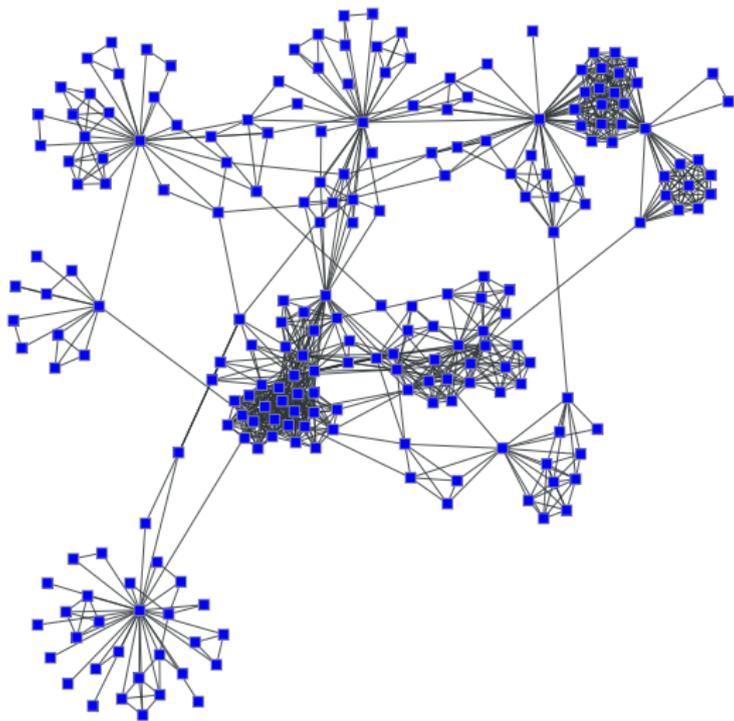


Role of community structure on network polarization

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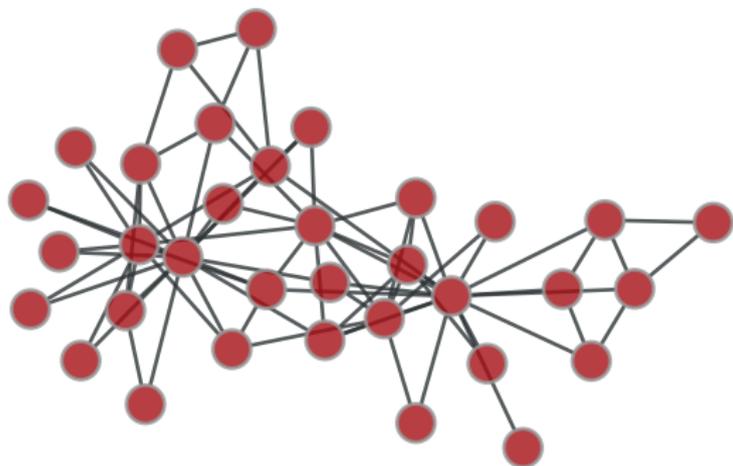
Community structure in networks

- Friend circles in social networks
- Wikipedia pages of similar topics
- Proteins with similar functionality inside a biological cell

Division of the nodes of the network in response to a yes-no type question

- 1 To vote for candidate A or candidate B?
- 2 Should the capital punishment be practiced or not?
- 3 Should taxes be raised or not?

