

*Summer School on Data Science*

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# CRIMINOPHYSICS

## THE PHYSICS OF CRIME

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Brazilian Federal Police Officer*

*Rio de Janeiro, 11 Feb 2020*



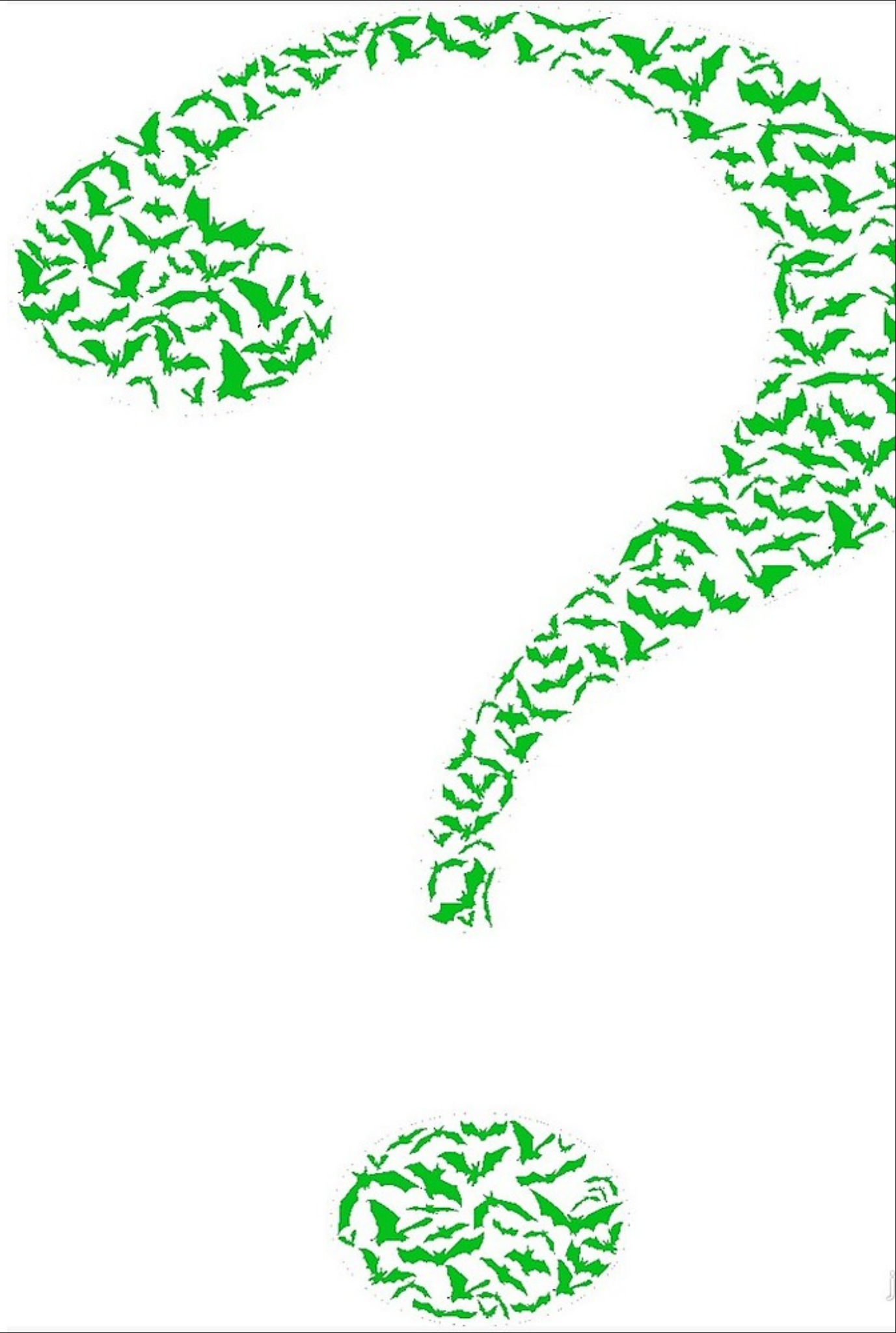
*What is data science?*

*What is crime?*

*What is science?*

*What is physics?*

*What is criminophysics?*



# MOTIVATION

*Crime is a complex phenomenon that depends non-linearly on different variables.*

*However, mathematical regularities in the social world and in collective human action are robust with observation - Nicholas Kaldor (1908–86).*

*Sociological literature supports network science.*





# MOTIVATION

*David Hume (1711-76): A Treatise of Human Nature*

*Adolphe Quetelet (1796–1874): Essays on Social Physics*

*Auguste Comte (1798–1857): Introduction to positive philosophy*





# MOTIVATION

- *Celular automata x Social segregation*
- *Magnetism x Opinion dynamics*
- *Epidemics and spreading phenomena*
- *Chaos x Emergent behavior*
- *Criminal hotspots x Attraction fields*
- *Game theory x social dilemma*
- *Criminal networks x graph/network theory*



