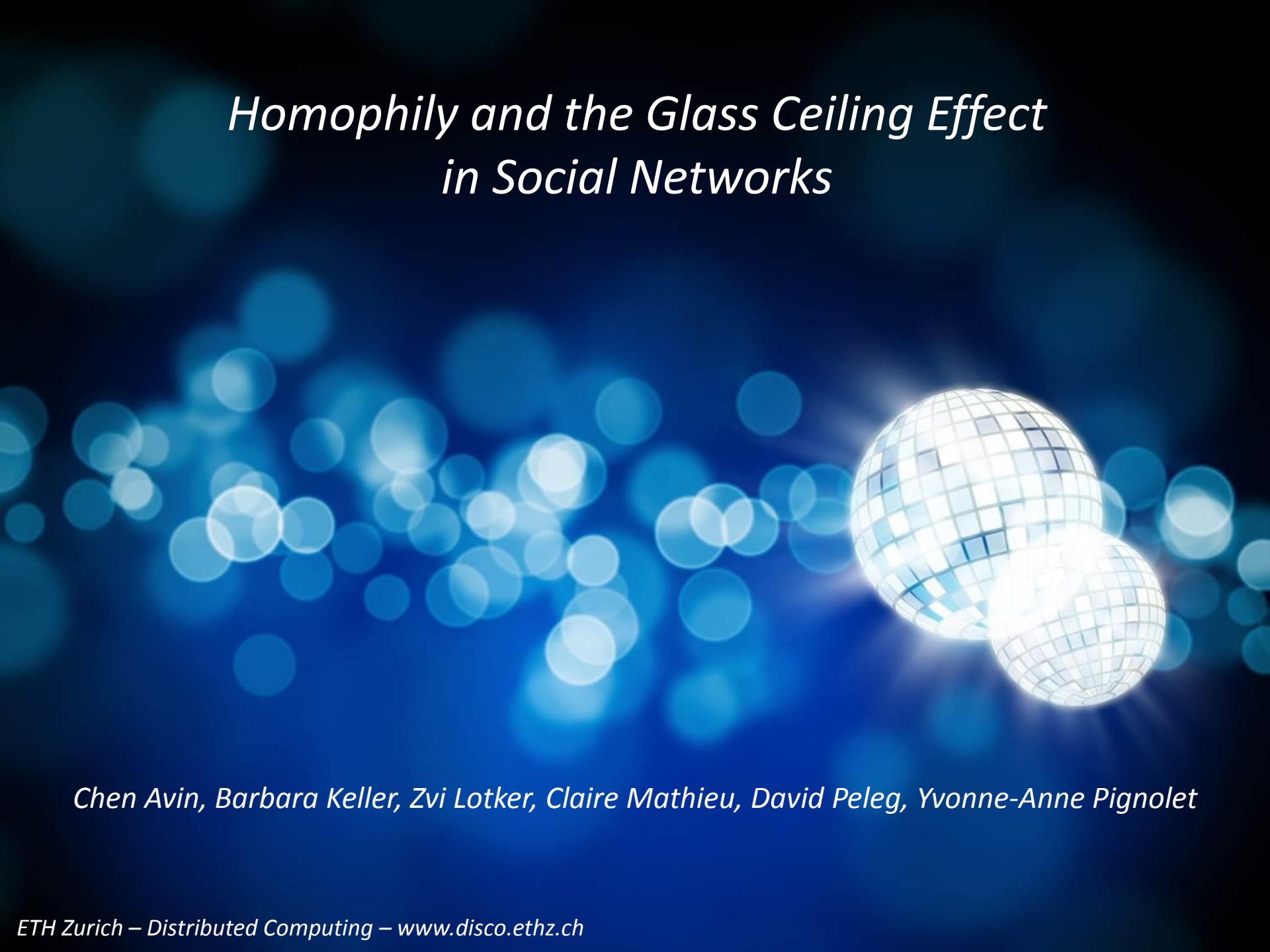
Homophily and the Glass Ceiling Effect in Social Networks

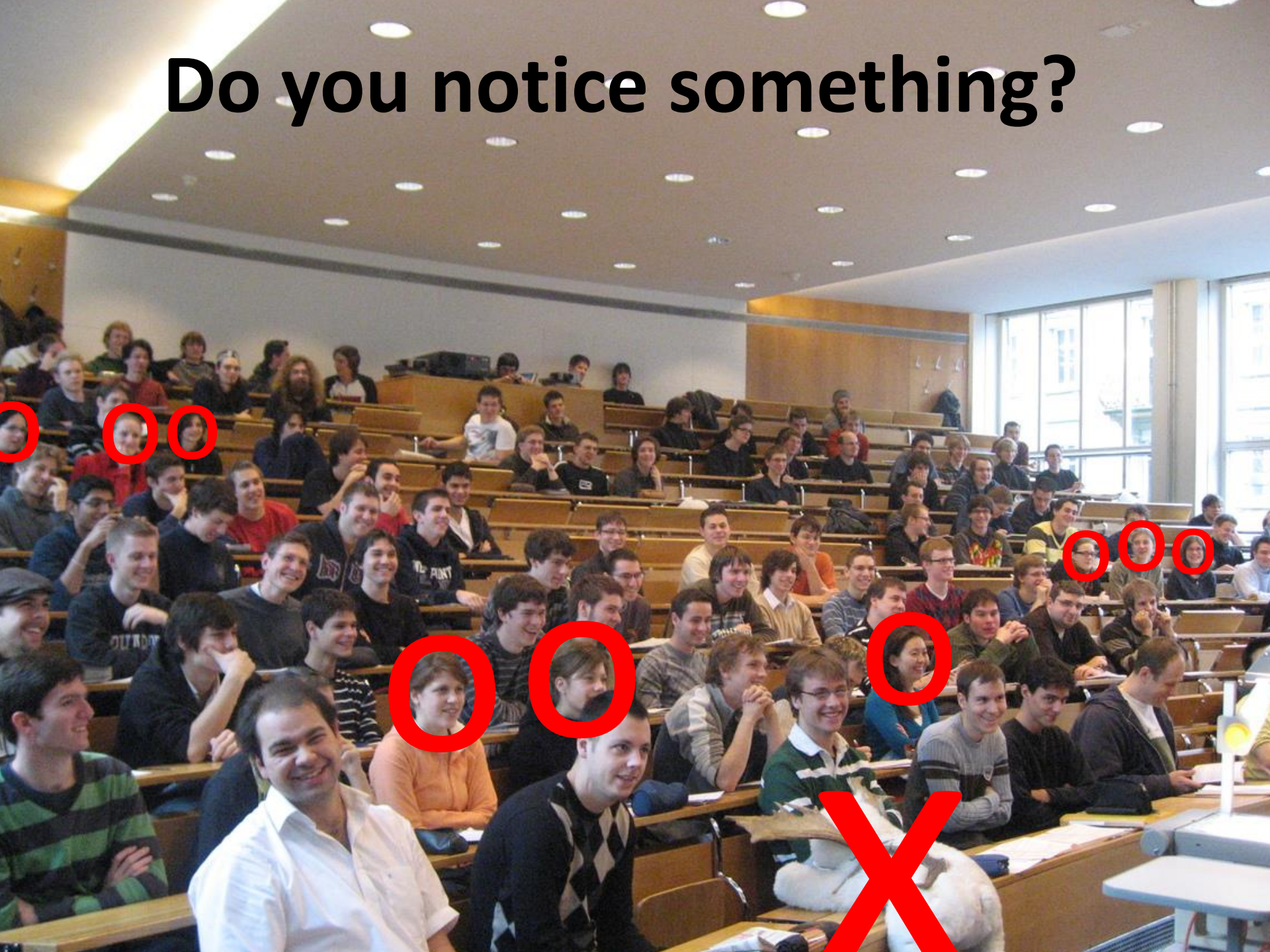


Chen Avin, Barbara Keller, Zvi Lotker, Claire Mathieu, David Peleg, Yvonne-Anne Pignolet

ETH Zurich – Distributed Computing – www.disco.ethz.ch


C 6b
am 12.06.2009

Do you notice something?

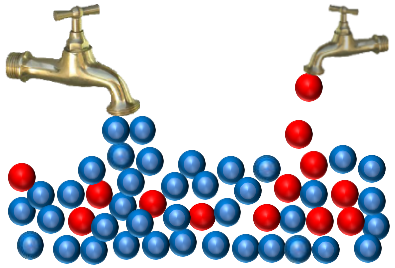


What is happening?

The "glass ceiling"... is the unseen, yet unbreakable barrier that keeps minorities and women from rising to the upper rungs of the corporate ladder, regardless of their qualifications or achievements.

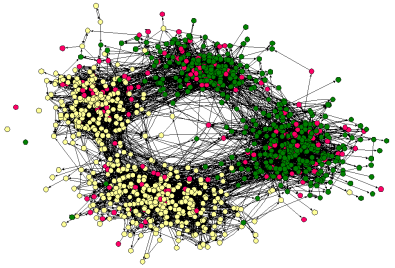
Federal Glass Ceiling Commission, US Government (1995)

PhD Students and their Advisor

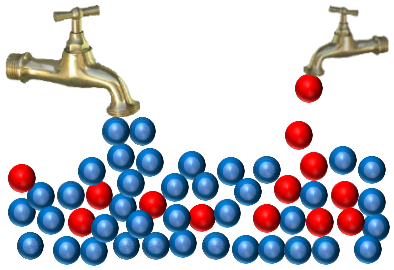


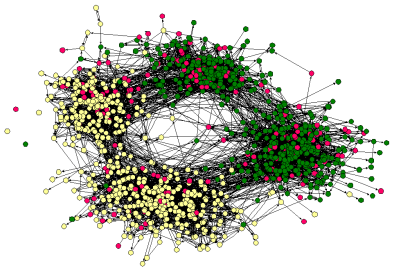
Unequal Entry Rates

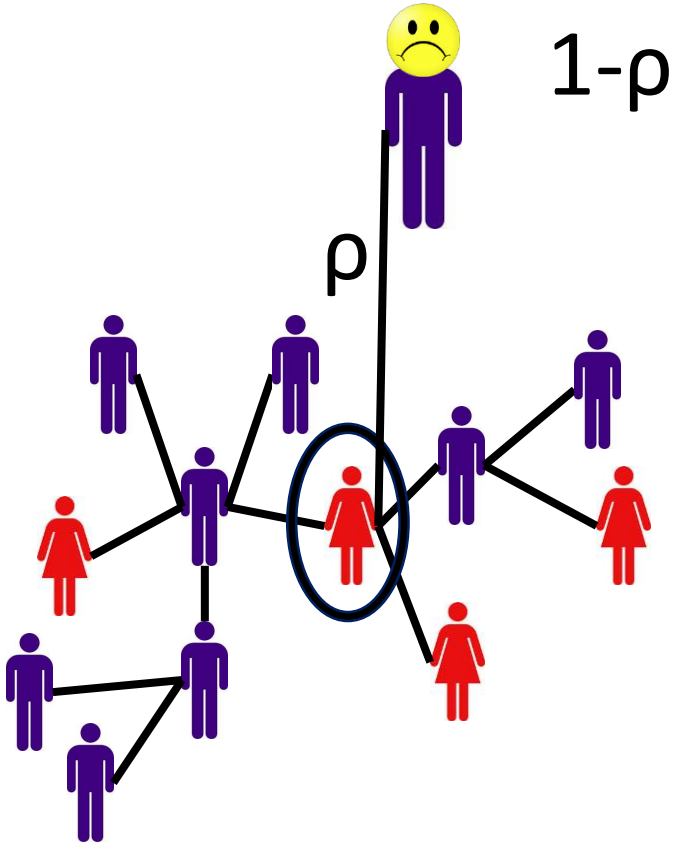
The Rich get Richer (Preferential Attachment)