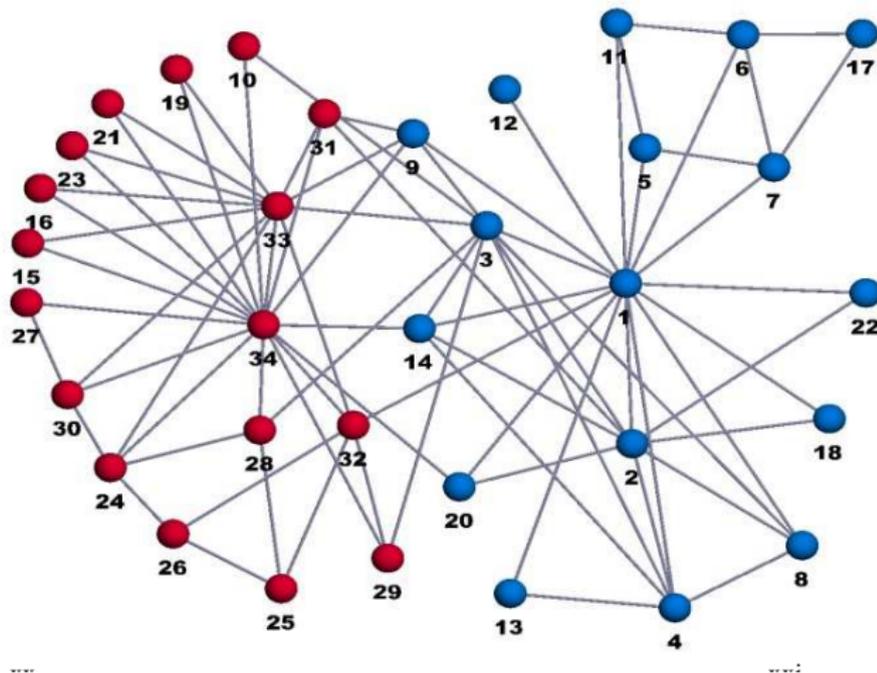
How does a community structure affect the polarization of a network?



Zachary's karate club

- Network of members of a karate club with 34 nodes
- A dispute about raising of the fees of the club
- Club broke into two parts: President/Coach

Zachary's karate club



Credit: Dona Beiers

What led to the splitting of the Zachary karate network?

Zachary's karate club

Zachary Karate Club Club [\[edit \]](#)

Zachary Karate Club Club is a honorific group^[4] that awards membership in the group, along with a traveling trophy, to a scientist who is the first to use Zachary's Karate Club as an example at a conference on networks. The first scientist to be awarded was [Cristopher Moore](#)^[5] in 2013.

ZKCC Trophy recipients^[4] [\[edit \]](#)

- 12th Amir Rubin (January 2017)
- 11th Federico Battiston (September 2016)
- 10th Giona Casiraghi (July 2016)
- 9th Filippo Radicchi (May 2016)
- 8th Qing Ke (September 2015)
- 7th Manlio De Domenico (July 2015)
- 6th Tiago Peixoto (June 2015)
- 5th [Mark Newman](#) (June 2014)
- 4th [Marián Boguñá](#) (September 2013)
- 3rd [YY Ahn](#) (July 2013)
- 2nd [Mason Porter](#) (June 2013)
- 1st [Cristopher Moore](#) (May 2013)

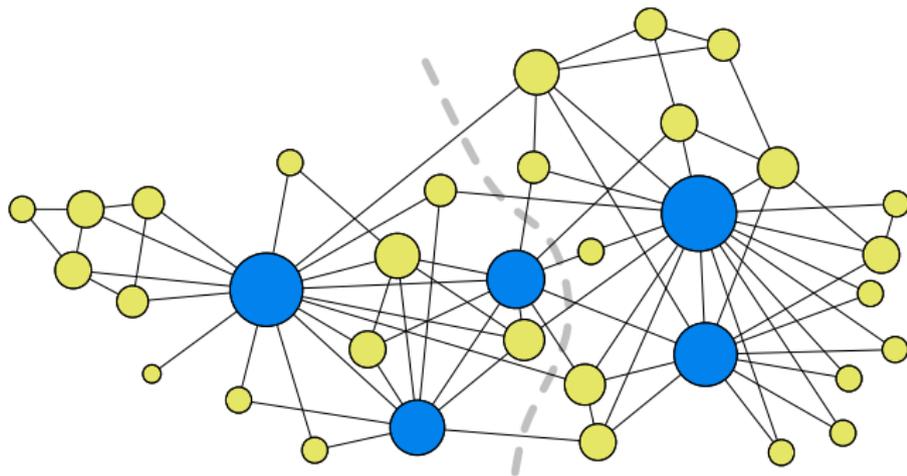
Underlying community structure caused the breaking!

Find an algorithm which produces the split communities..

If your method doesn't work on this network, go home!