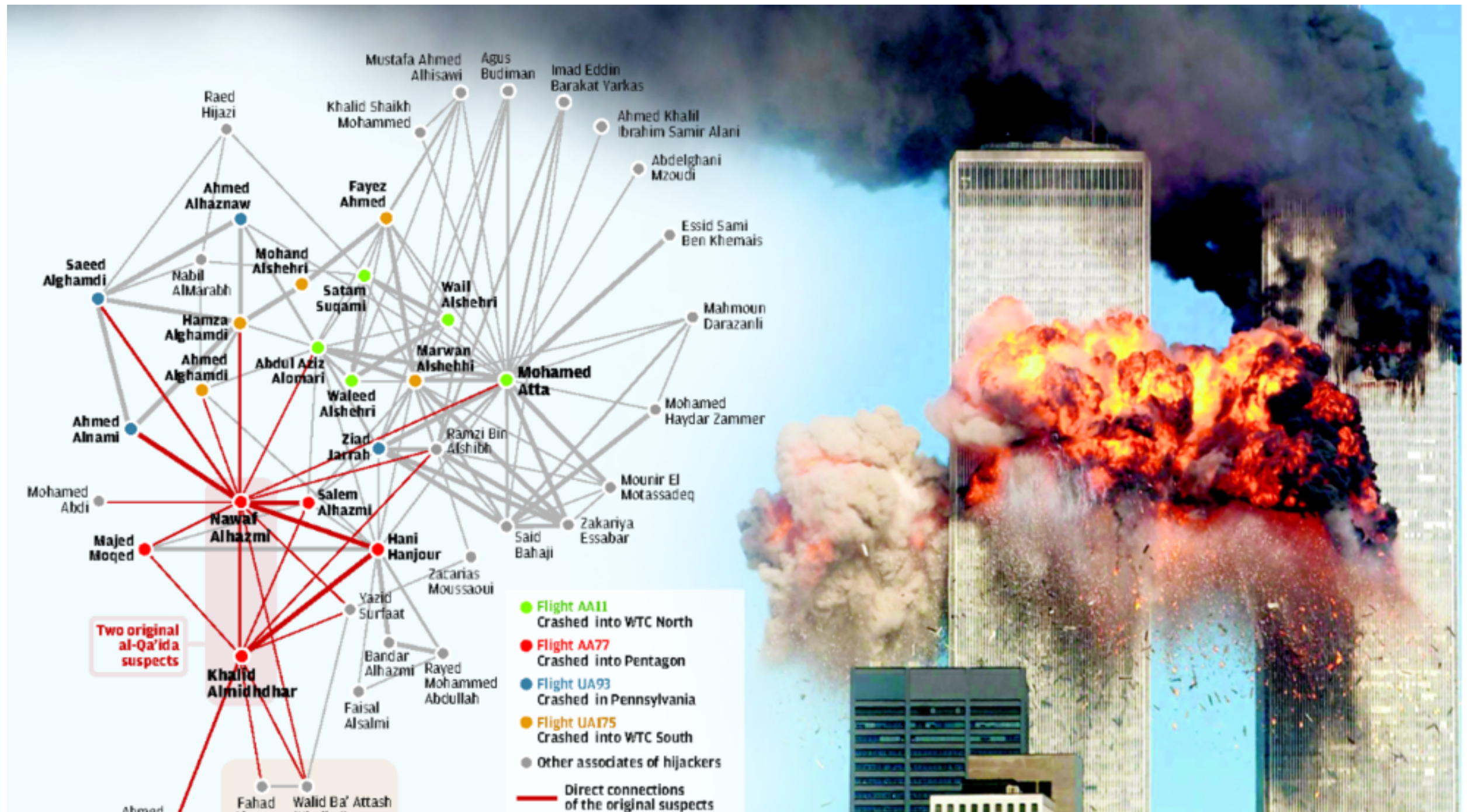
# SOCIAL FACILITATION MODEL

ROBERT ZAJONC – 1969

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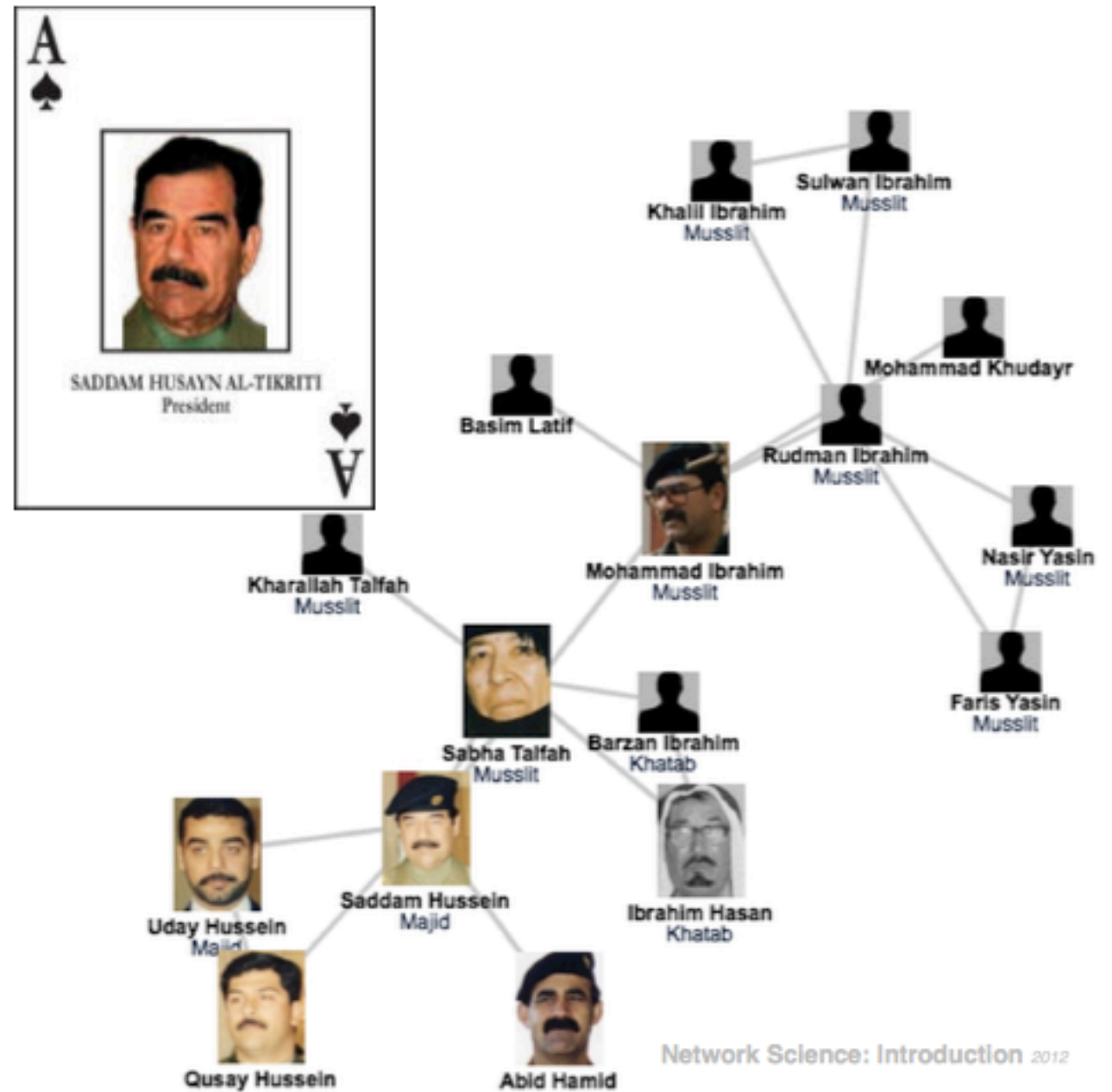
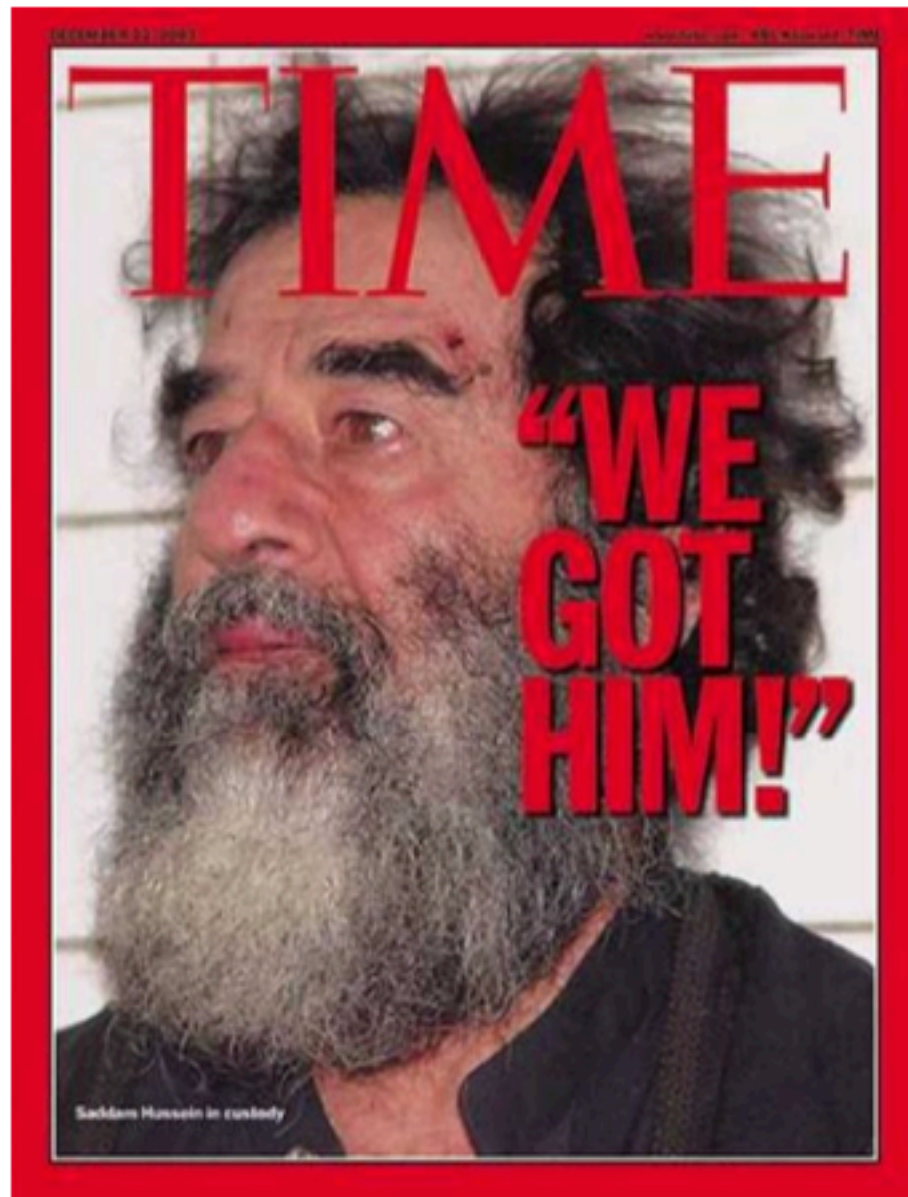
- *Behavior, beliefs, attitudes and values of each individual are shaped by their social contacts.*
- *When we interact with other people, we become stimulated by the group and the overall effect depends if it is a habitual task or not:*
  - *unpredictable = social inhibition*
  - *predictable = social facilitation*
- *Breaking down the network structure of criminal networks should decrease and limit processes such as social facilitation and social conformity, decreasing criminality levels.*

# TWIN TOWERS ATTACK (2001)





# OPERATION RED DAWN (2003)





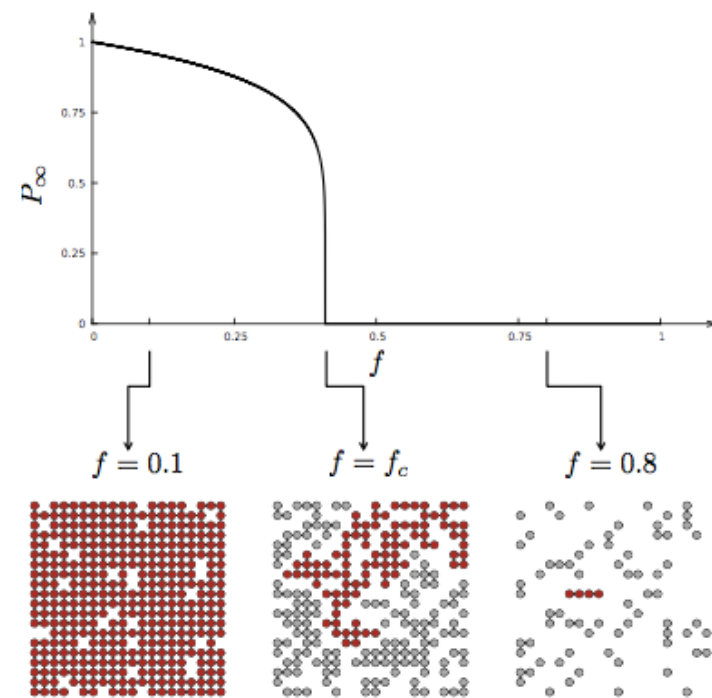


## Força-Tarefa Lava Jato

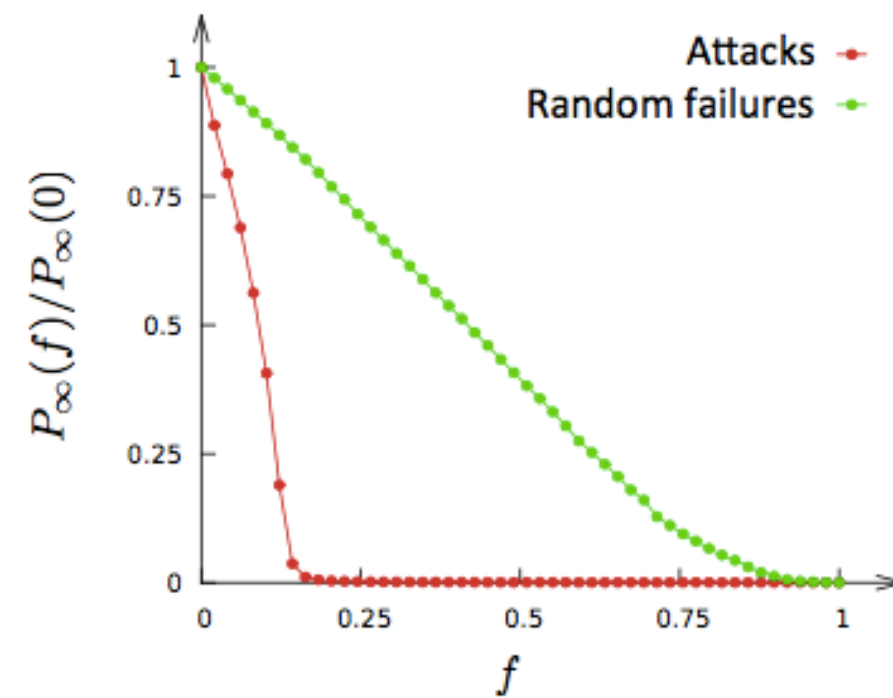
# WHY IS IT IMPORTANT?