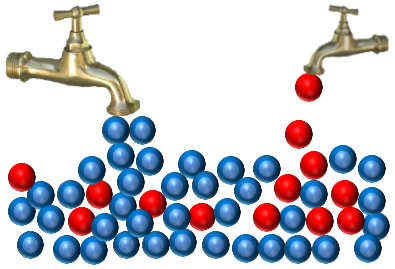


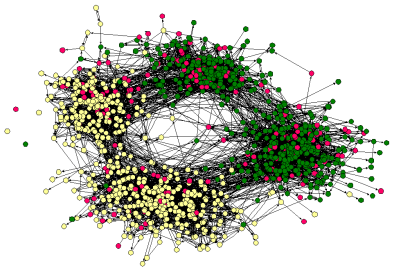
Homophily

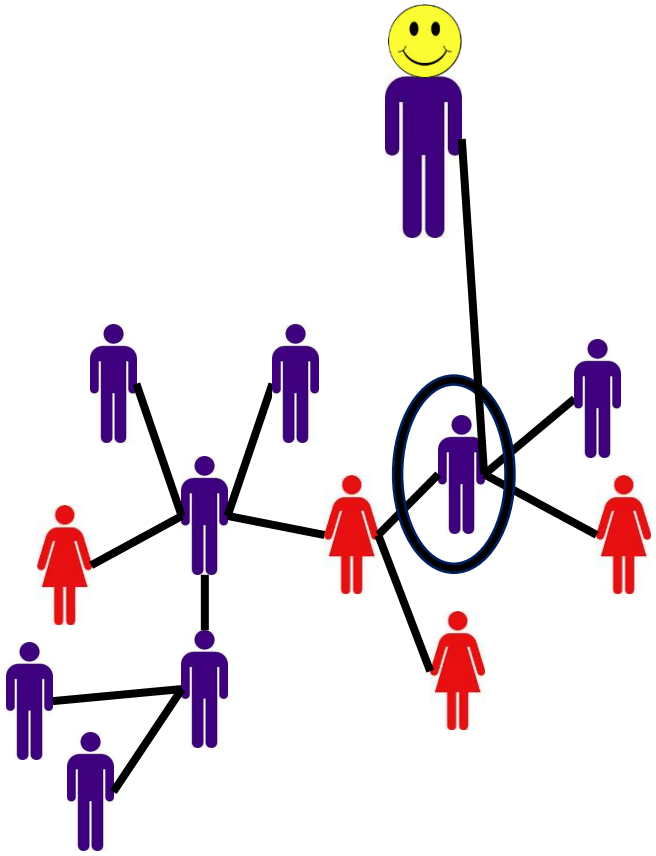





1-ρ
ρ

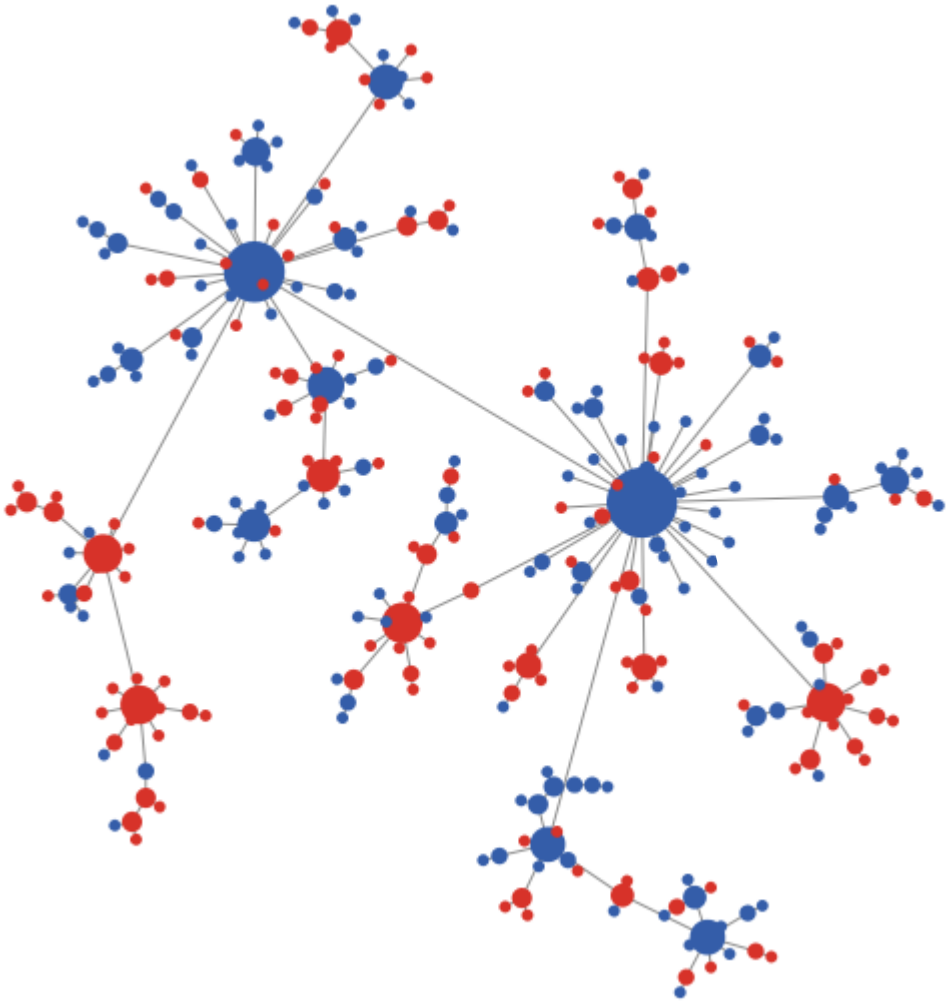






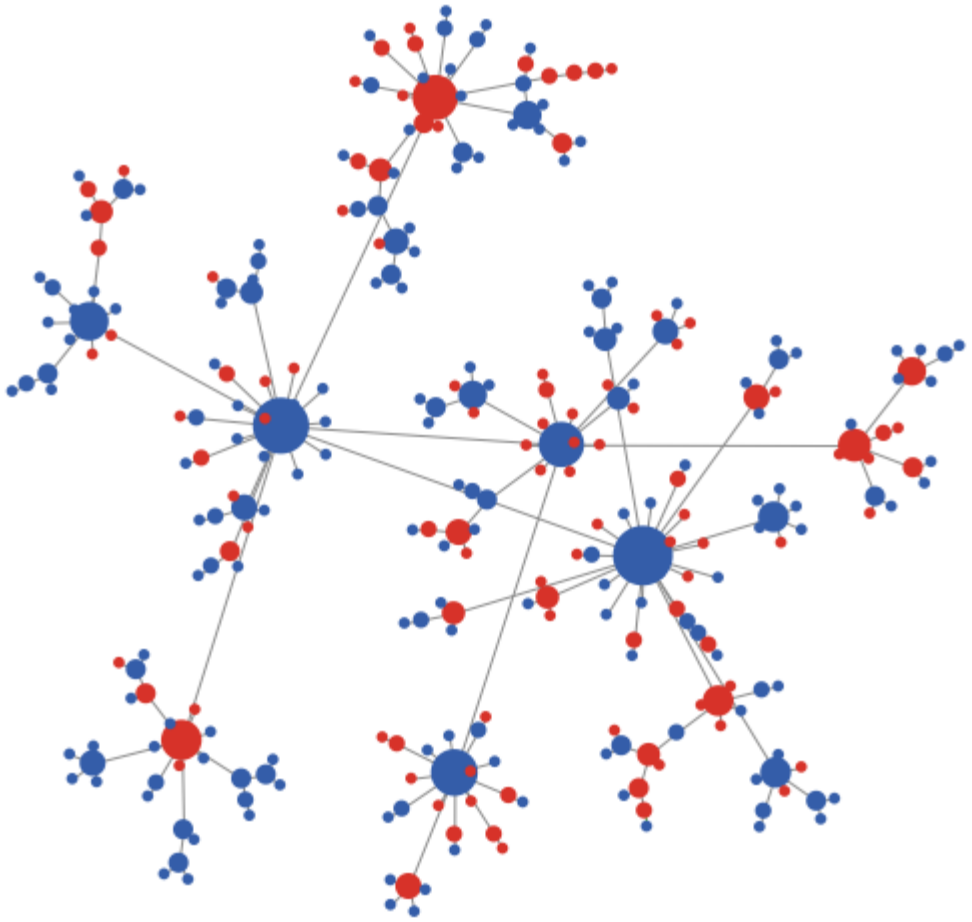
How does such a Network look like?

r = 0.5, ρ = 0.7



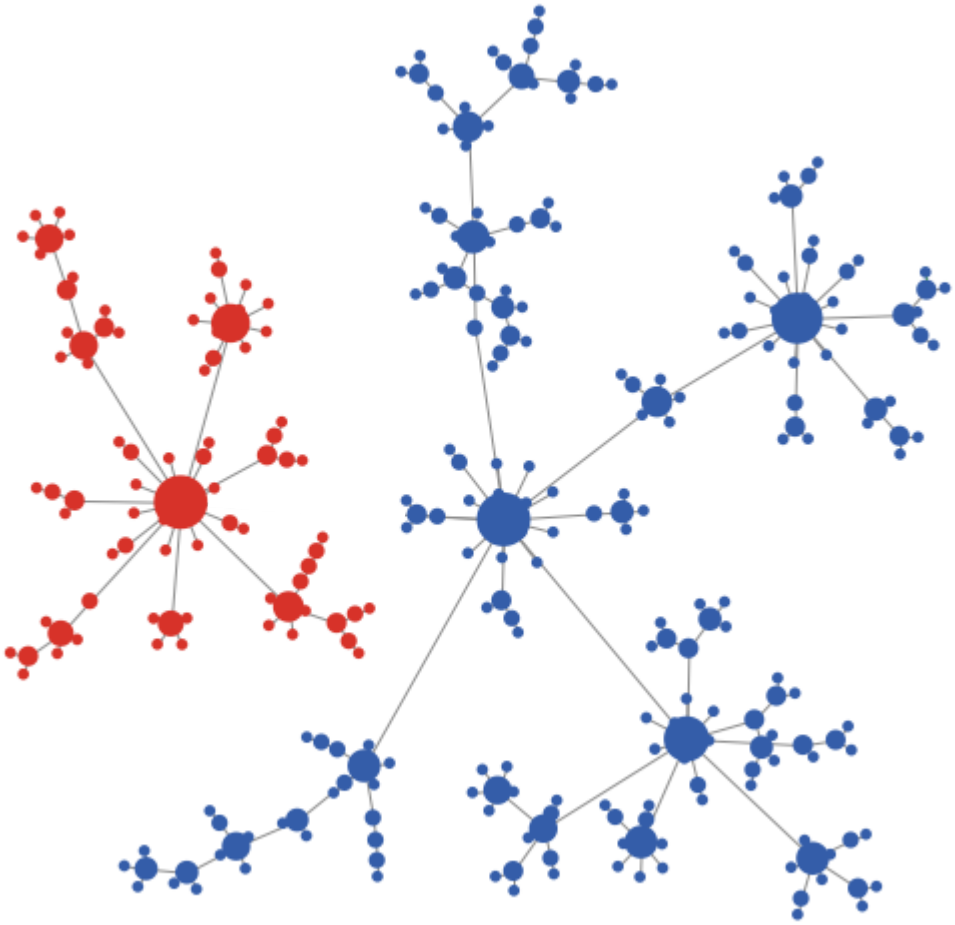
How does such a Network look like?

r = 0.3, ρ = 1



How does such a Network look like?

r = 0.3, ρ = 0



How does such a Network look like?