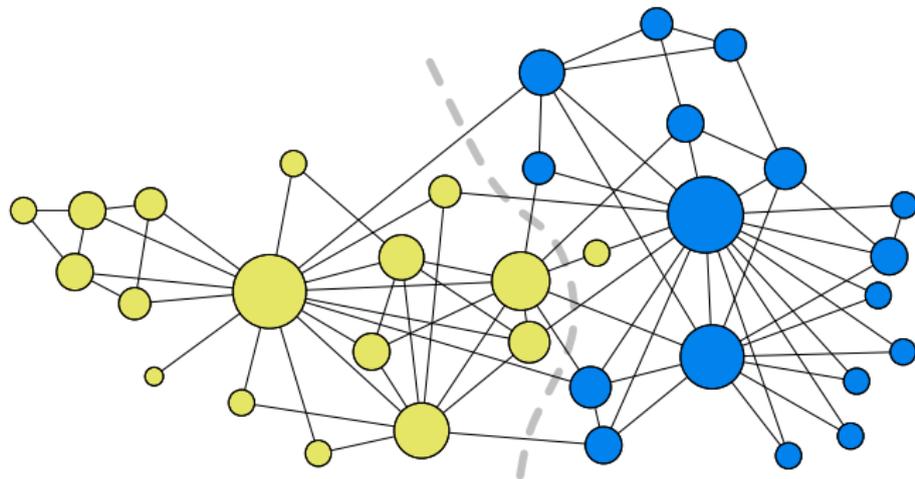


Stochastic Block Model



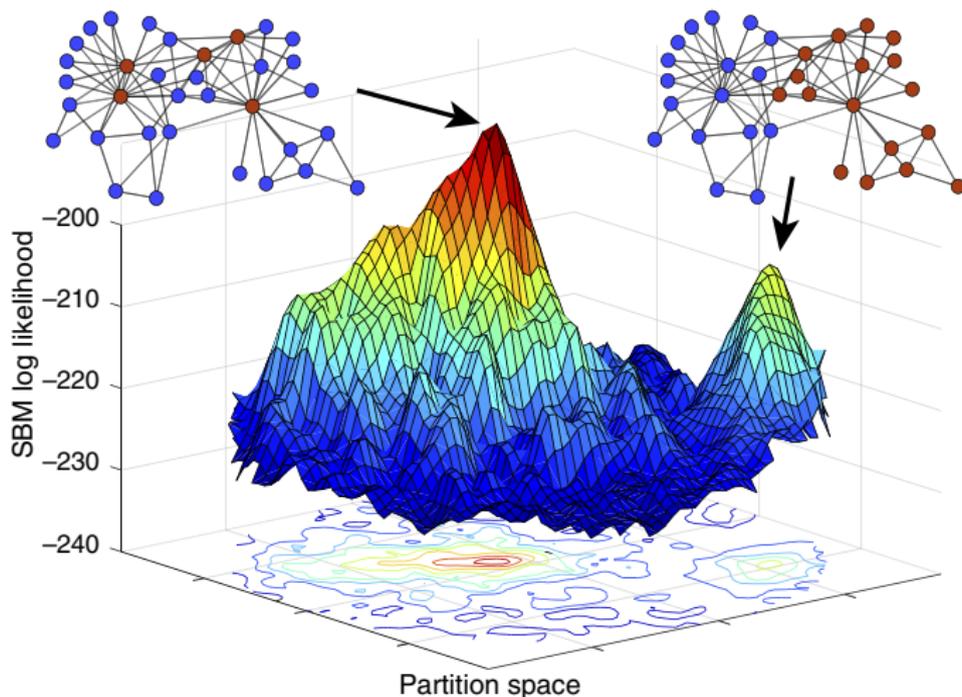
Credit: Karrer, Newman, Phys. Rev. E, 2011