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## *Random connections*

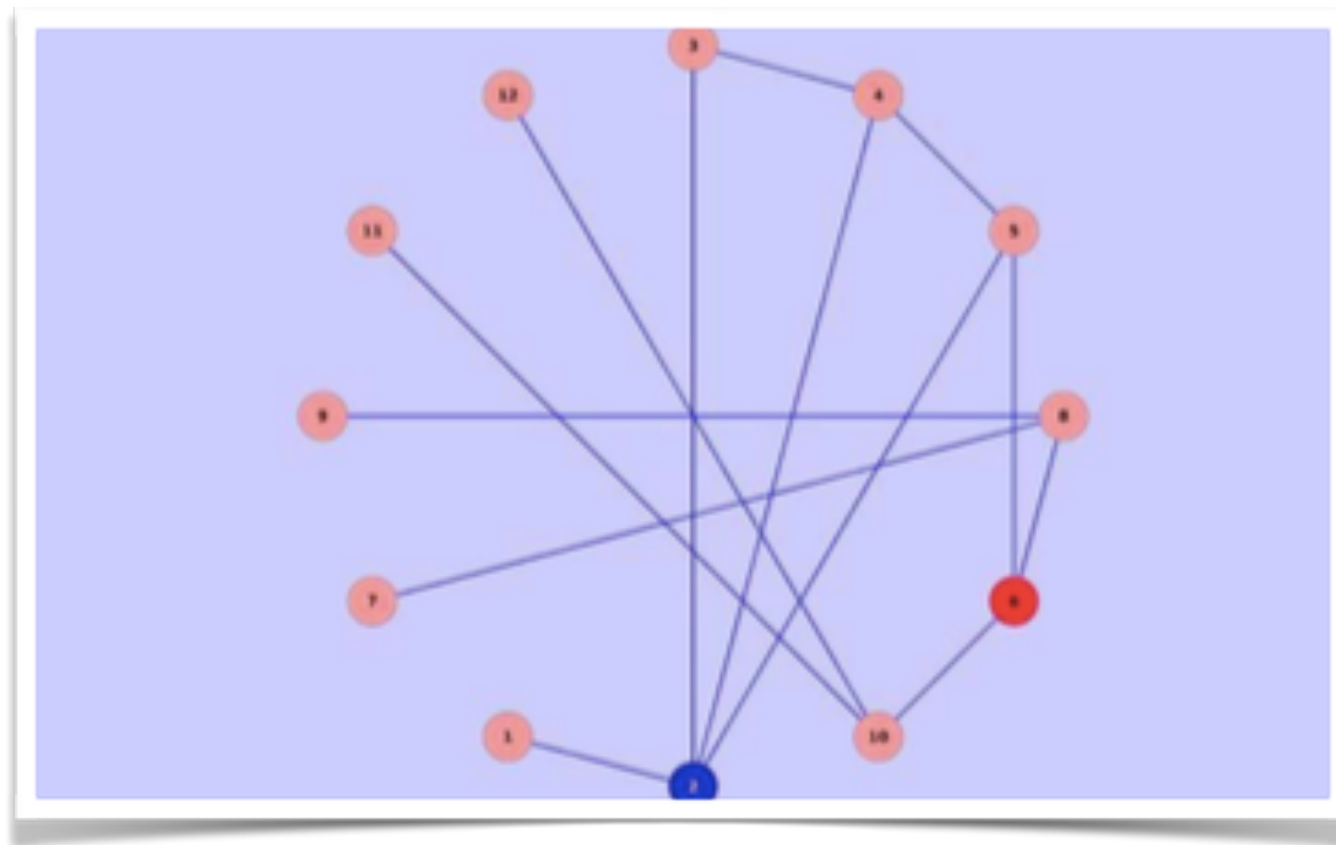


## *Heavy-tailed distributions*

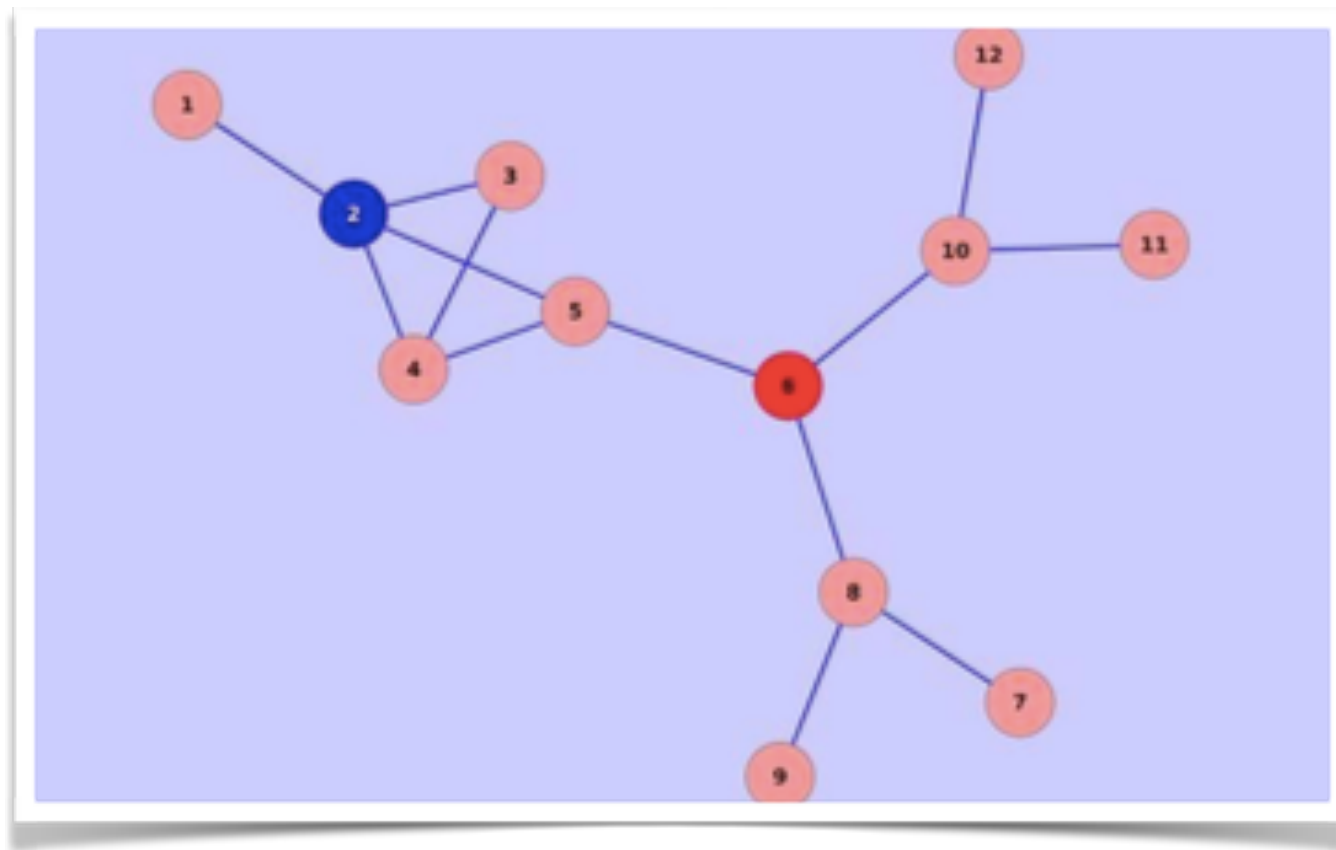




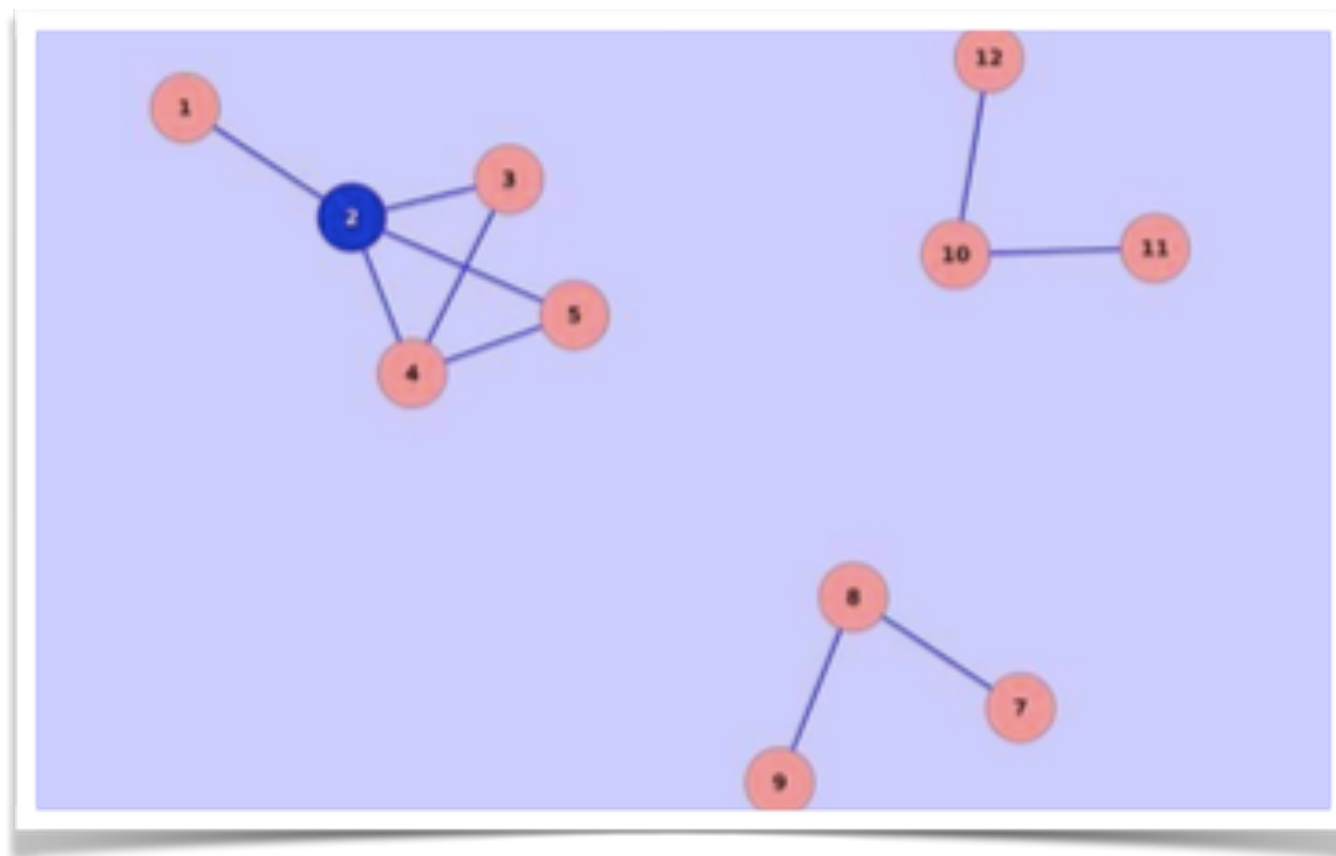
# WHICH IS MORE IMPORTANT? BLUE OR RED?



