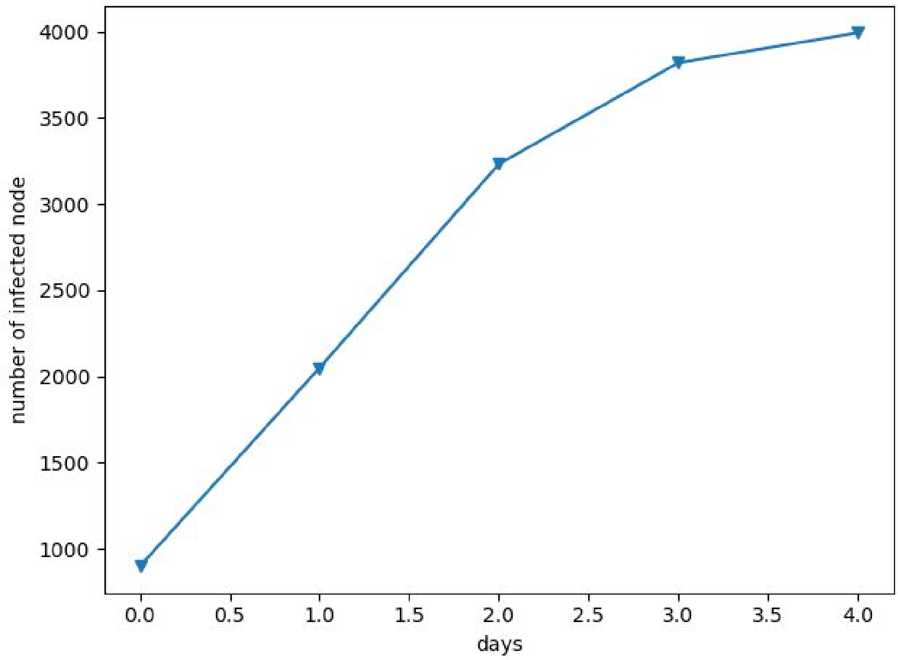




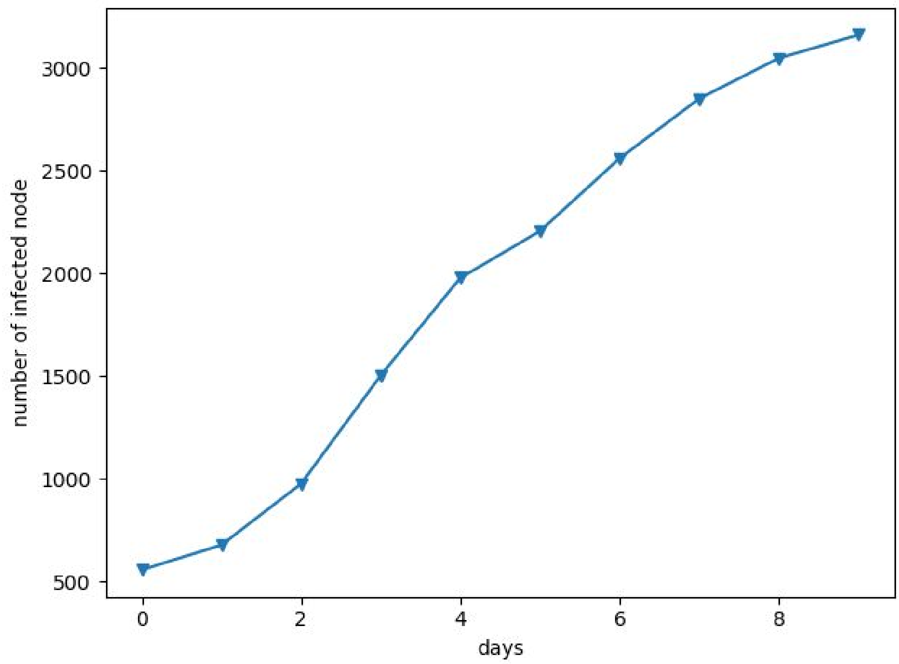
Using **b = 5 (a=1)**, in only six days, we can infect the whole Facebook Network. Below there is the plot about the number of infected nodes per day.



Using **b=4 (a=1)** we can see that the infections increase with a low slope. In particular, after 4 days, the whole graph is not infected. Probably, one more day may complete the contagion.



Now we try to increase the number of days. Using **b=3.1 (a=1)** we can see that the infections increase with a low slope. In particular, after 10 days, the whole graph is not infected. Probably, one more day may complete the contagion.



Here we try to understand what happened to our two network.

We saw that in the Petersen graph, using contagion (b) > 2.1, after three days all nodes are infected. Here there is a dense internal connectivity. So, the spread is easy also because there is no complex communities. In addition, Petersen graph is a strongly regular small graph. It is also symmetric, meaning that it is edge transitive and vertex transitive (more strongly, it is 3-arc-transitive).

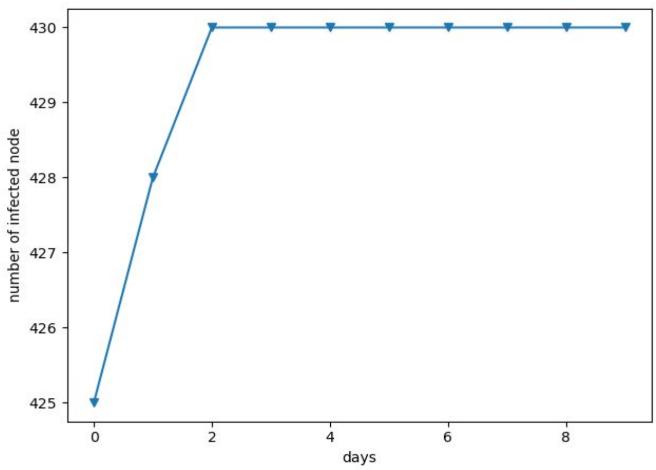
Instead, in our Social Network, only using contagion (b) > 5, we infect the whole net in six days. Why? The number of nodes are really different. Anyway, this is a Social Network. It's really big and it's not regular. But the dimension of the network doesn't matter! It's a scale free network: it's organized into groups of different sizes. In particular, the diameter is equal to 8. In the Petersen graph it's equal to 2.