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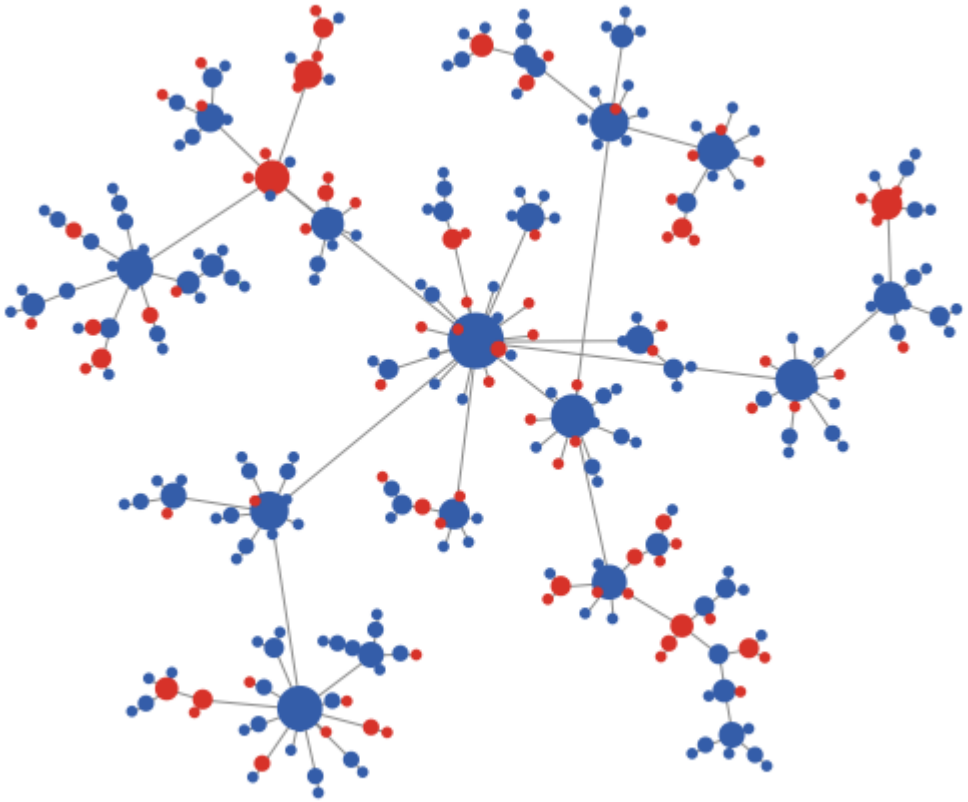
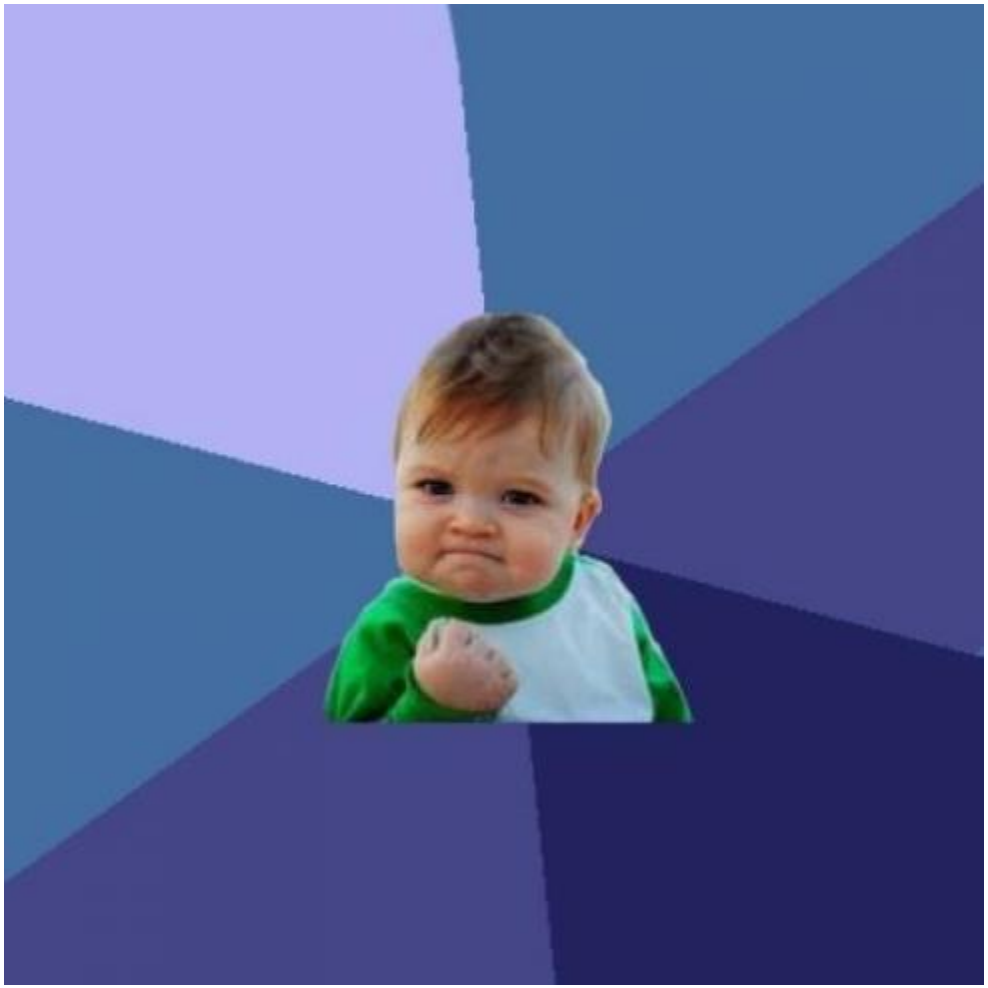
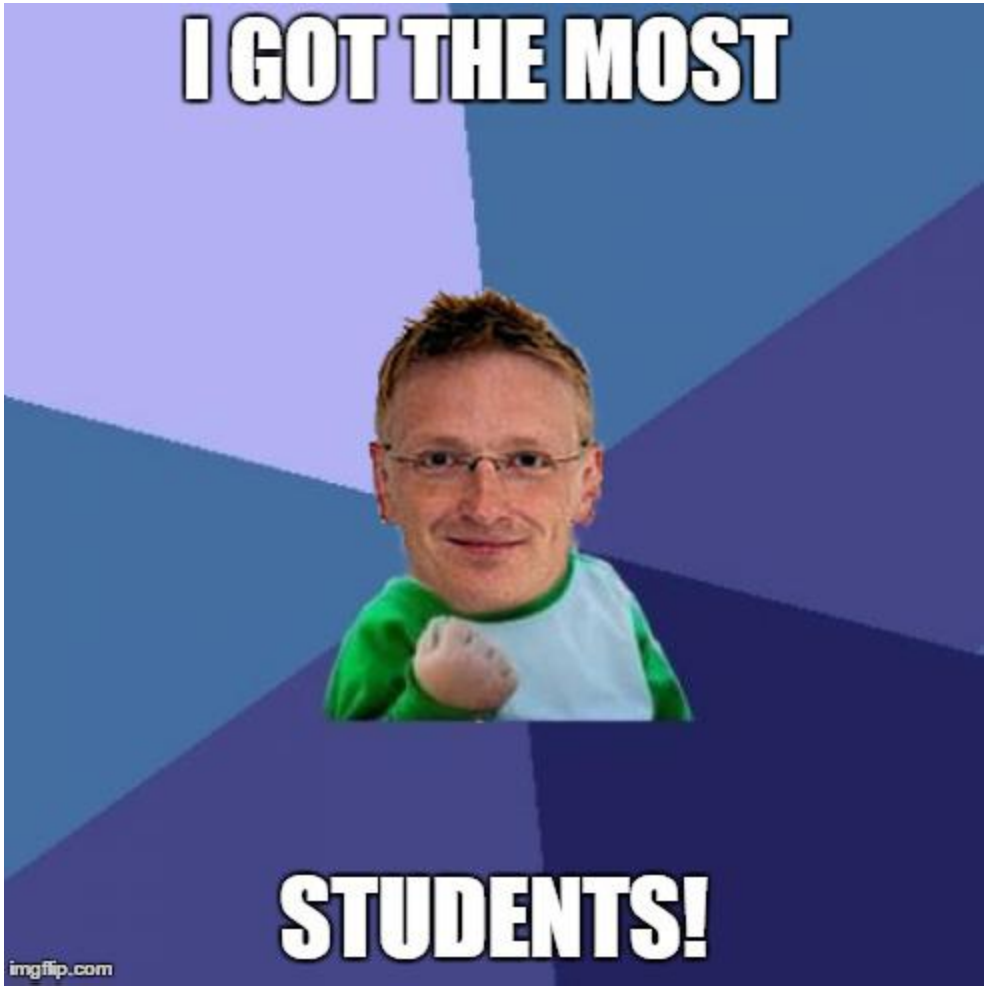


Definition of Success?



Definition of Success?



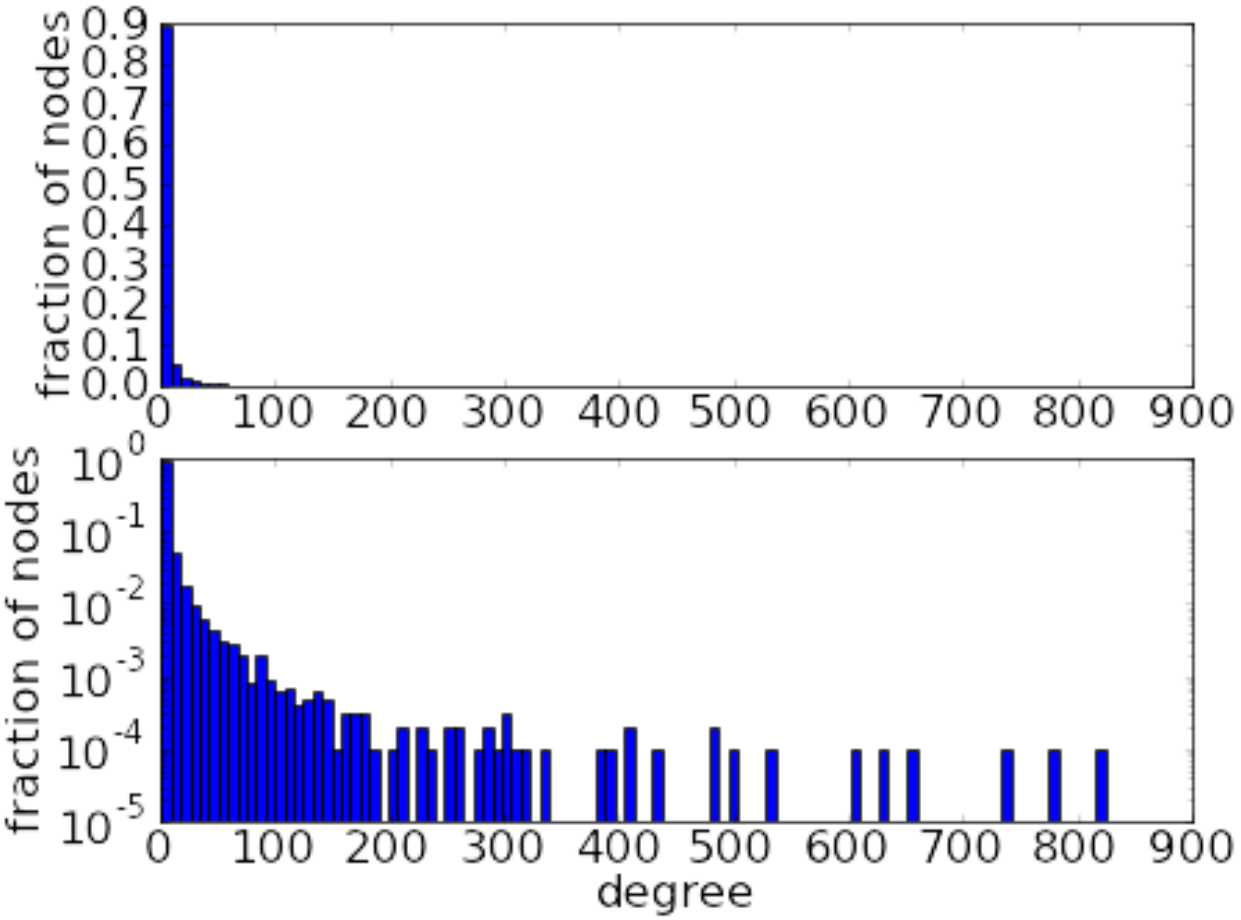
Glass Ceiling: How is it defined?