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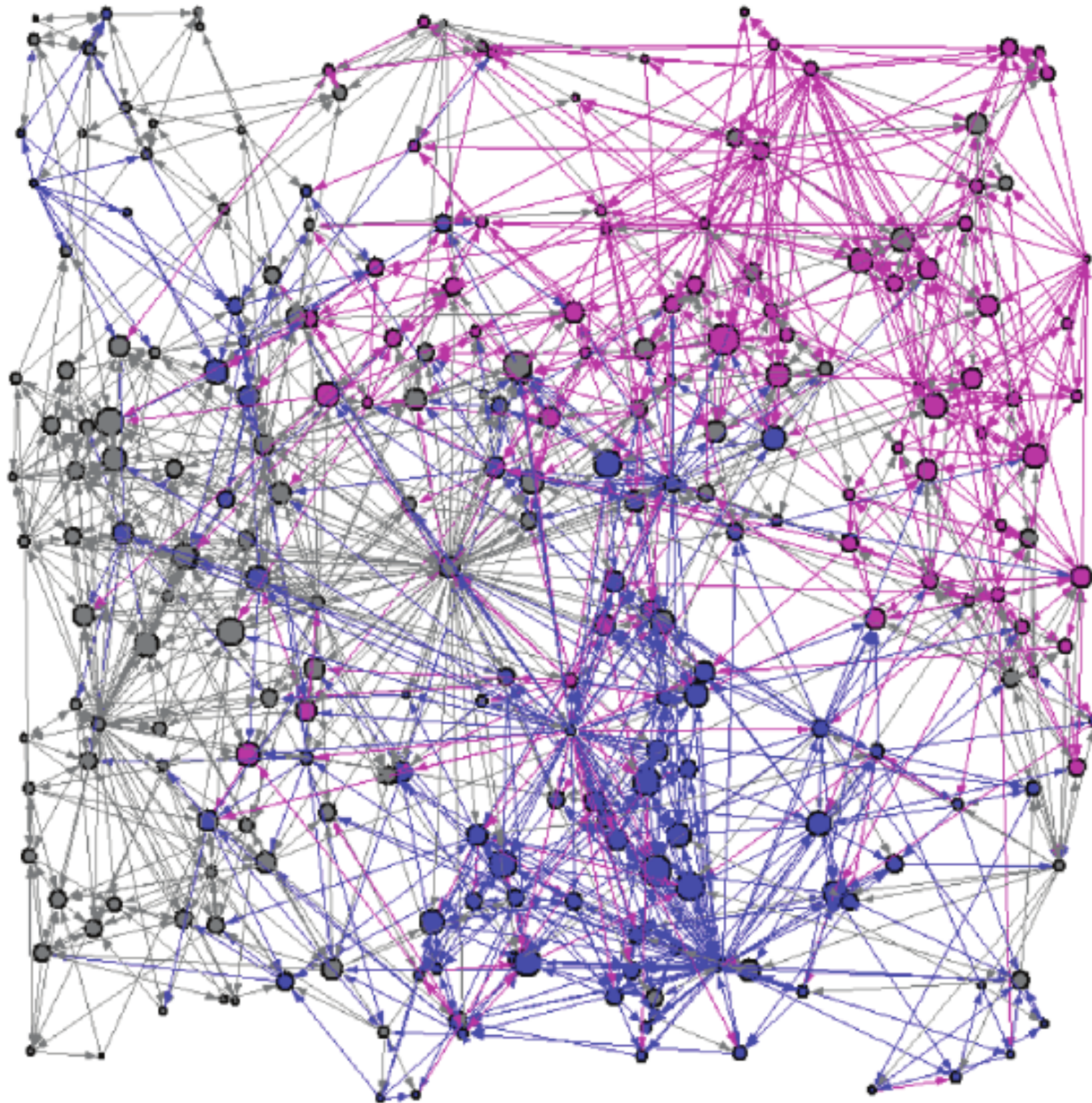


# WHICH IS MORE IMPORTANT? BLUE OR RED?



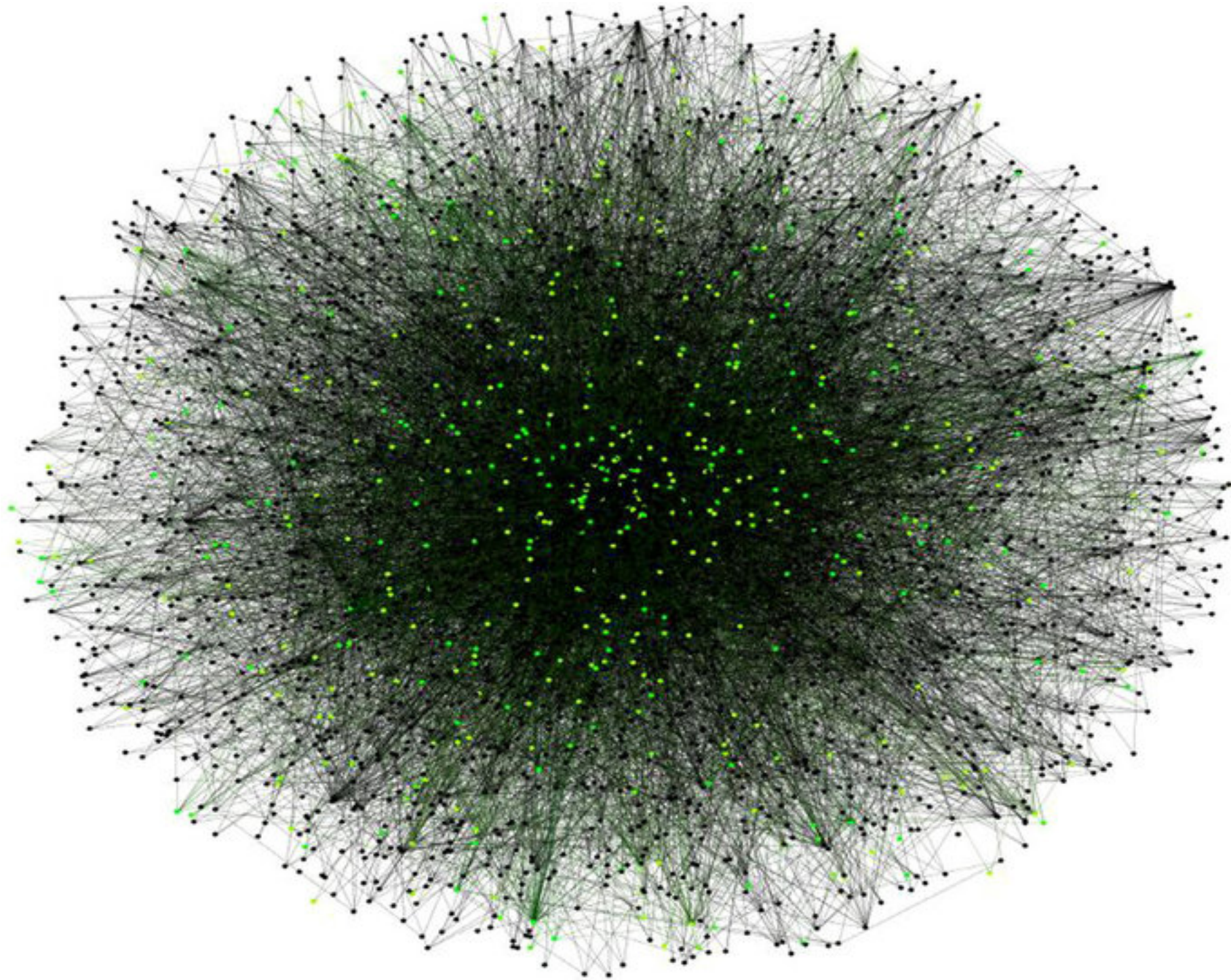


**AND IN THIS NETWORK? WHO IS MORE IMPORTANT?**



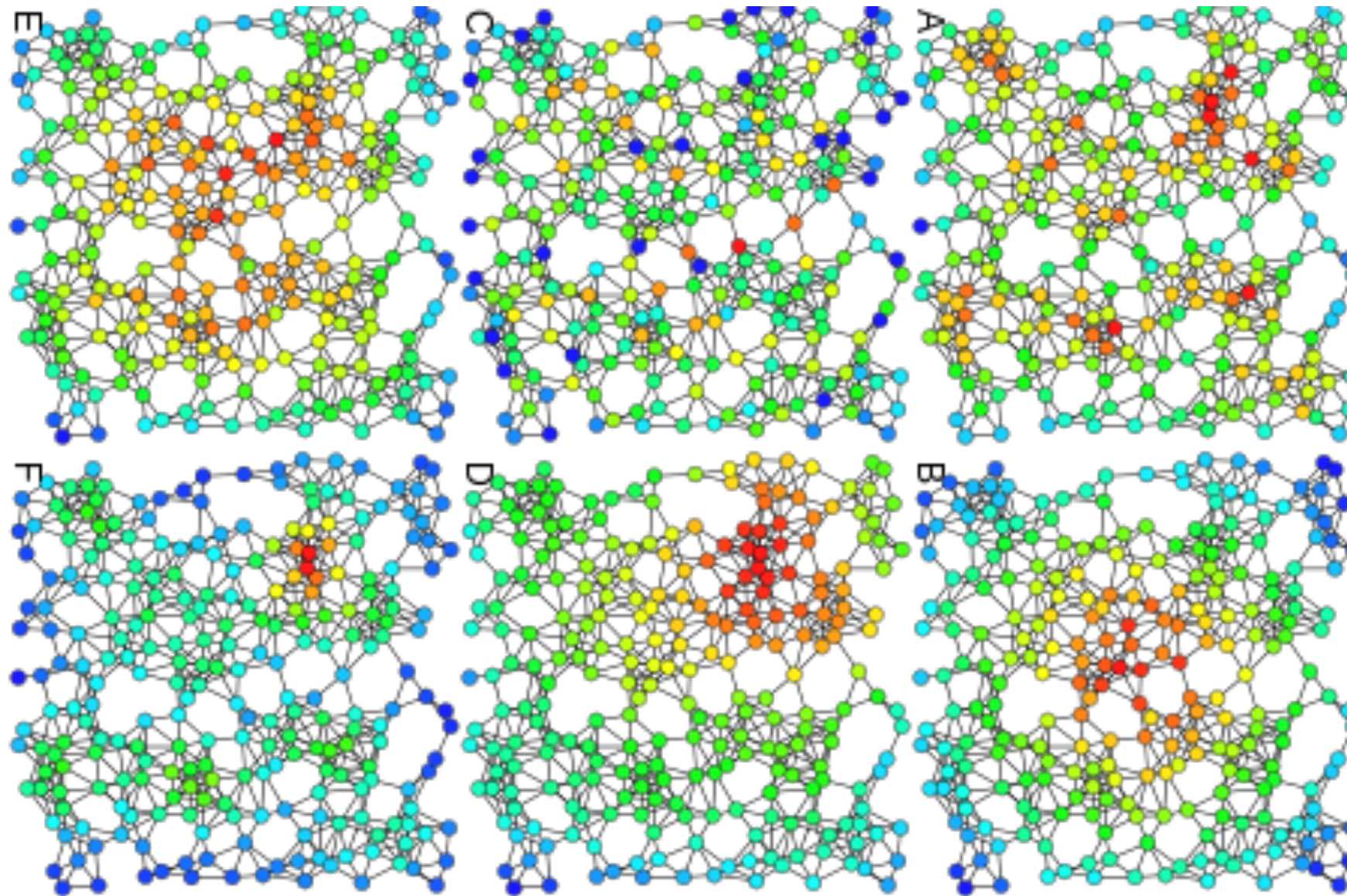


**AND IN THIS ONE?**





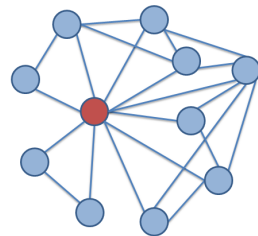
# WHAT DOES IT MEAN TO BE MORE IMPORTANT?