Degree-corrected stochastic block model



Credit: Karrer, Newman, Phys. Rev. E, 2011

Likelihood's of the partitions: splitting/leader-follower



Credit: Peel et al, Science Advances, 2017

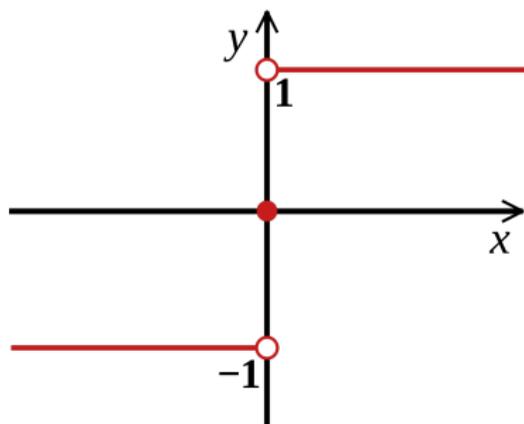
Structure isn't sufficient: Look at the dynamics!

- Raising of fees is a “Yes-no” question
- An opinion of a node is affected by its neighbors
- **What if the opposite answers emerge on two different nodes?**

Look at the dynamics!

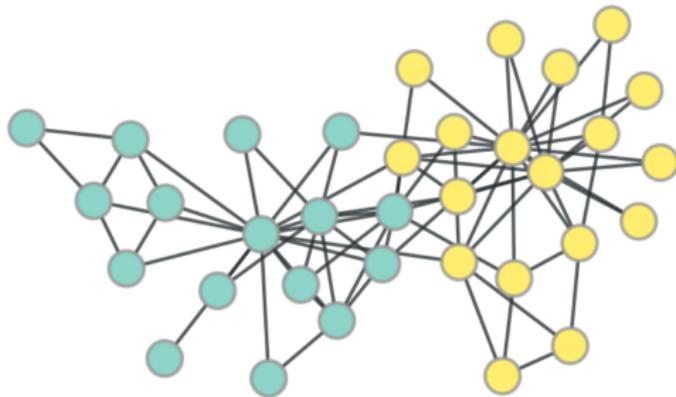
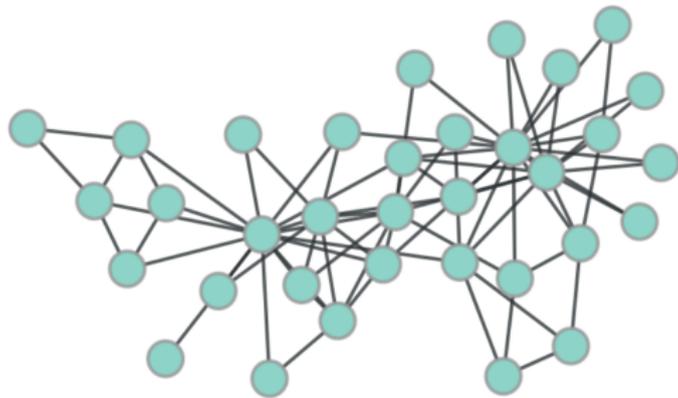
$x_i(t)$: state (opinion) of node i at time t , $x \in \{-1, 0, 1\}$

$$x_i(t+1) = f_i(x_i(t), \sum_j A_{ij}x_j(t)) = \operatorname{sgn} \left(x_i(t) + \sum_j A_{ij}x_j(t) \right)$$