Tail glass ceiling: $G(n)$ exhibits glass ceiling effect for the red nodes if:

$$\lim_{G \to \infty} \frac{\text{top}_k(\text{R})}{\text{top}_k(\text{B})} \longrightarrow 0$$

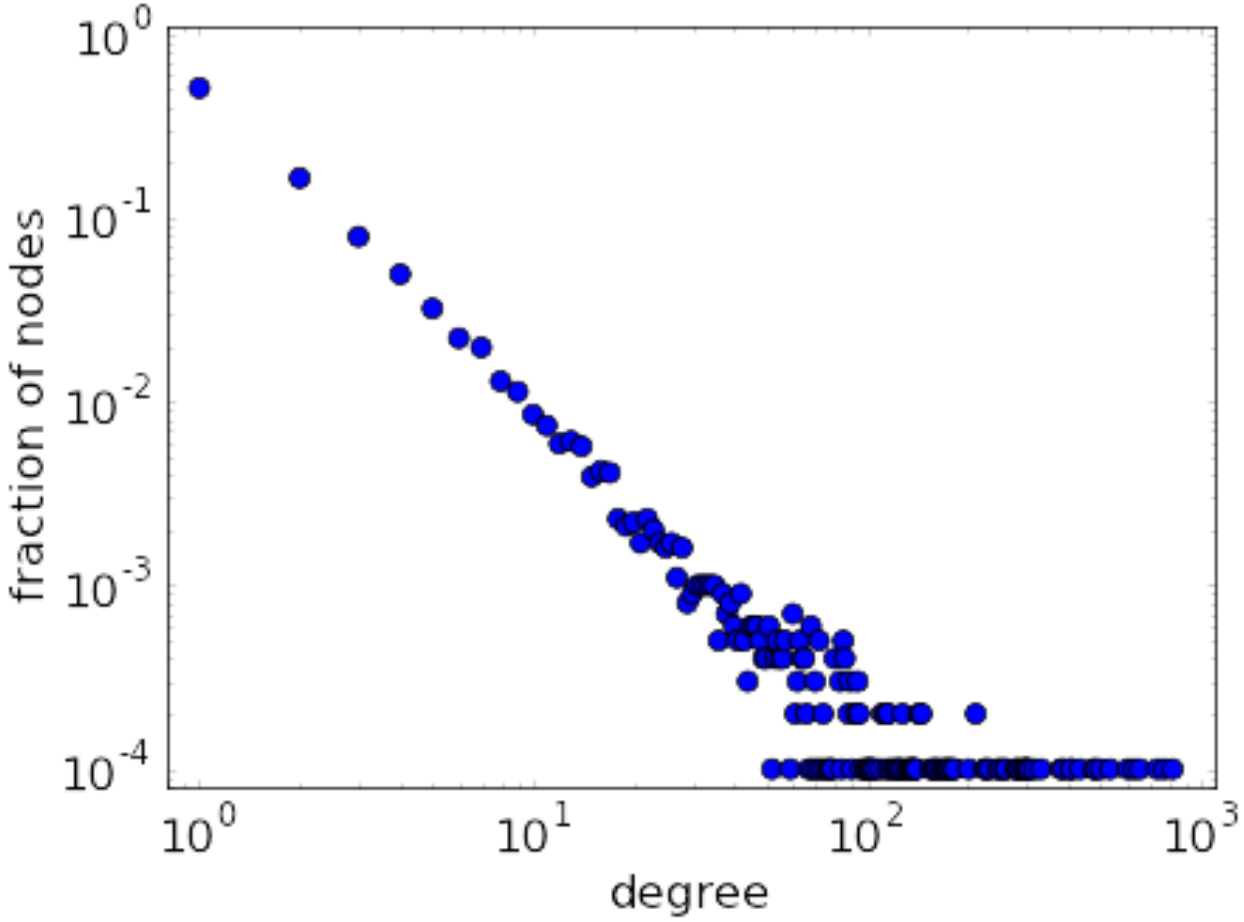
while: $\text{top}_k(\text{B}) \to \infty$

Power Law



$$P(k) \approx k^{-\beta}$$

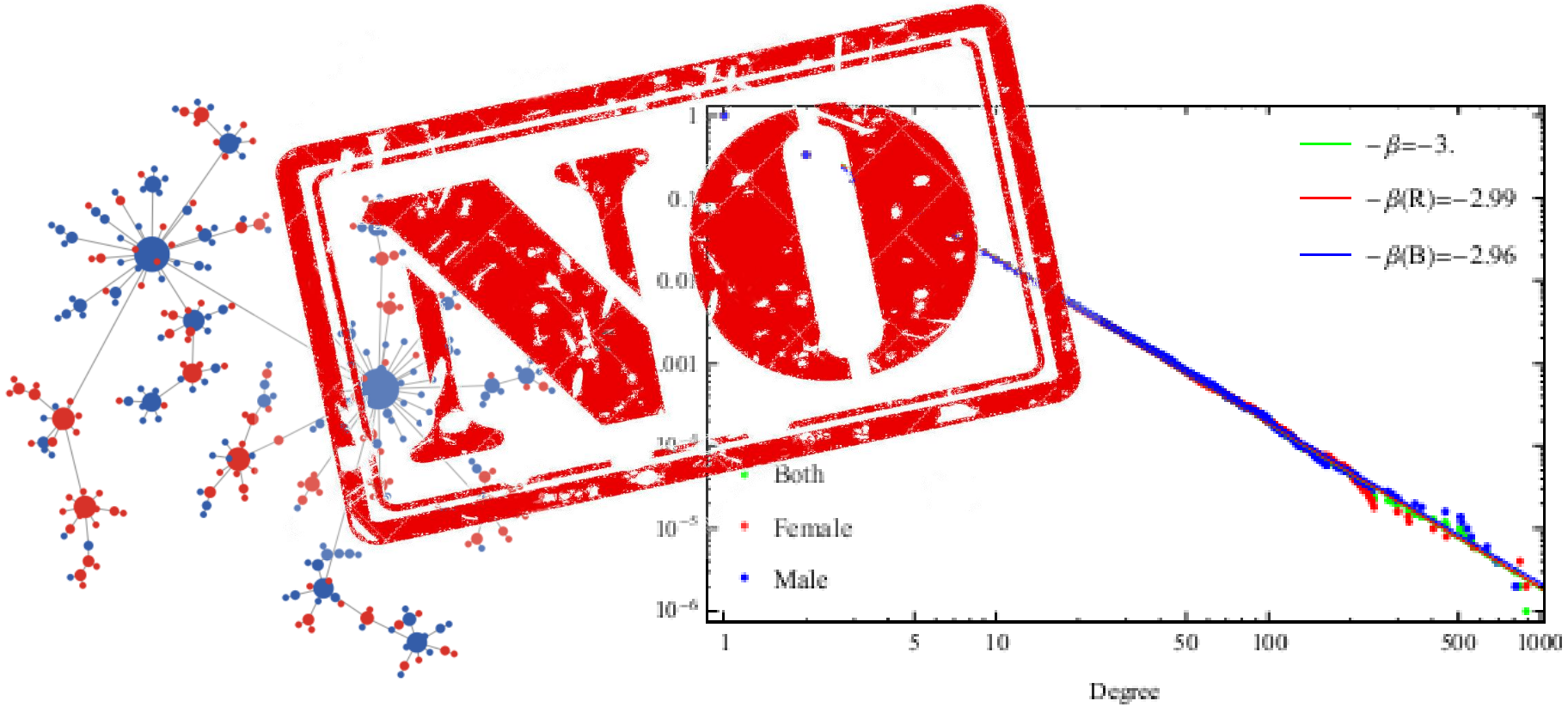
Power Law



$$P(k) \approx k^{-\beta}$$

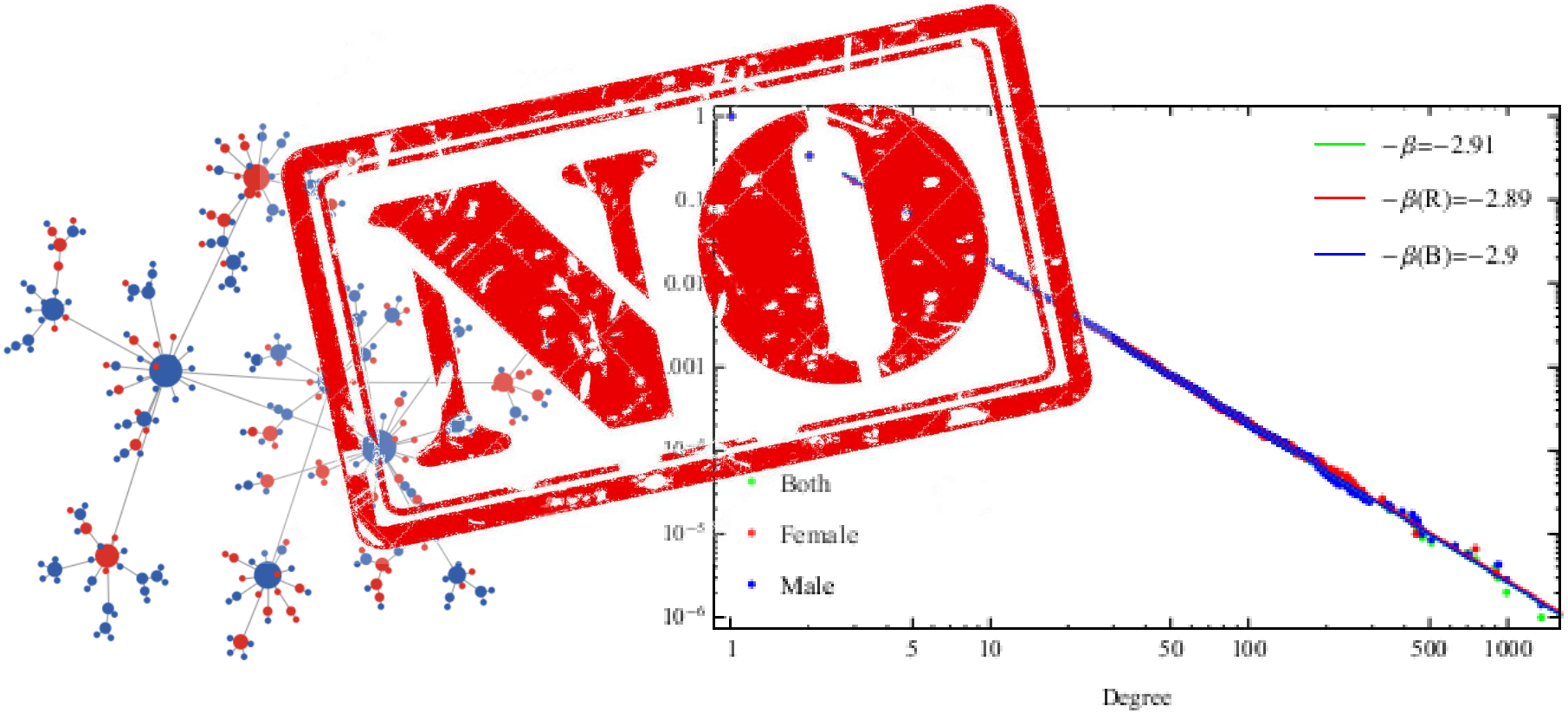
Does this Produce a Glass Ceiling?