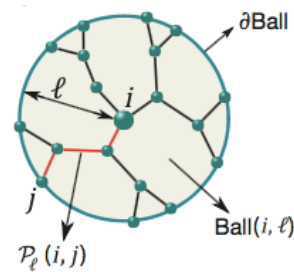


# CENTRALITY METRICS

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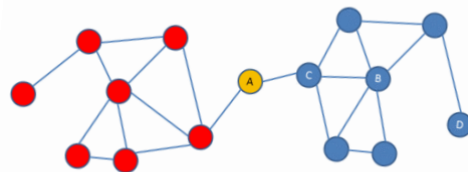


*Degree*



*Collective influence*

$$\text{CI}_\ell(i) = (k_i - 1) \sum_{j \in \partial \text{Ball}(i, \ell)} (k_j - 1)$$



*Betweenness*

$$c_B(k) = \sum_{i \neq k} \sum_{j \neq k} \frac{g_{ij}(k)}{g_{ij}}$$

# THE STRENGTH OF WEAK TIES

MARK GRANOVETTER (1973)

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*Weak ties, eg acquaintances*

*Strong ties, eg family, friends, business associates*



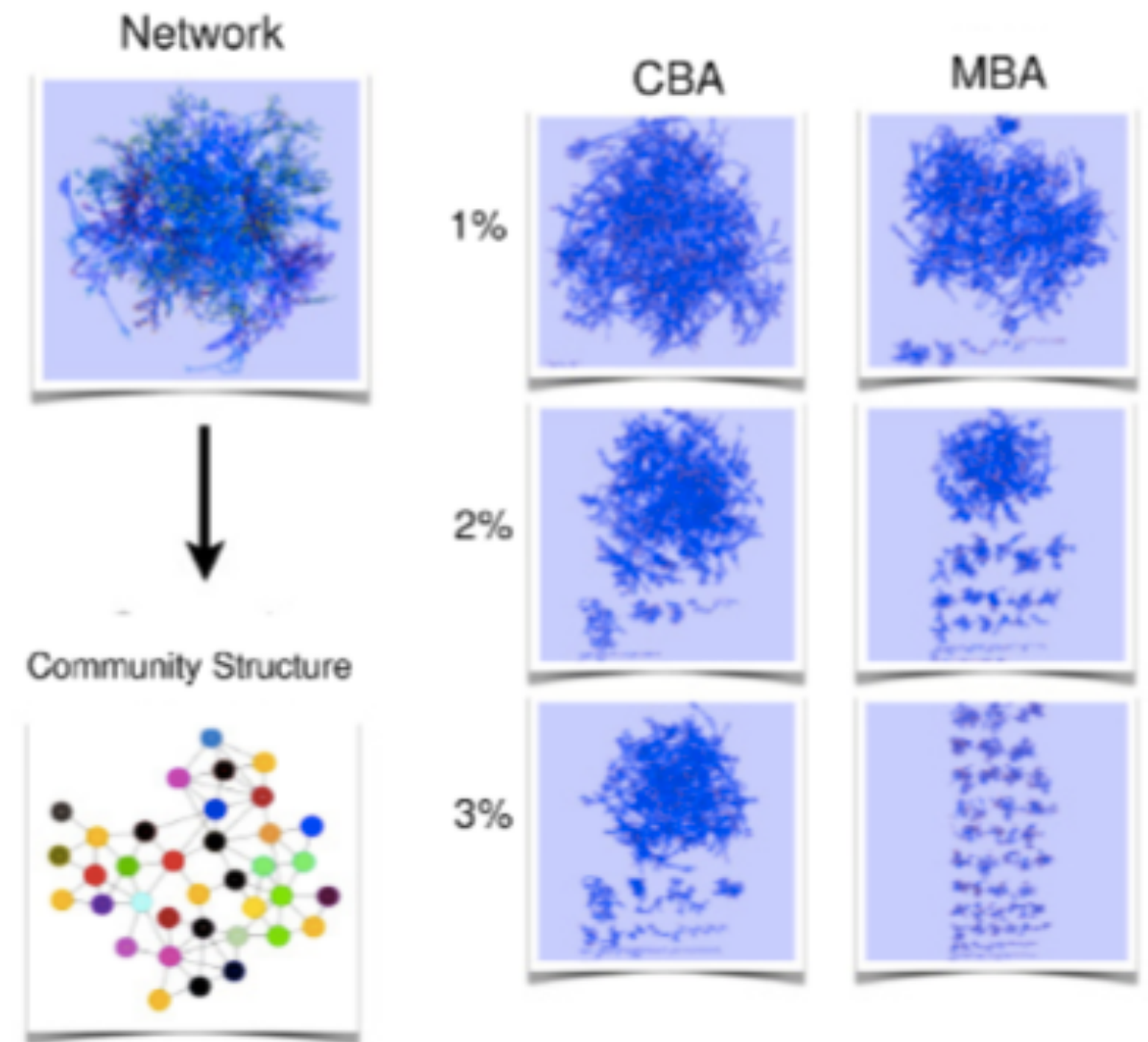
*Weak ties can be more important than strong ties in keeping networks running!*

# NETWORK BREAKING BY ATTACKING WEAK TIES

BRUNO REQUIÃO DA CUNHA ET AL (2015)

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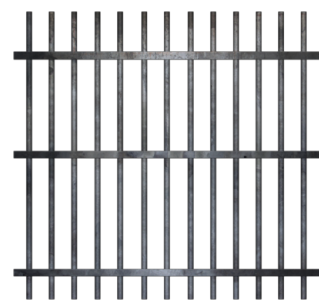
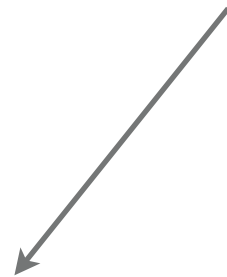
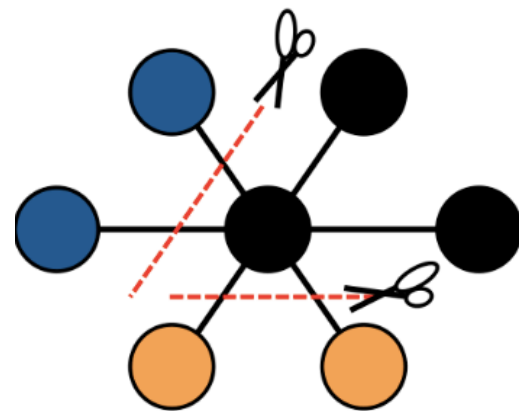
*Targetting the weak ties is more efficient than targetting the most central nodes.*



# BASIC CONCEPTS

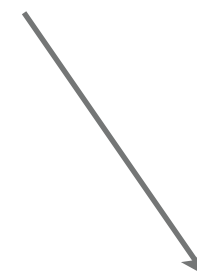
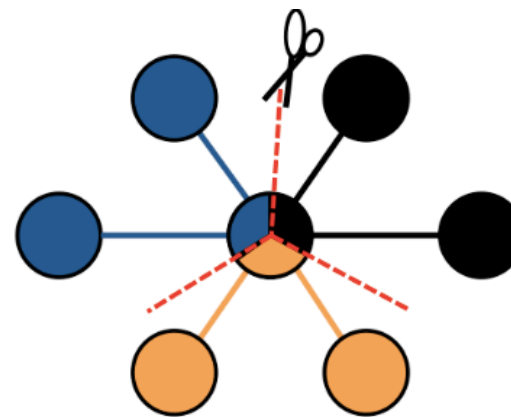
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*Edge removal*



*Imprisonment*

*Node removal*



*Death*



*Resocialization*

- psychological freedom explosion





# BRAZILIAN FEDERAL CRIMES NETWORK

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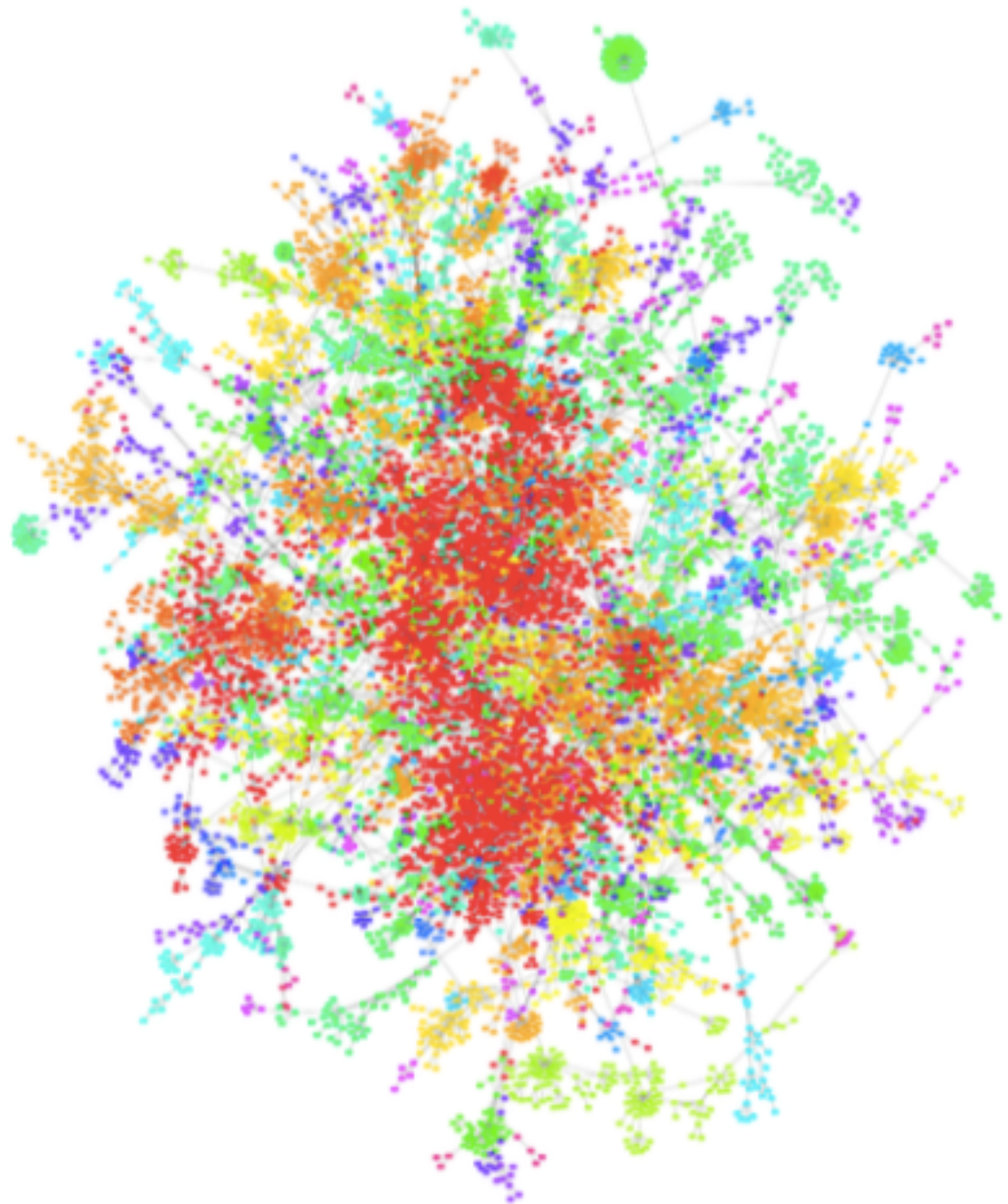
$$N=23,666$$