Initial conditions

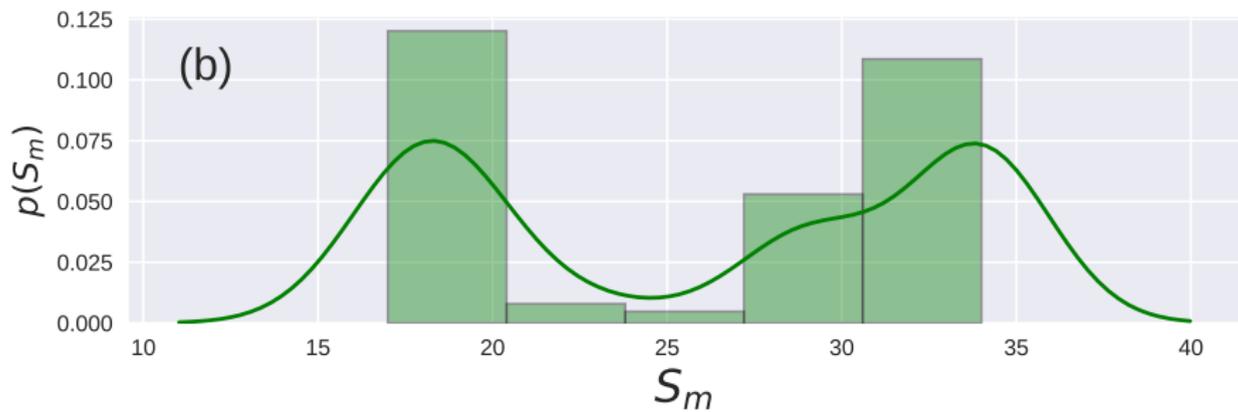
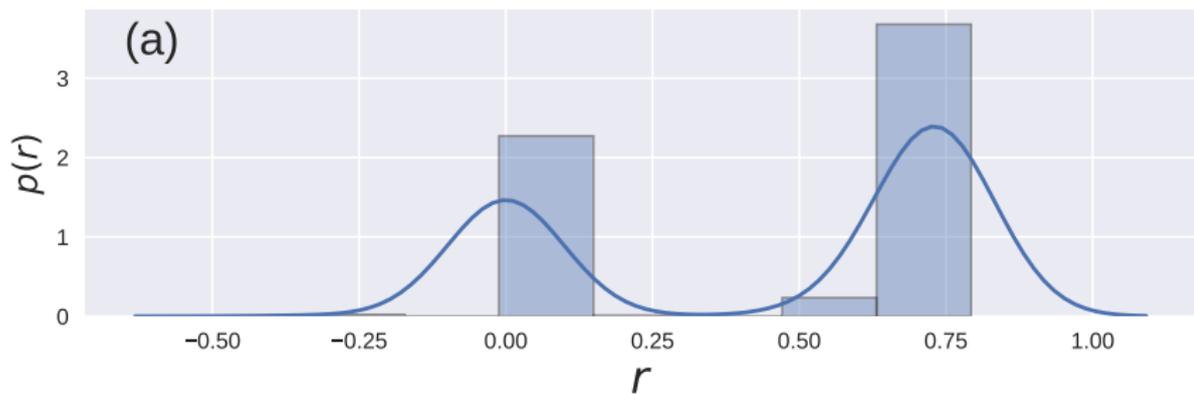
- Start with neutral ($x = 0$) opinions on all nodes except two of them
- Infect the remaining two nodes (seed nodes) with opposite opinions ($x = +1$ and $x = -1$) and run the dynamics
- The system quickly reaches a steady state



Assortativity coefficient

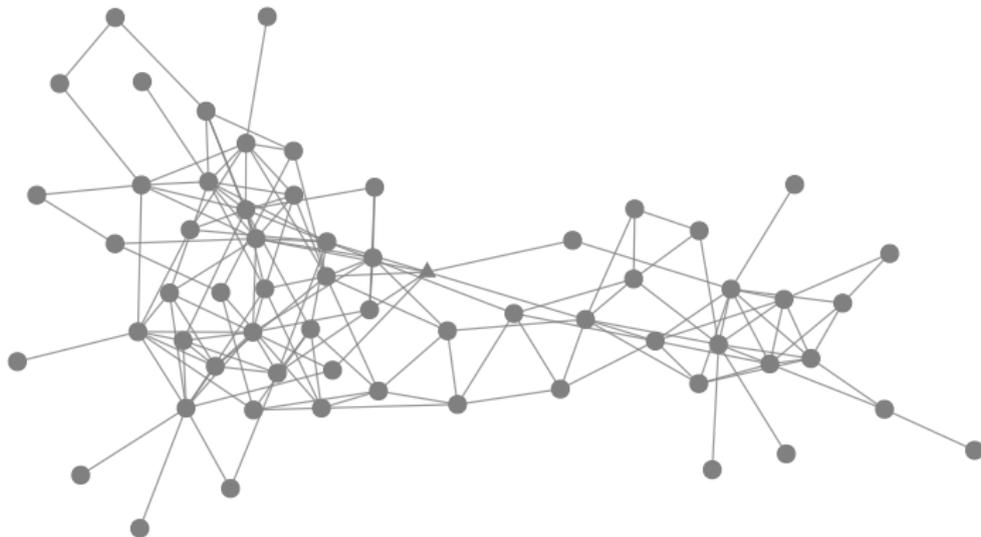
$$r = \frac{\sum_{ij}(A_{ij} - k_i k_j / 2m)x_i x_j}{\sum_{ij}(k_i \delta_{ij} - k_i k_j / 2m)x_i x_j}$$

r is close to 1 for highly polarized states and close to 0 for unpolarized states