r = 0.5, ρ = 0.7



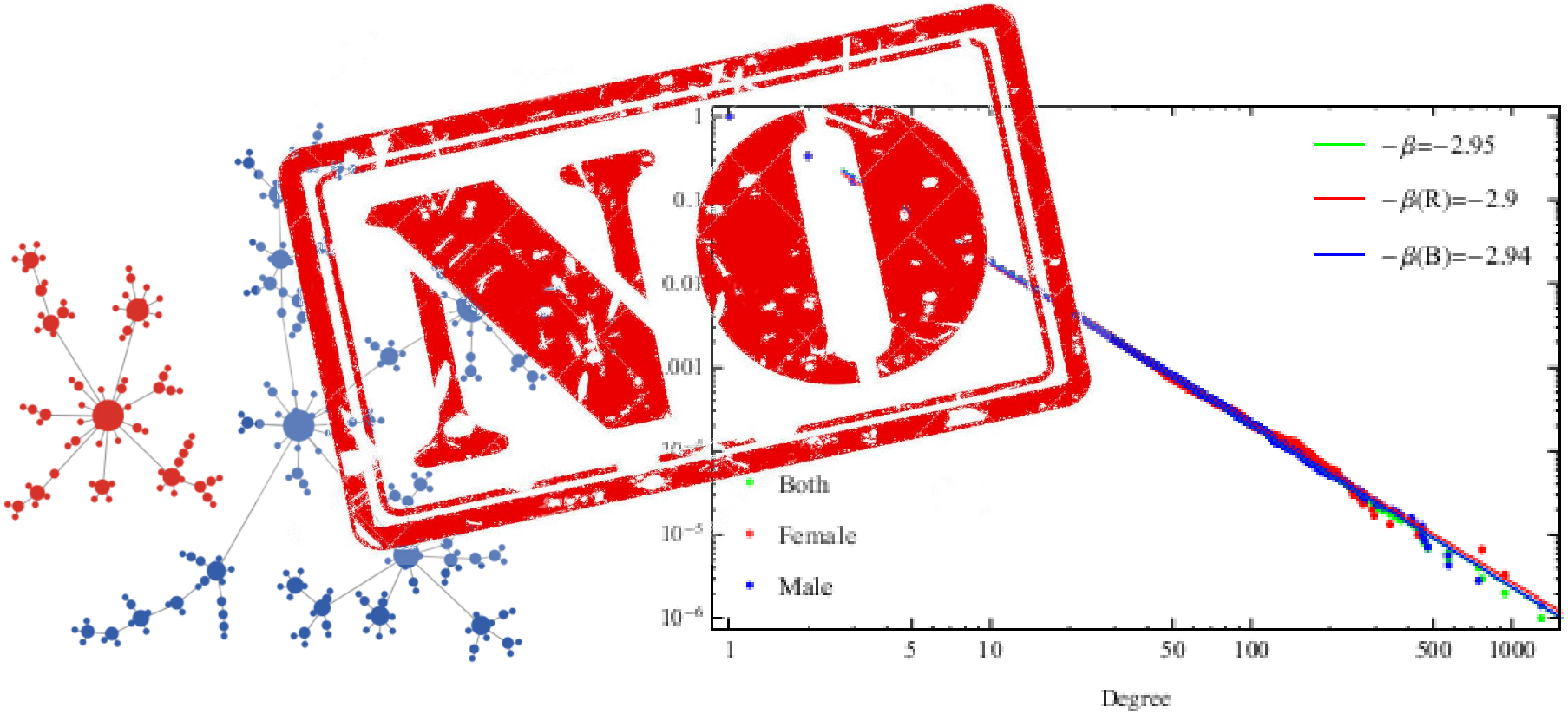
Does this Produce a Glass Ceiling?

r = 0.3, ρ = 1



Does this Produce a Glass Ceiling?

r = 0.3, ρ = 0



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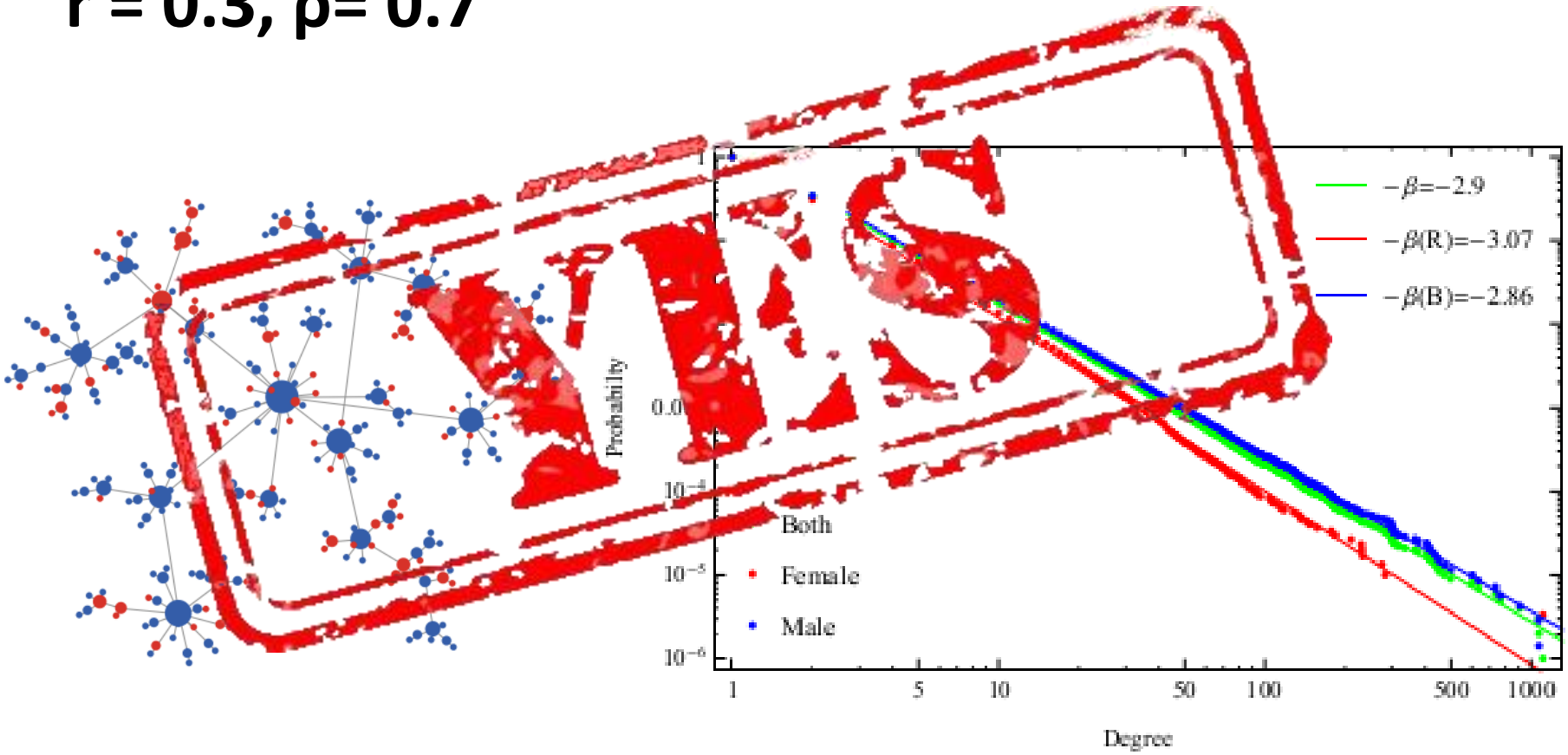


Formal Results

Theorem:

Let $0 < r < ½$ and $0 < \rho < 1$ then $G(n, r, \rho)$ exhibits a **glass ceiling** effect (for any starting condition).

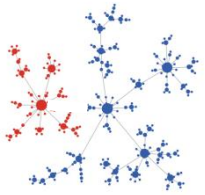
Formal Results

Theorem:

G(n, r, ρ) will **not** have glass ceiling effect in the following cases:

1. If the rate r = ½ (and for any value of ρ).

2. If ρ = 0 or ρ =1 (and for any value of r).

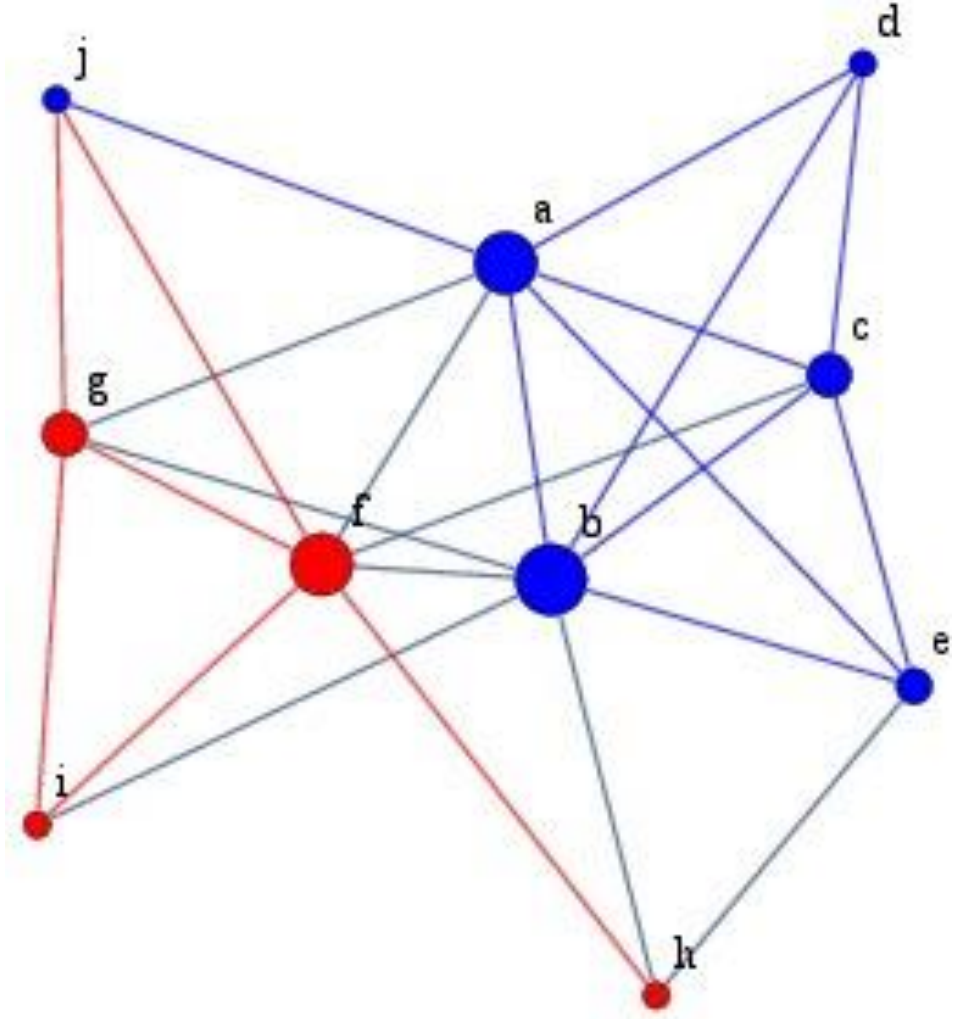


3. If a new vertex at time t selects its advisor uniformly at random from all nodes at time t-1 (and for any value of r and ρ).