$$E=35,913$$

Molloy-Reed

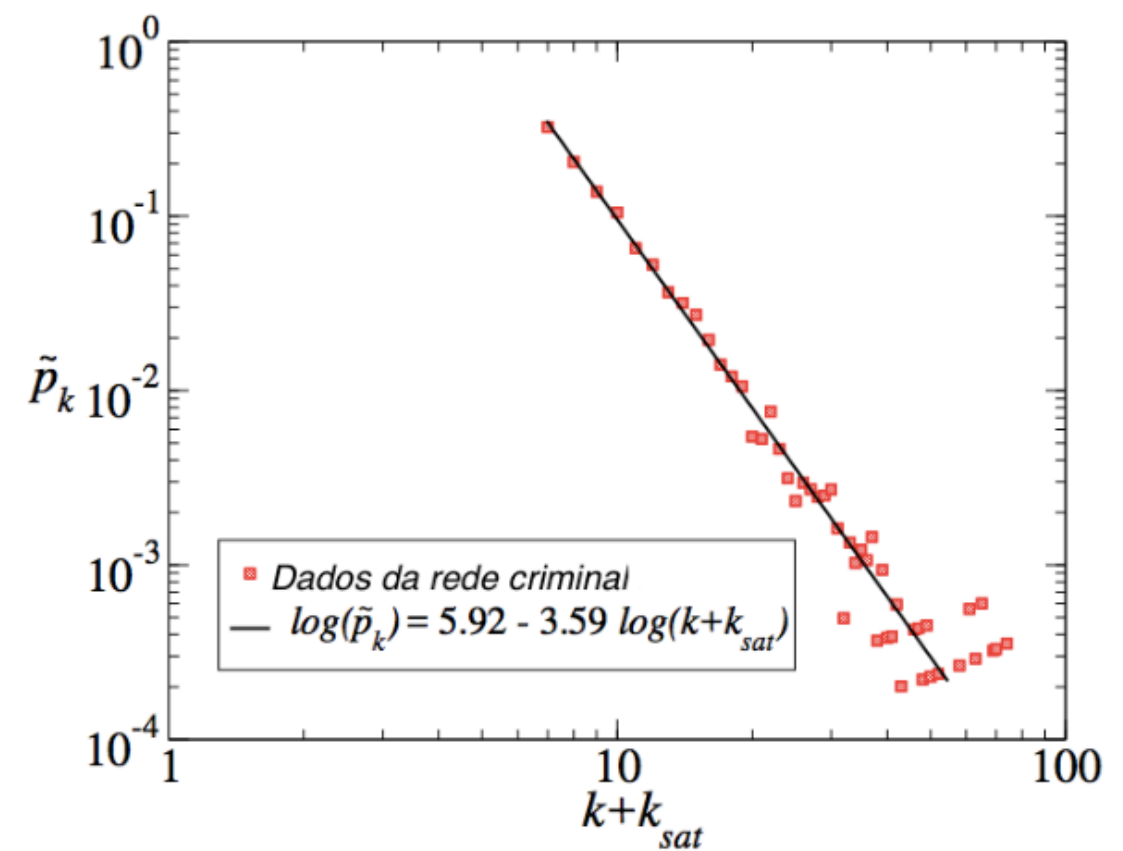
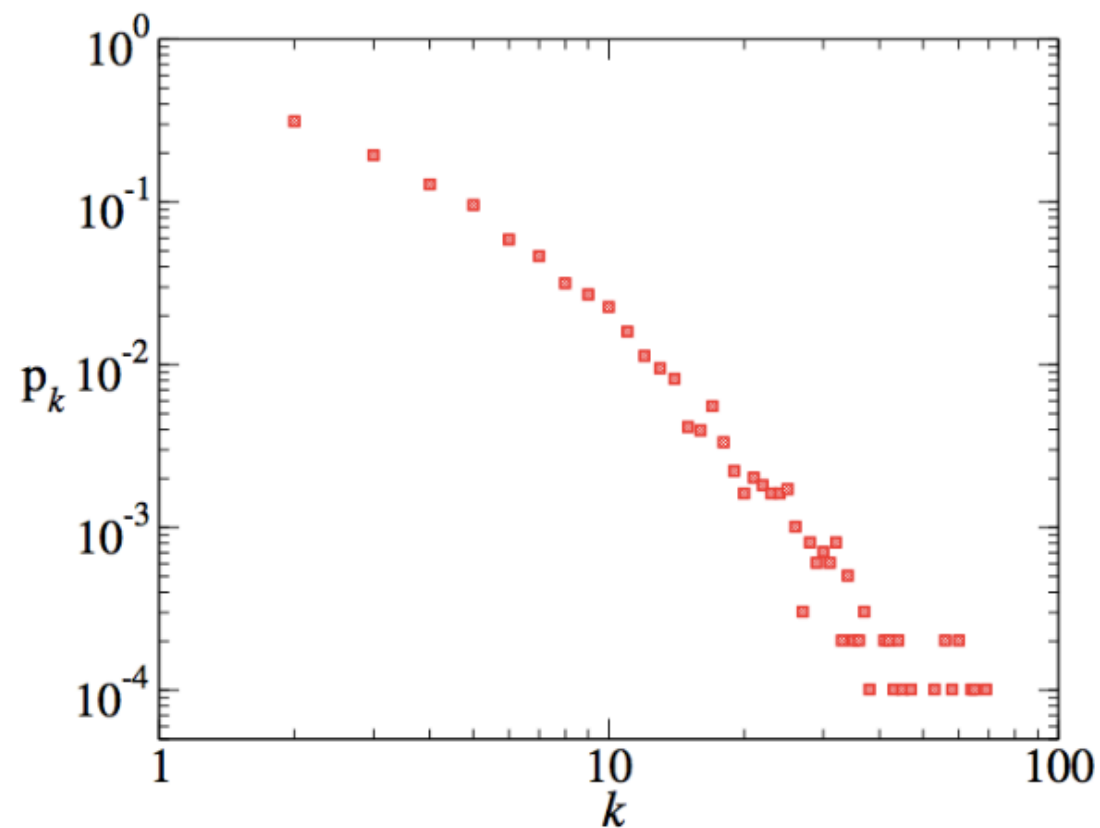
$$\langle k^2 \rangle / \langle k \rangle = 7.42$$

- *Darker than typical soc net*
- *Small-world*
- *Heavy-tailed distribution*
- *Highly modular*



# DEGREE DISTRIBUTION

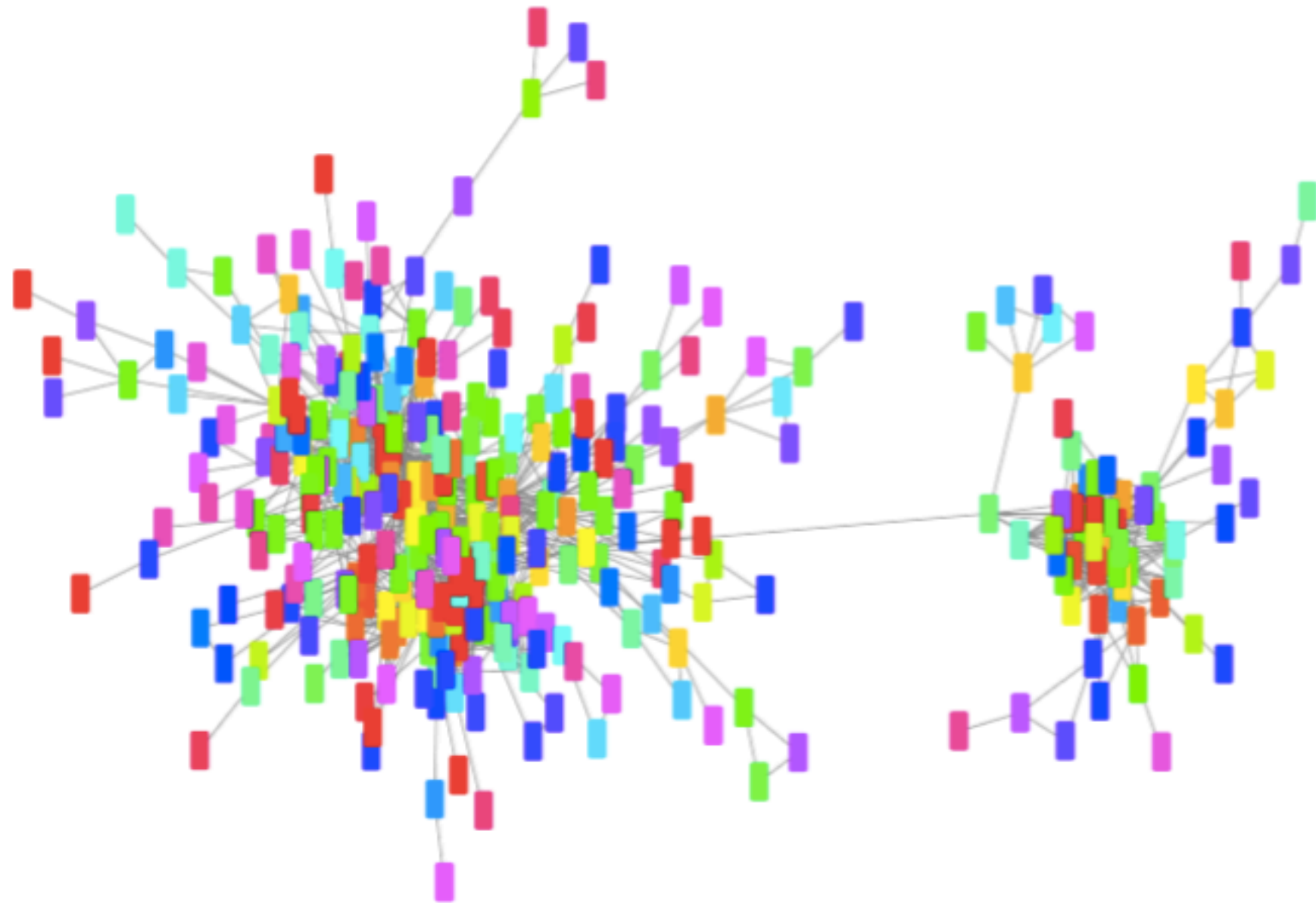
*Remember that some collective human behavior show mathematical regularities?*