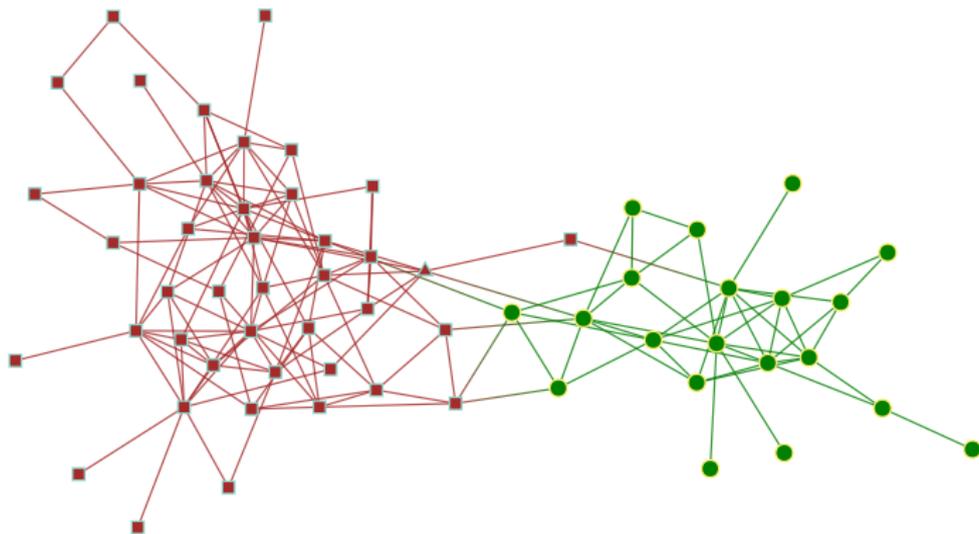
Network of dolphins

Look for the triangular node!



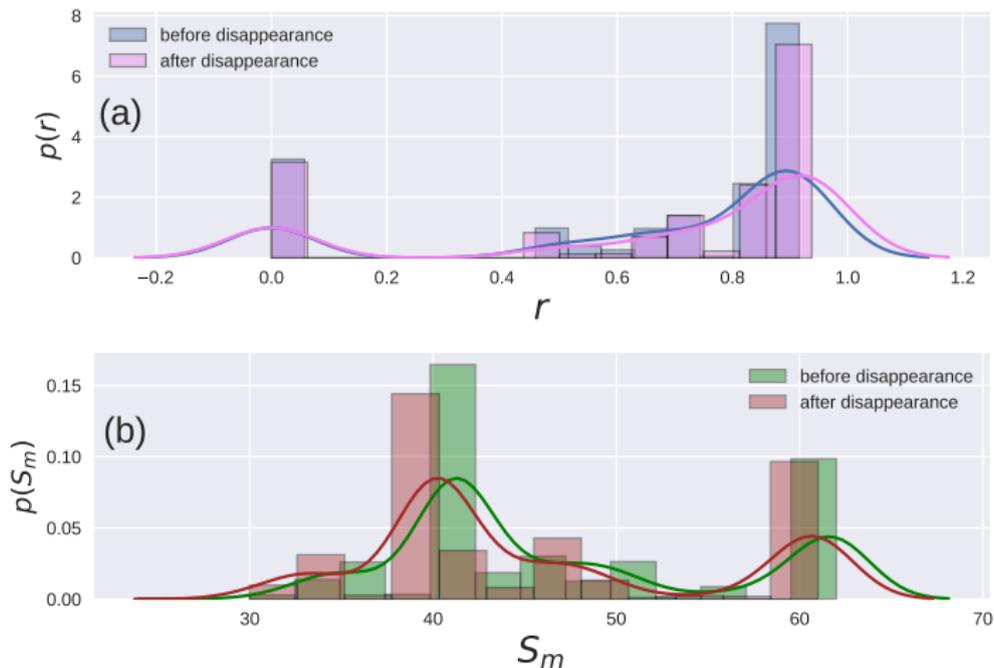
Network of dolphins

Look for the triangular node!