Power Inequality

Power Inequality

$$\lim_{n\to\infty} \frac{\frac{1}{n(\mathtt{R})}\sum_{v\in\mathtt{R}}\delta(v)}{\frac{1}{n(\mathtt{B})}\sum_{v\in\mathtt{B}}\delta(v)} = \frac{d(\mathtt{R})/n(\mathtt{R})}{d(\mathtt{B})/n(\mathtt{B})} \leq c$$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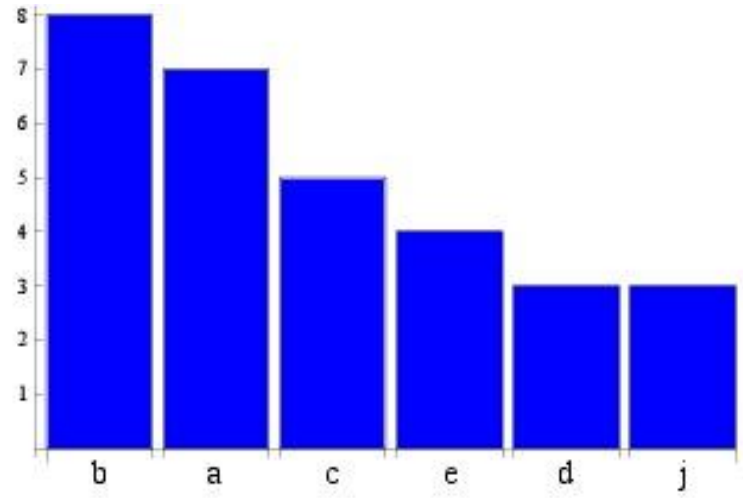
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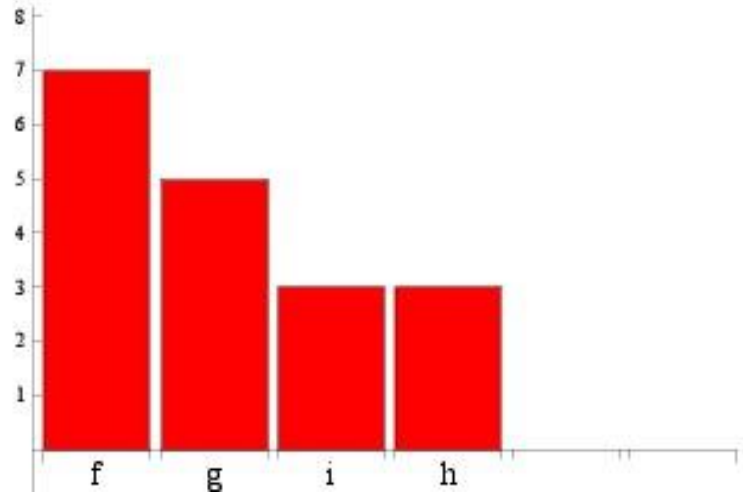
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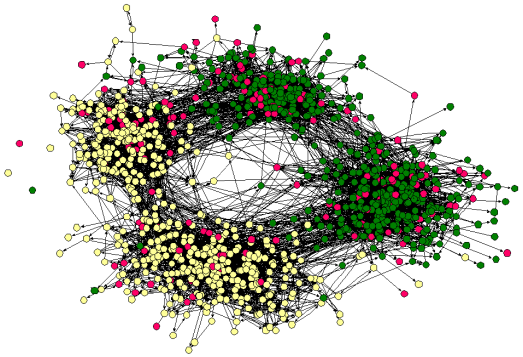
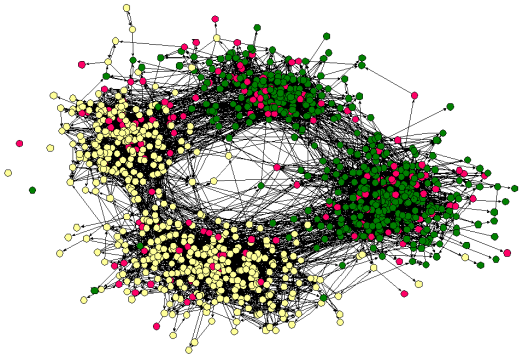


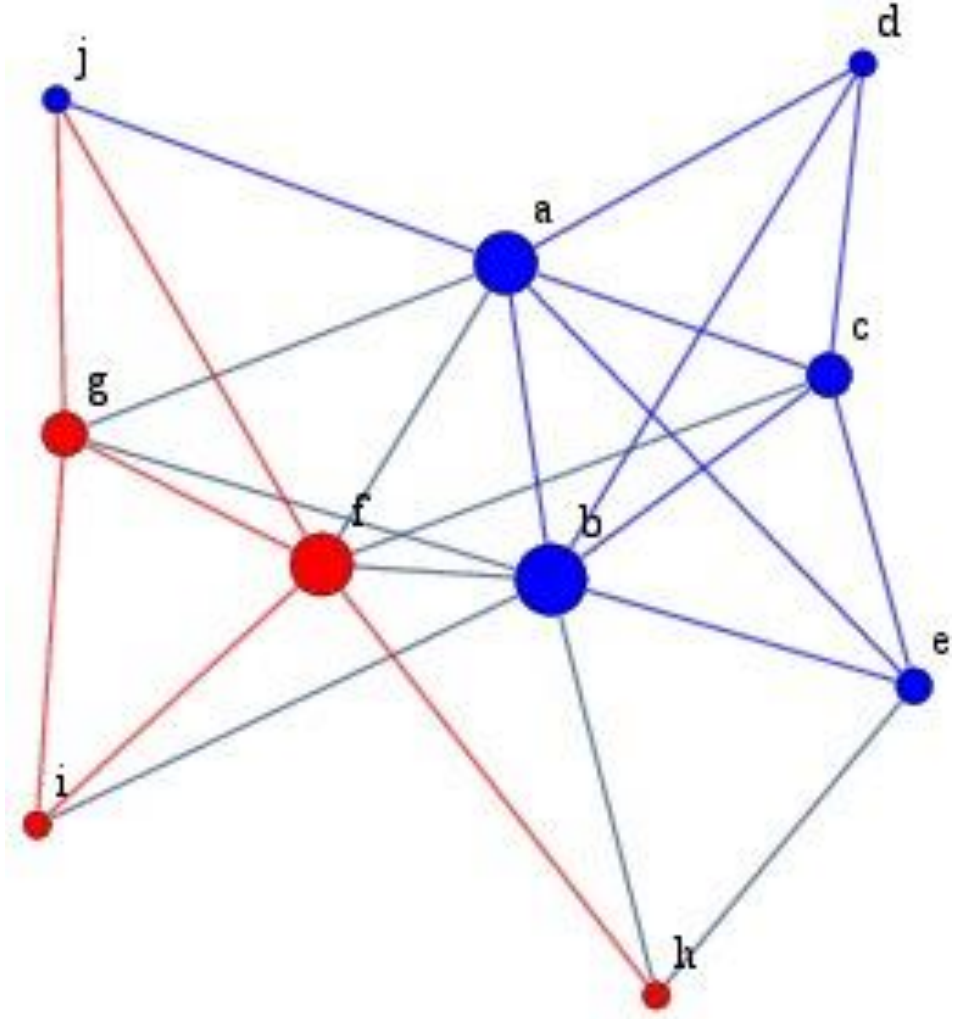
Homophily-Test

$$\frac{\#mixed\ edges}{\#all\ edges} \ll 2\mathrm{r} \cdot (1 - r)$$



Homophily-Test with PI

$$\frac{\#mixed\ edges}{\#all\ edges} \ll 2\,\frac{d(R)}{2m} \cdot \left(1 - \frac{d(R)}{2m}\right)$$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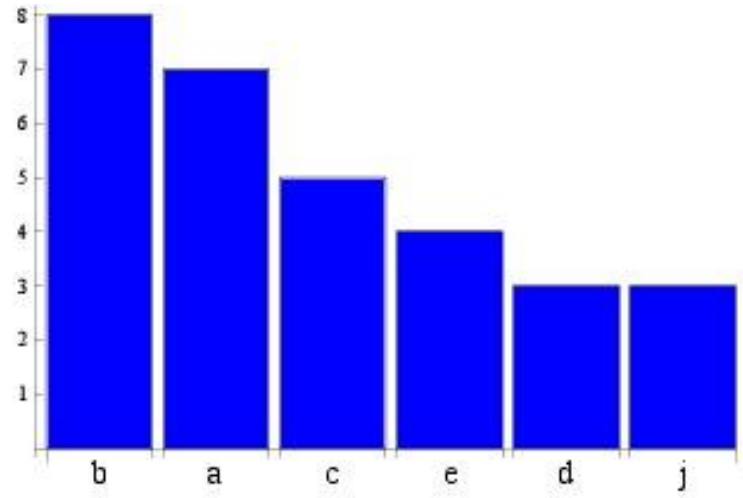
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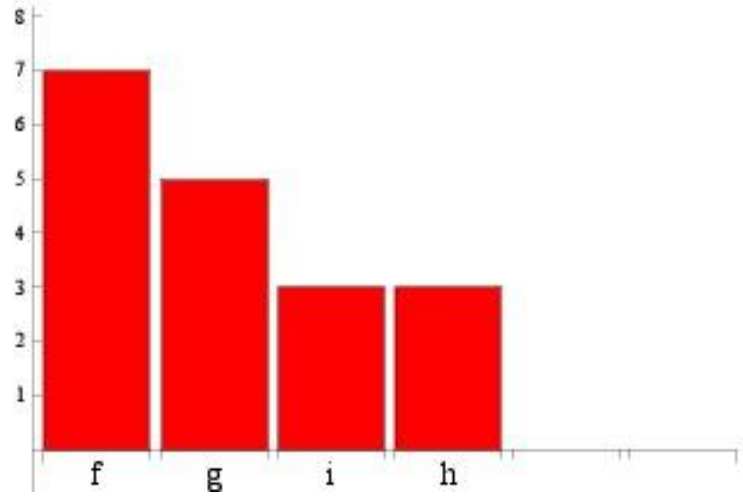
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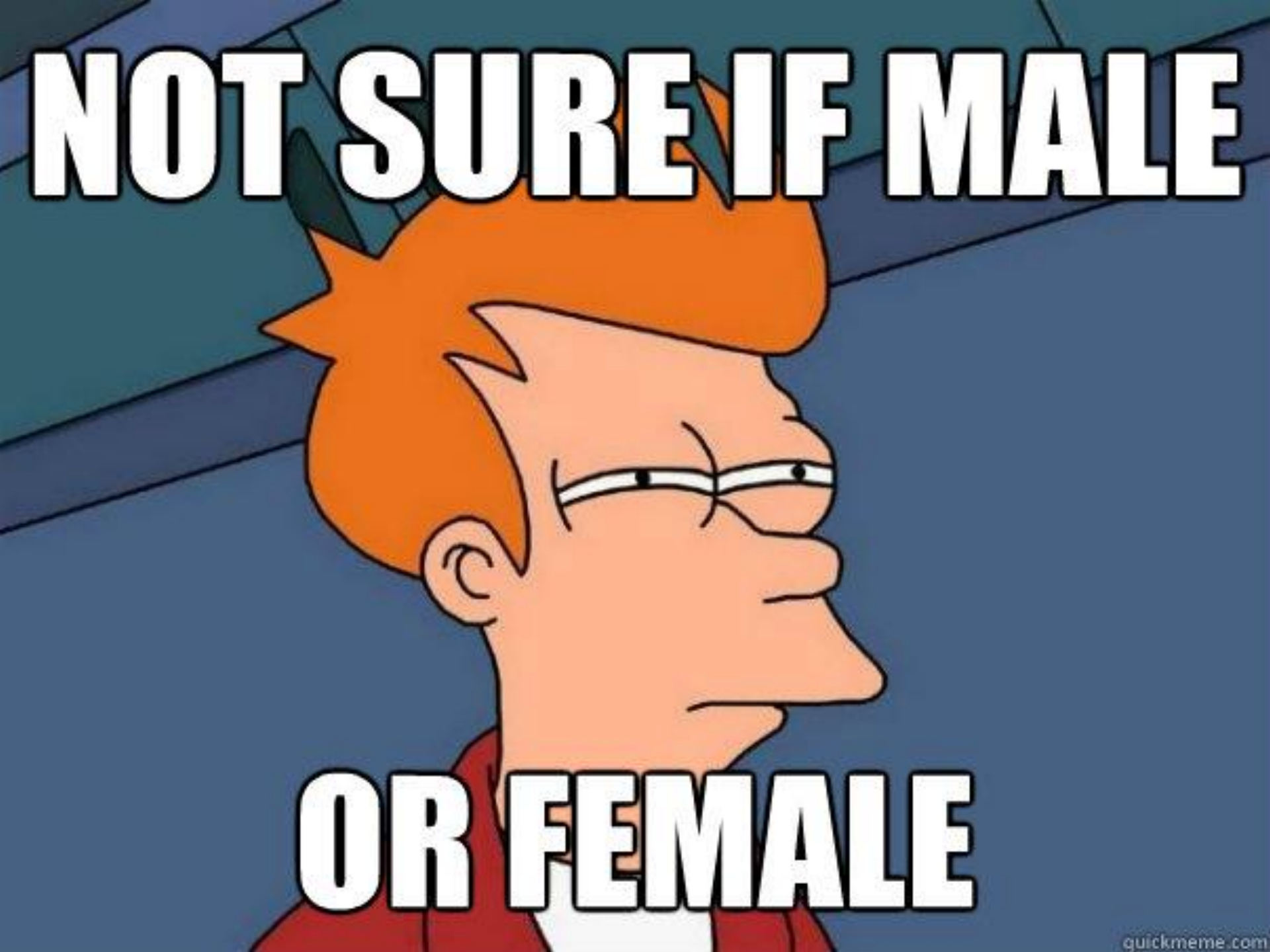
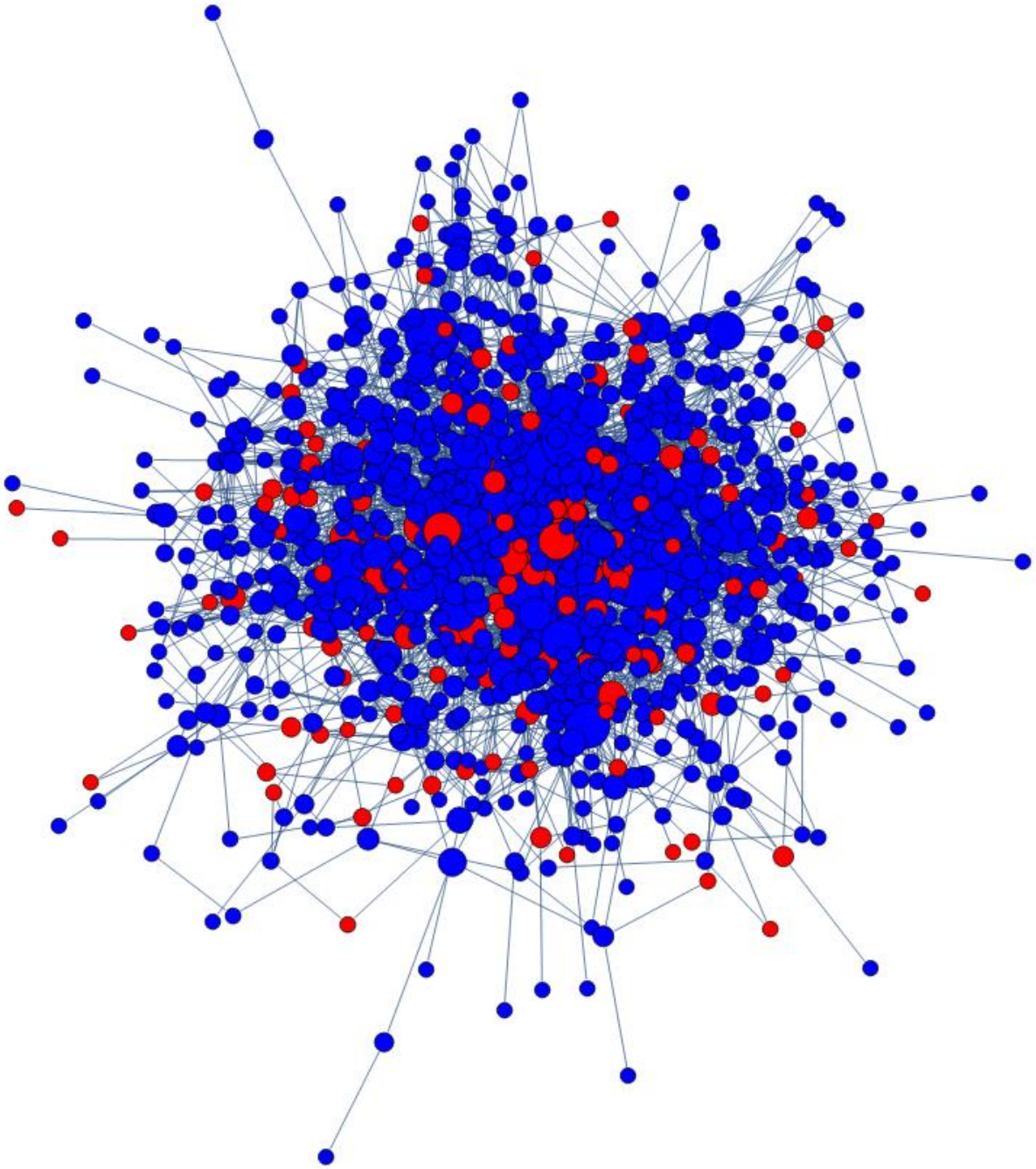
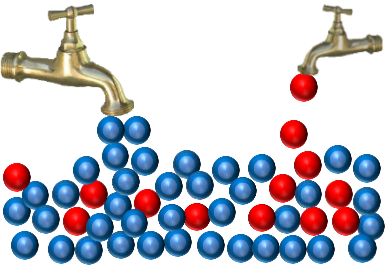
Where to get Data?