# TOPOLOGICAL COMMUNITIES

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*Each node represents a community*

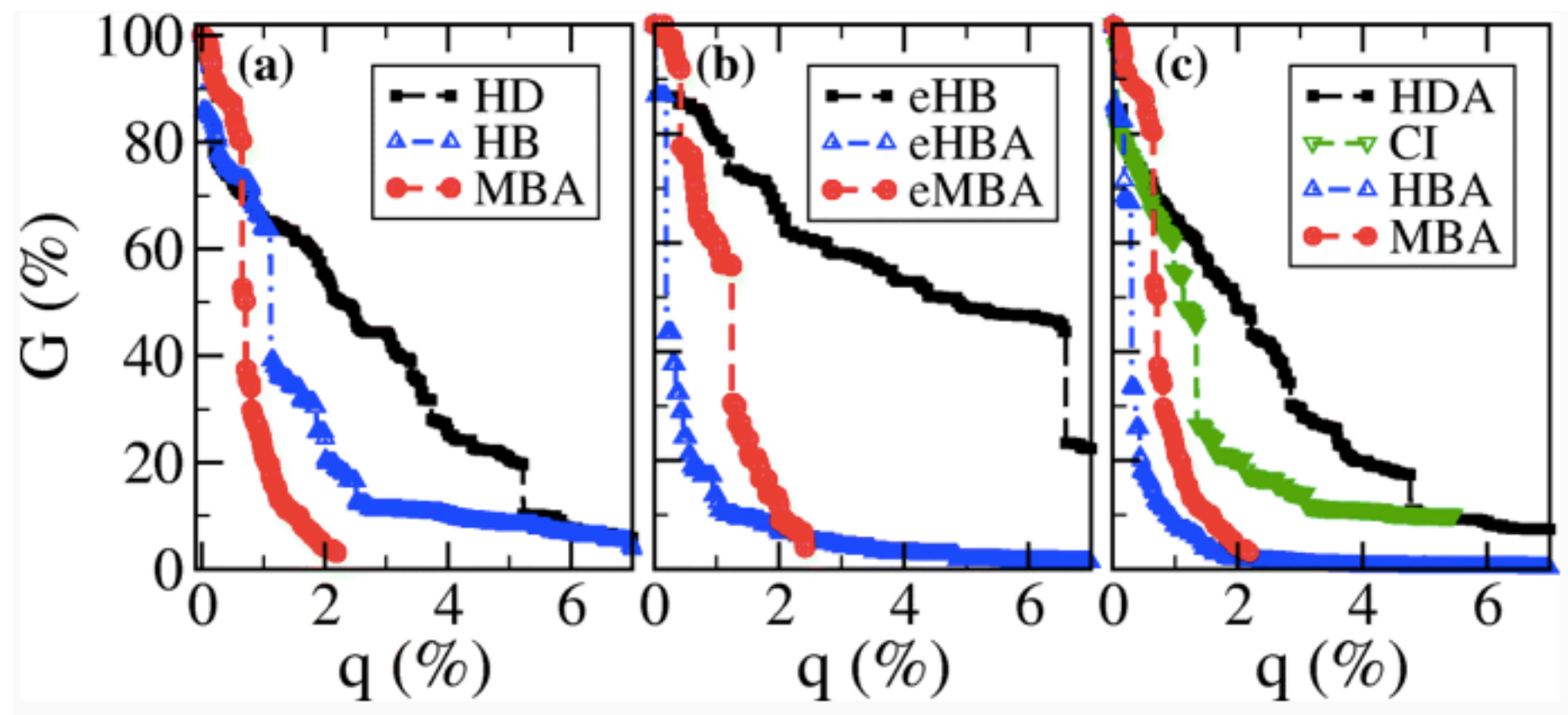




# TOPOLOGICAL WEAKNESSES

*Network robustness*

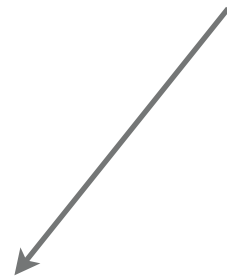
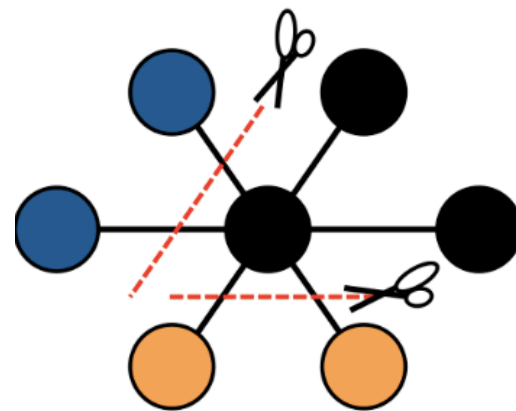
$$R = \frac{1}{N(1 - \sigma_{min})} \sum_{\rho=0}^{\rho_{max}} \sigma(\rho)$$



# BASIC CONCEPTS – VIRTUAL NETWORKS

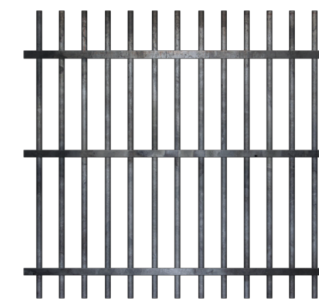
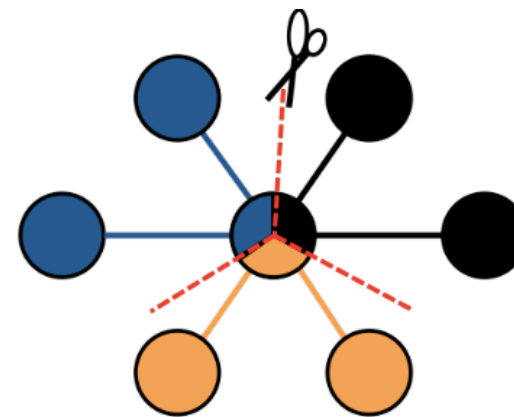
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*Edge removal*



*Unfollow*

*Node removal*



*Imprisonment*

# THAT BEING SAID, HOW EFFICIENT IS POLICE WORK IN THE NETWORK SCIENCE POINT OF VIEW?

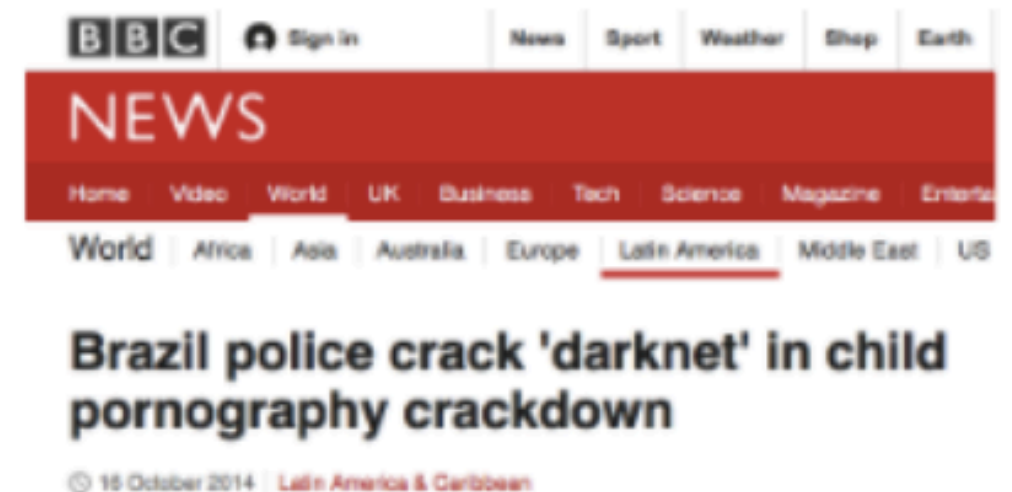
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# OPERATION DARKNET

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# OPERATION DARKNET

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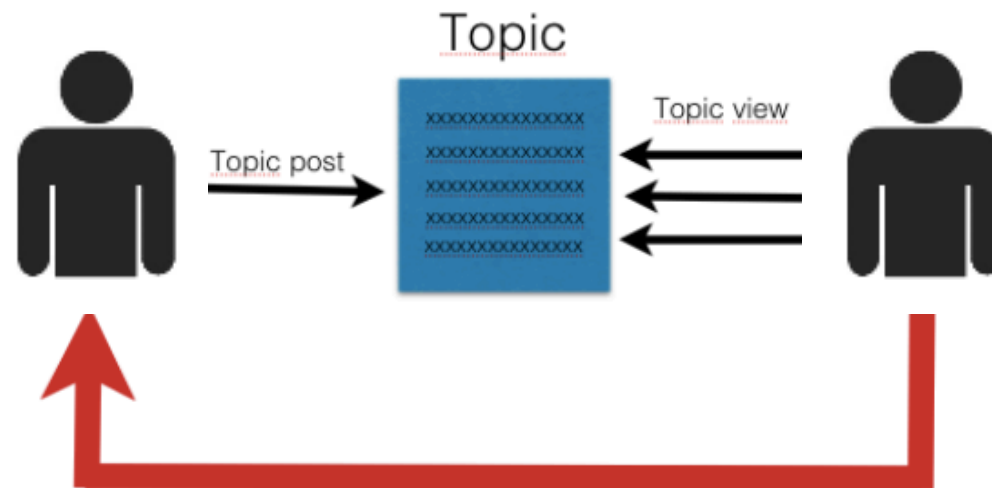
# OPERATION DARKNET

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- *In virtual networks, removing a node is the same as arresting that individual.*
- *Edge removal means only that the user stoped following the forum.*