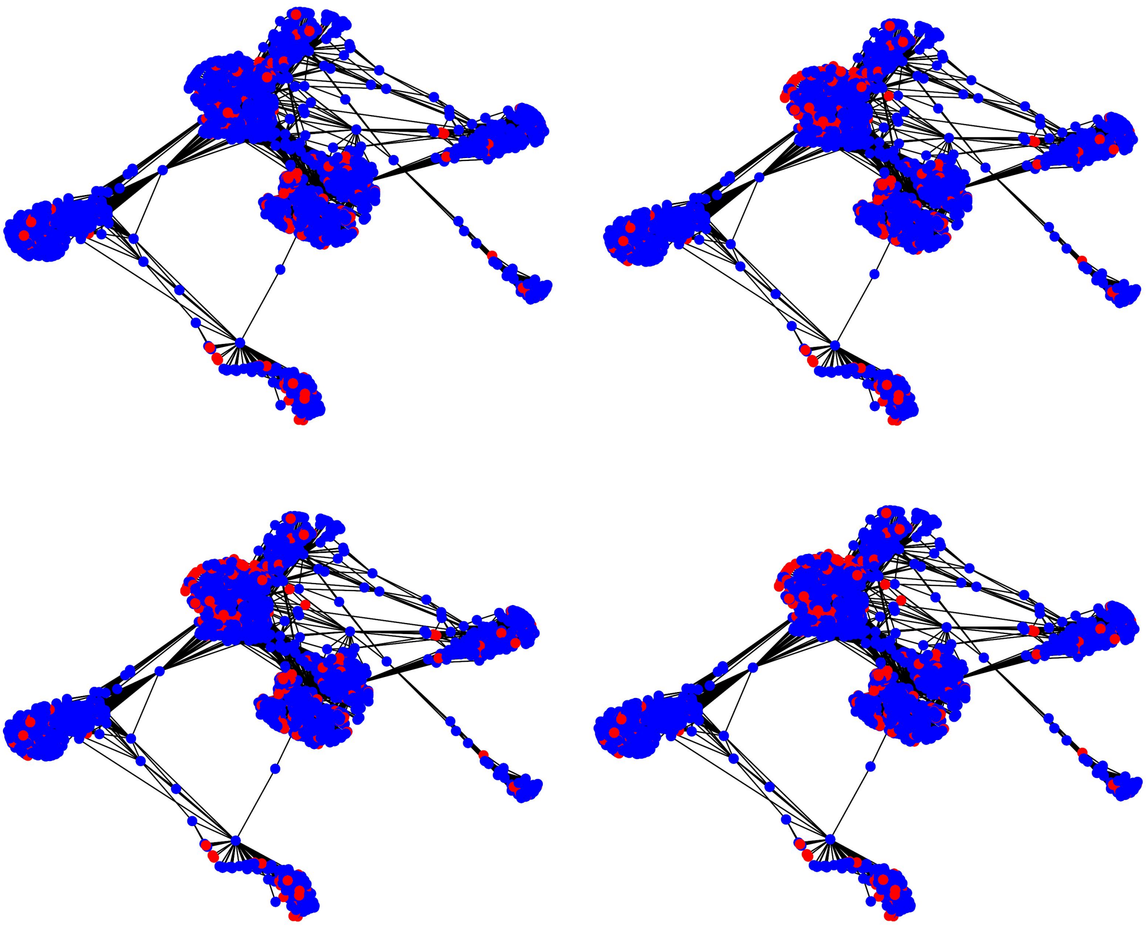
At the beginning the scenario it's the same: the 10% of the graph is infected. However the structure of the network is the key. In the Petersen graph scenario, the contagion can infects all the nodes because they are regularly connected and the diameter is really low.

Petersen graph density (=0,33333) >> My real Social Network's density (=0.010820).

In our Facebook social network, there are nodes that can be really far from the infected ones (reds), so the contagion needs more times to infect the healthy ones (blues). So, as we can see, the dimension of the network it's not a big deal. The structure and the density of the network defines how a contagion may intact the entire network.

In conclusion, we will see that setting a=2 and b=3 in our social network, the contagious will reach-infect a number of nodes and it will not be able to grow up again. In fact, after 3 days there are 430 infected nodes. And after 10 days, there are again 430 infected nodes. (See the picture below)





Day 1 (on top left) = 425 infected node (10% of 4039 nodes);

Day 2 (on top right) = 428 infected node;

Day 3 (on bottom left) = 430 infected node;

Day 4, 5, 6, … = again 430 infected node.

Giacomo Usai

Note

Diffusion models can be studied as a **coordination game**:

1. Each node in the network has a **choice** between two possible behaviors, labeled A and B;
2. If nodes v and w are linked by **an edge**, then there is an incentive for them to have their behaviors match.

A. We can capture this with a game in which v and w are the players and A and B are the possible strategies

B. The payoffs are defined as follows
   - if both v and w choose A, they get payoff a > 0
   - if both v and w choose B, they get payoff b > 0
   - if one chooses A while the other chooses B, their payoff is 0

A was only able to spread to a set of nodes where there was sufficiently dense internal connectivity.

The role of communities in complex contagion is that can create isolated groups impervious to outside ideas. We will see it in the real case-Facebook Social network.