NOT SURE IF MALE
OR FEMALE
quickmeme.com

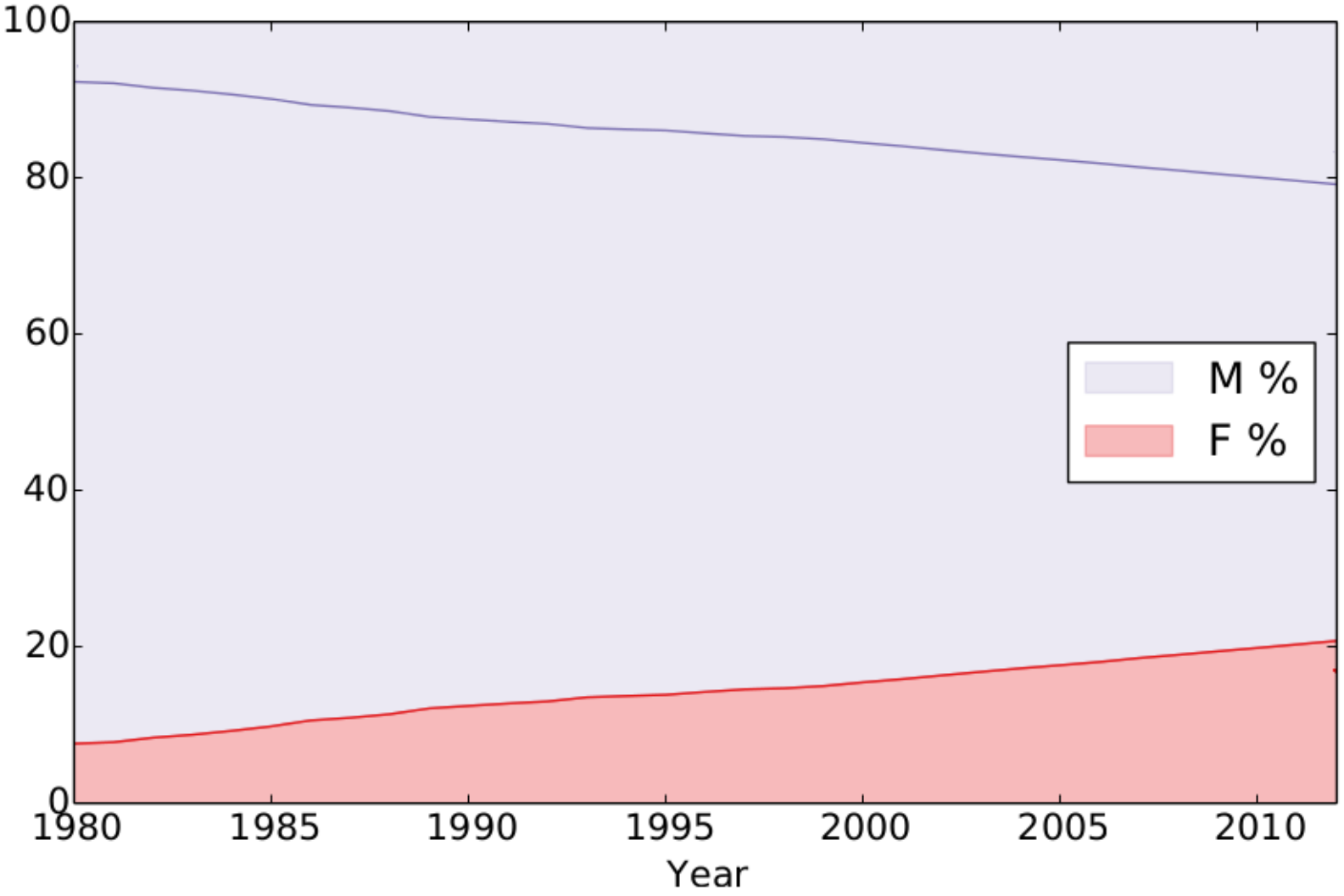
Who’s your Professor?