10,407 users

842,247 views



Weighted and directed network

3 topic views, edge's weight=3

# OPERATION DARKNET

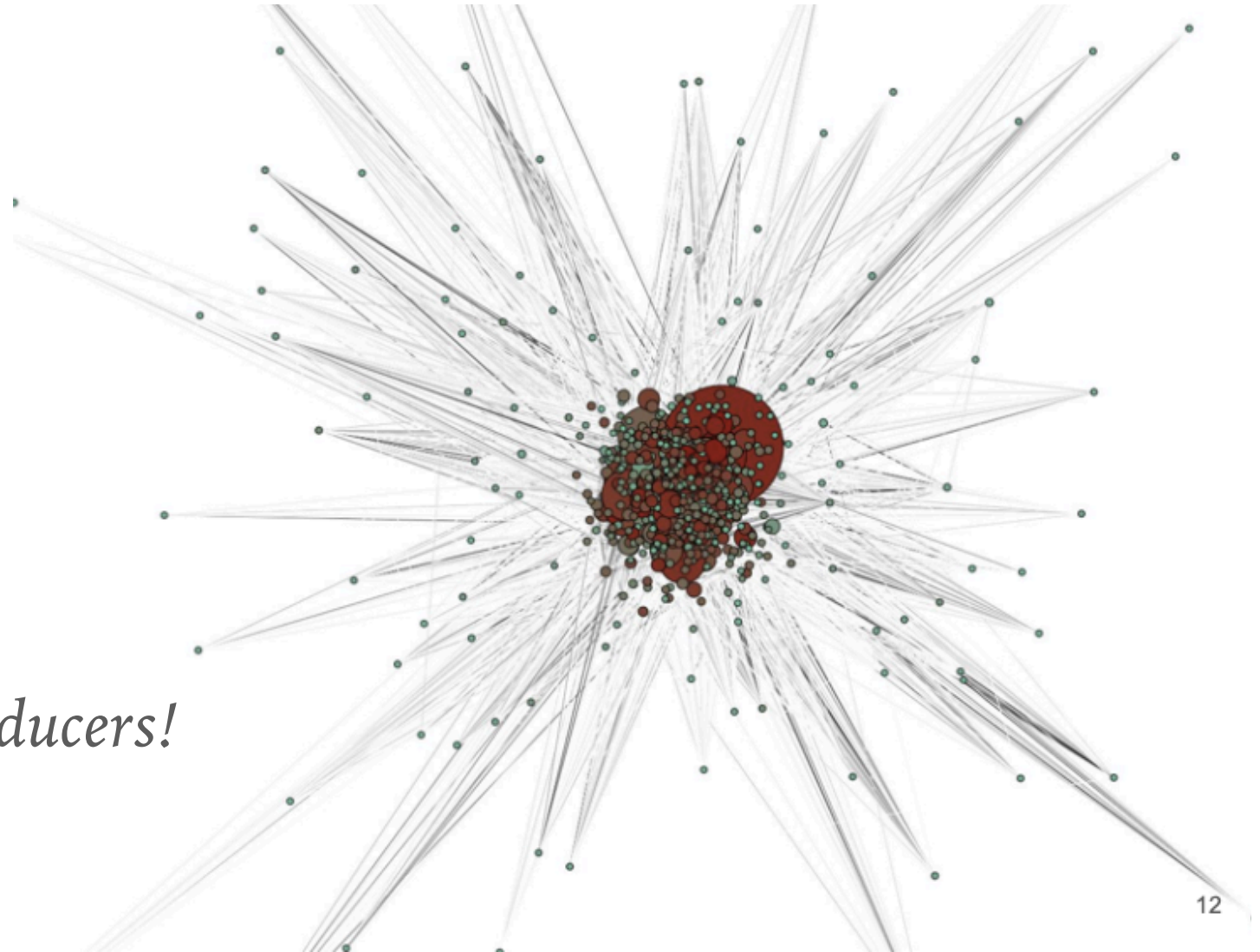
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*Virus-like topology*

*High in-degree: producer*

*High out-degree: consumer*

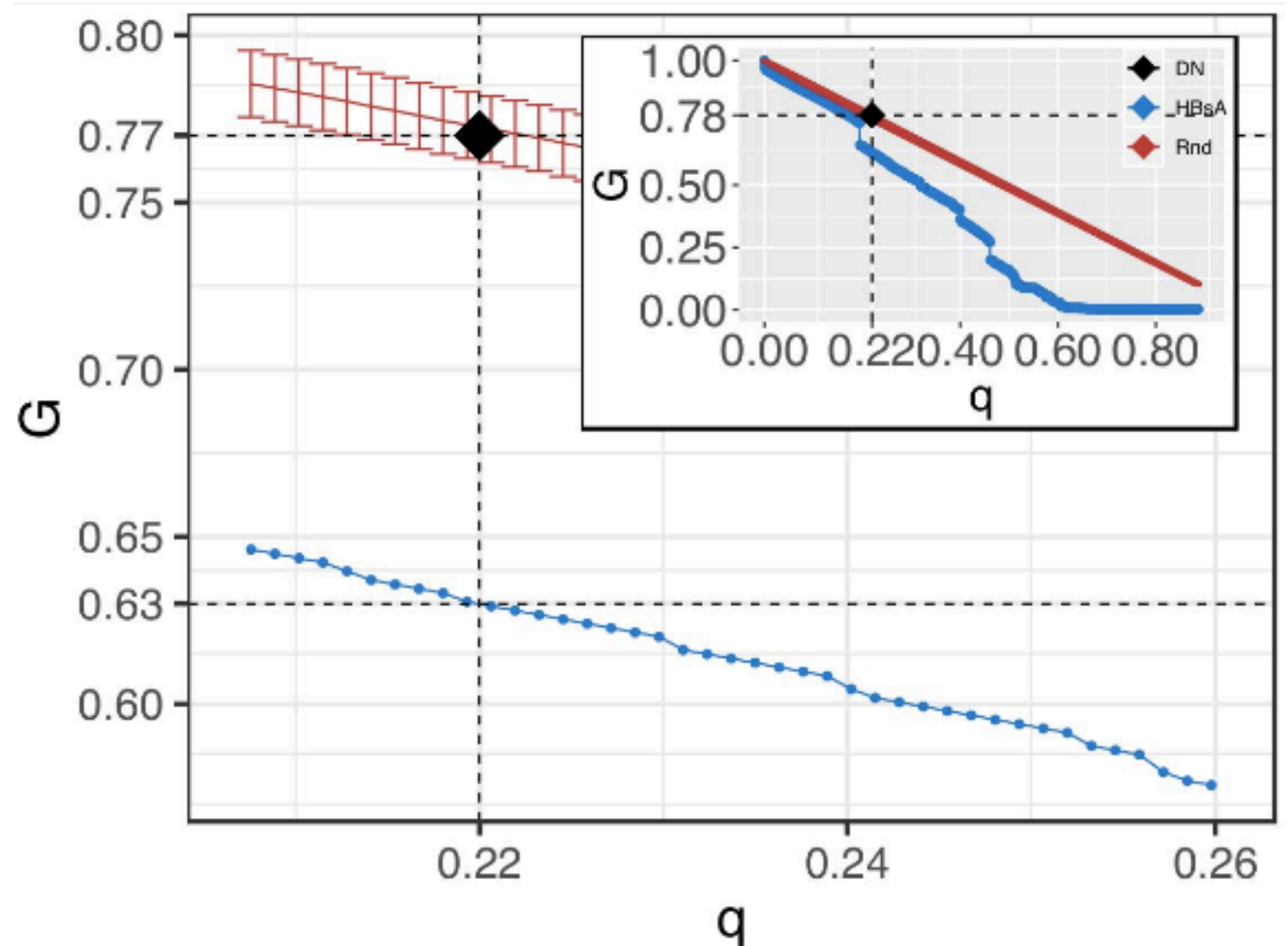
*Only 7% of individuals are producers!*



# POLICE INTERVENTIONS

*93% of individuals arrested by the police belonged to the core of producers.*

*Topological attacks could reduce the network connections 1.5 times more than real police interventions.*  
*However.....*



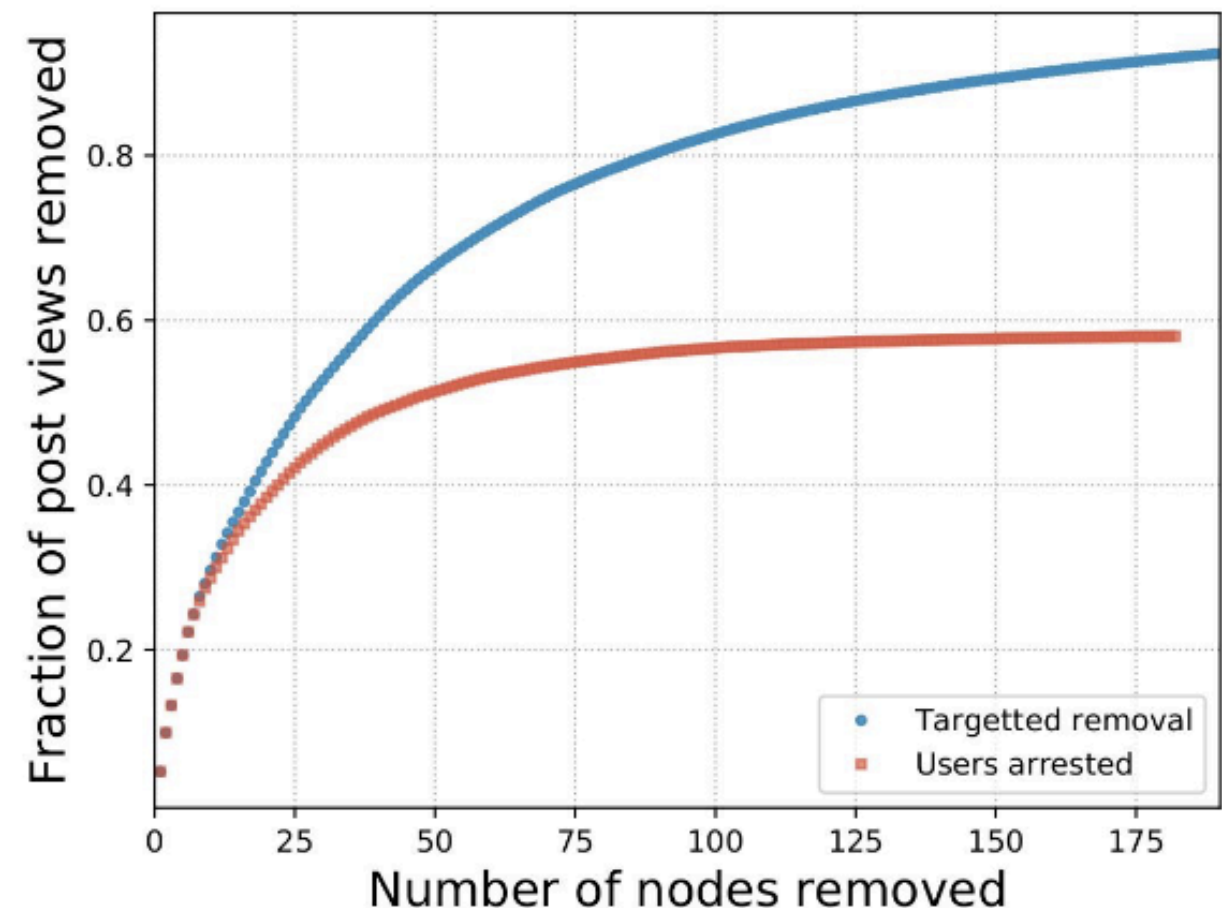


# POLICE INTERVENTIONS

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*If we take the amount of views that each user has, results are different! And the network becomes much more fragile!*

*In this case, police efficiency raises to 60% out of almost 90% possible.*



# REFERENCES

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2015



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2017



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2018



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2019



<https://doi.org/10.1038/s41598-019-56704-4>

“ No es lo mismo hablar de toros que estar en el redondel.  
(Talking about bulls is not the same as facing them in the ring.)  
– Spanish proverb



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