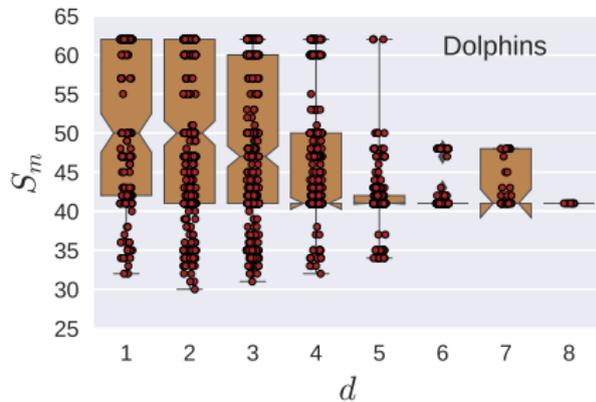
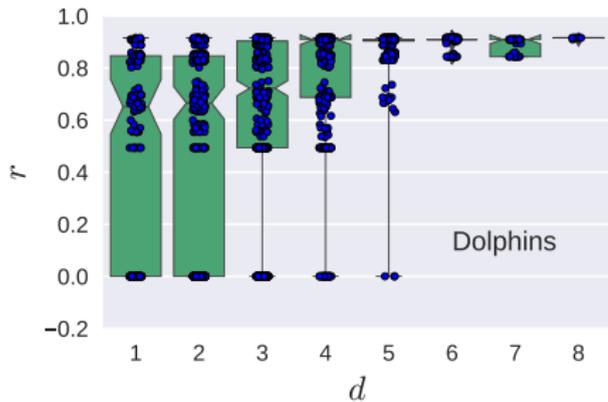
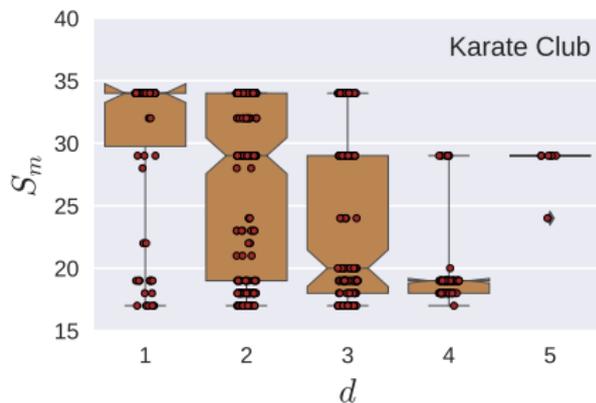
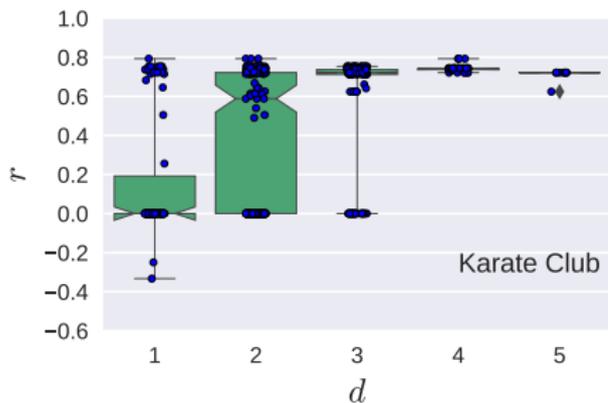


Disappearance caused splitting..

Polarization theory



Dependence on the distance between the seed nodes



- Network polarization may not be understood solely using the structure of the network
- Different initial conditions can lead to different polarized/unpolarized states in networks
- Distance between the seed nodes is a strong predictor of the network polarization

Thank You