DBLP top players graph

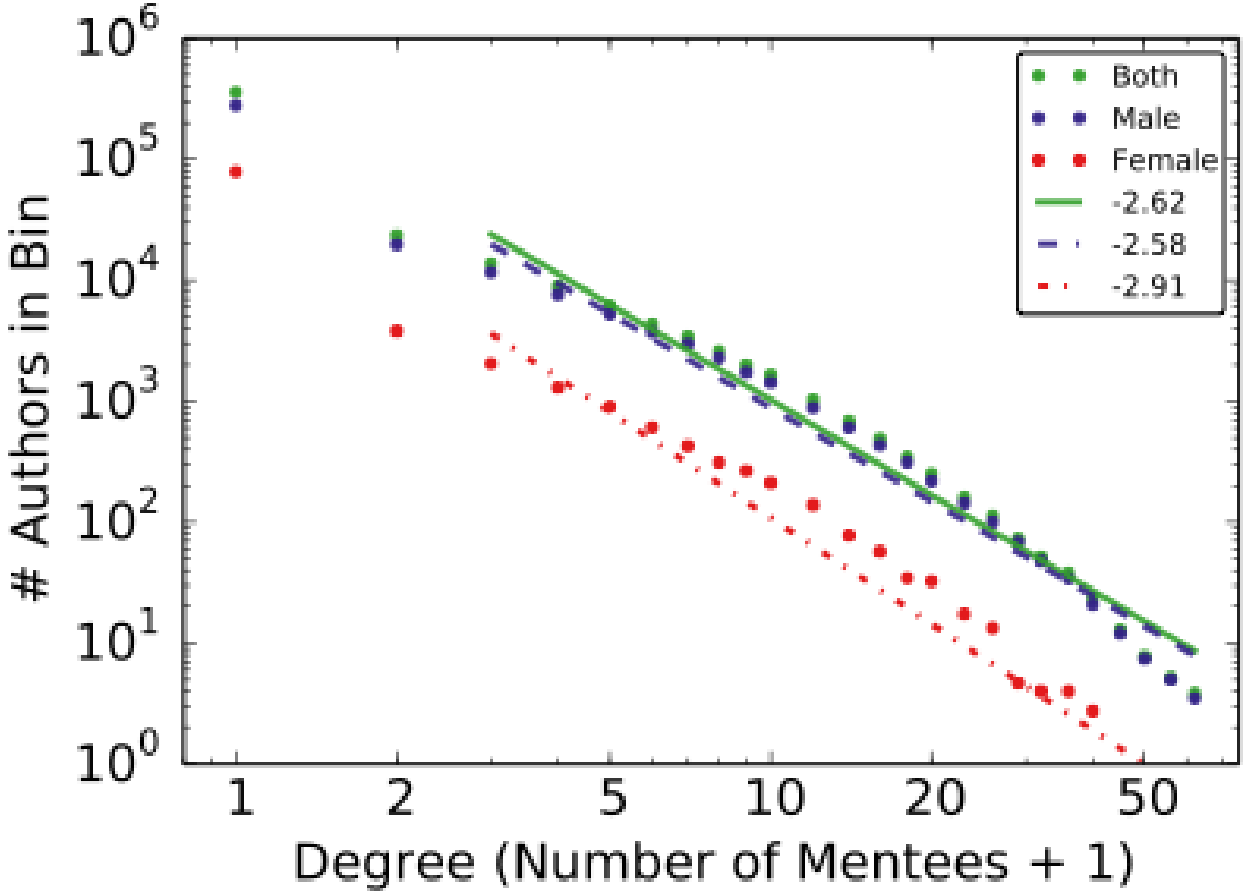


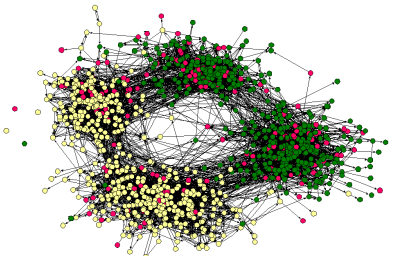


Unequal Entry Rate

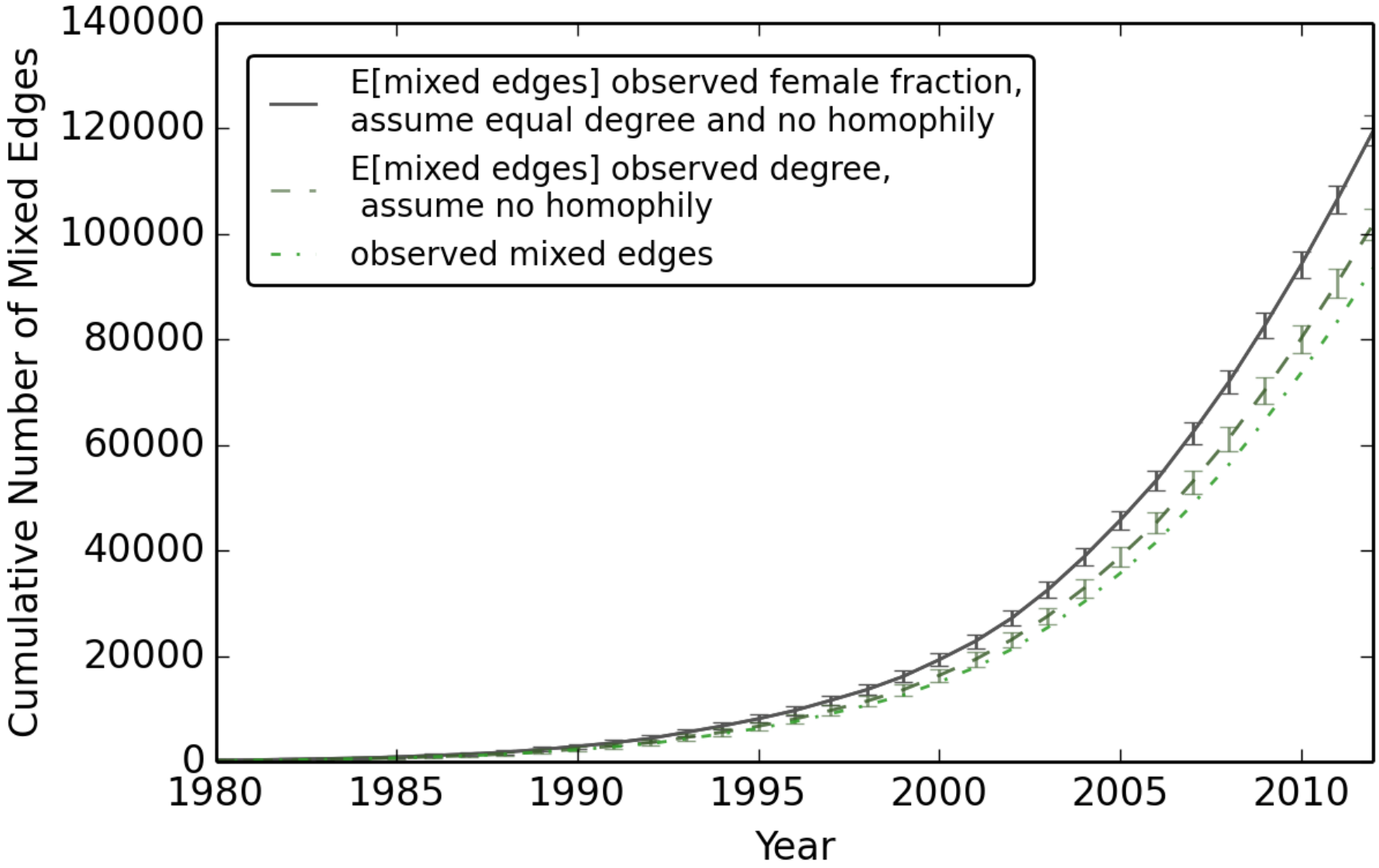


The Rich get Richer

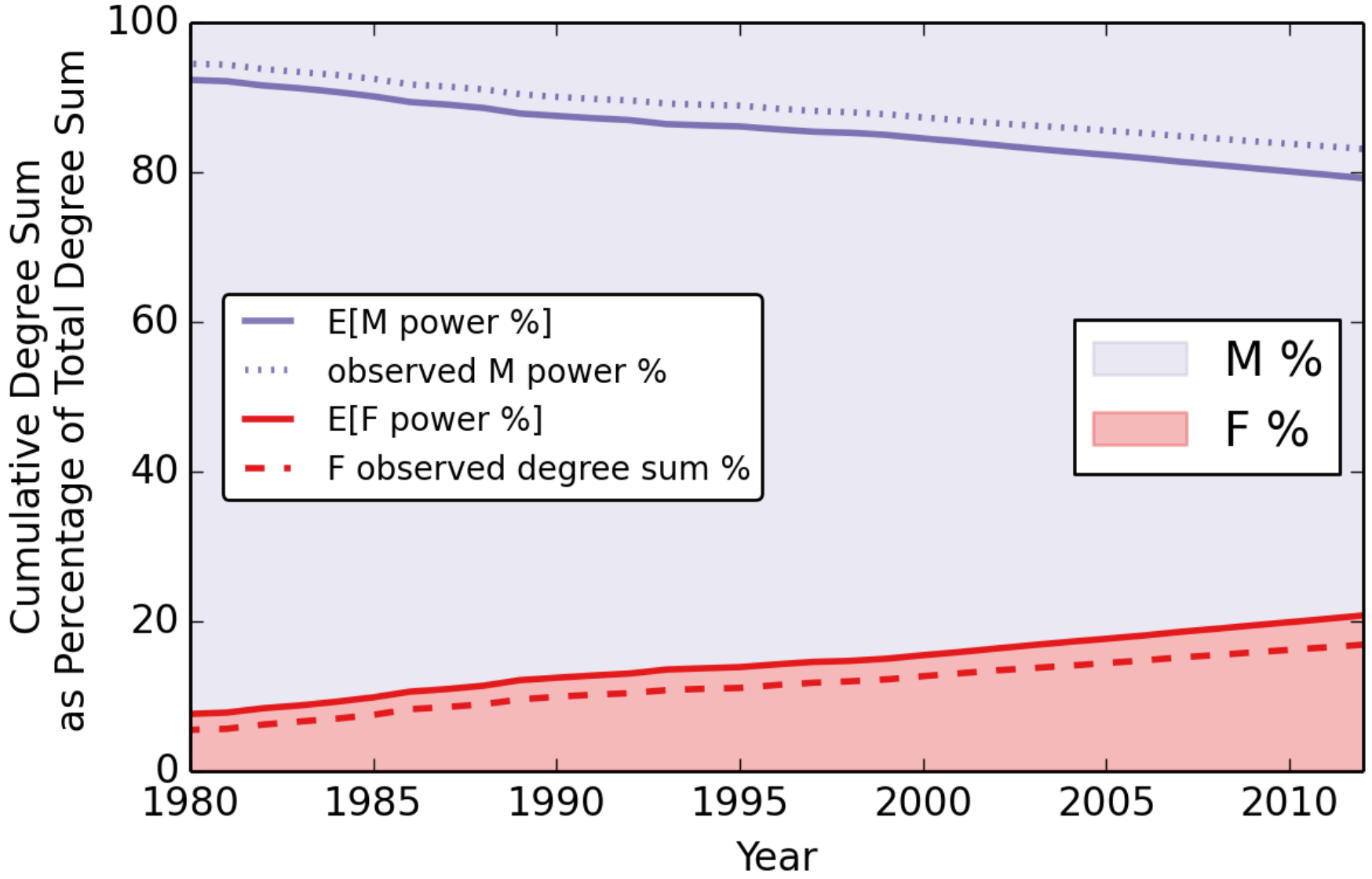




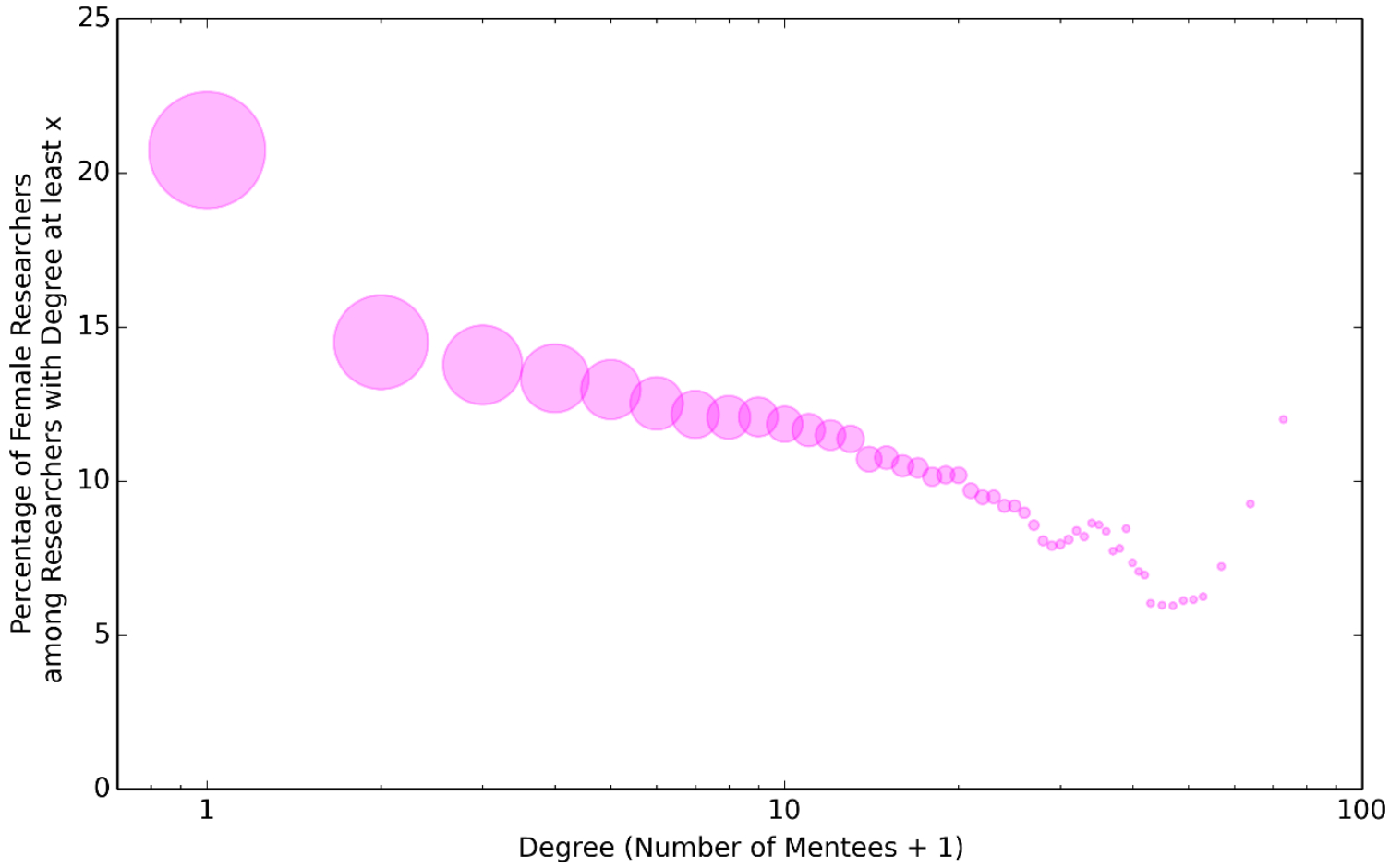
Homophily


E[mixed edges] observed female fraction, assume equal degree and no homophily
E[mixed edges] observed degree, assume no homophily
observed mixed edges
Cumulative Number of Mixed Edges
0
20000
40000
60000
80000
100000
120000
140000
1980
1985
1990
1995
2000
2005
2010
Year

Power Inequality



The Glass Ceiling



Summary

1. Definitions for glass celling effect in networks
2. Simple mathematical model:
   - Unequal entry rate, “rich get richer”, homophily
3. Proof for glass ceiling emergence
   - three assumptions → glass ceiling
   - any two assumptions → no glass ceiling.
4. Analyzed a PhD student mentor network

Future Work

- Include nodes leaving the network
- Evaluate network with higher percentage of females

Merci!