Opinion and spreading information models in complex networks

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Human Relationships-Social Network

FOUR QUESTIONS ON SOCIAL NETWORKS---PARTIAL ANSWERS

How social networks are created? **Gallos et al PRX (2012)**

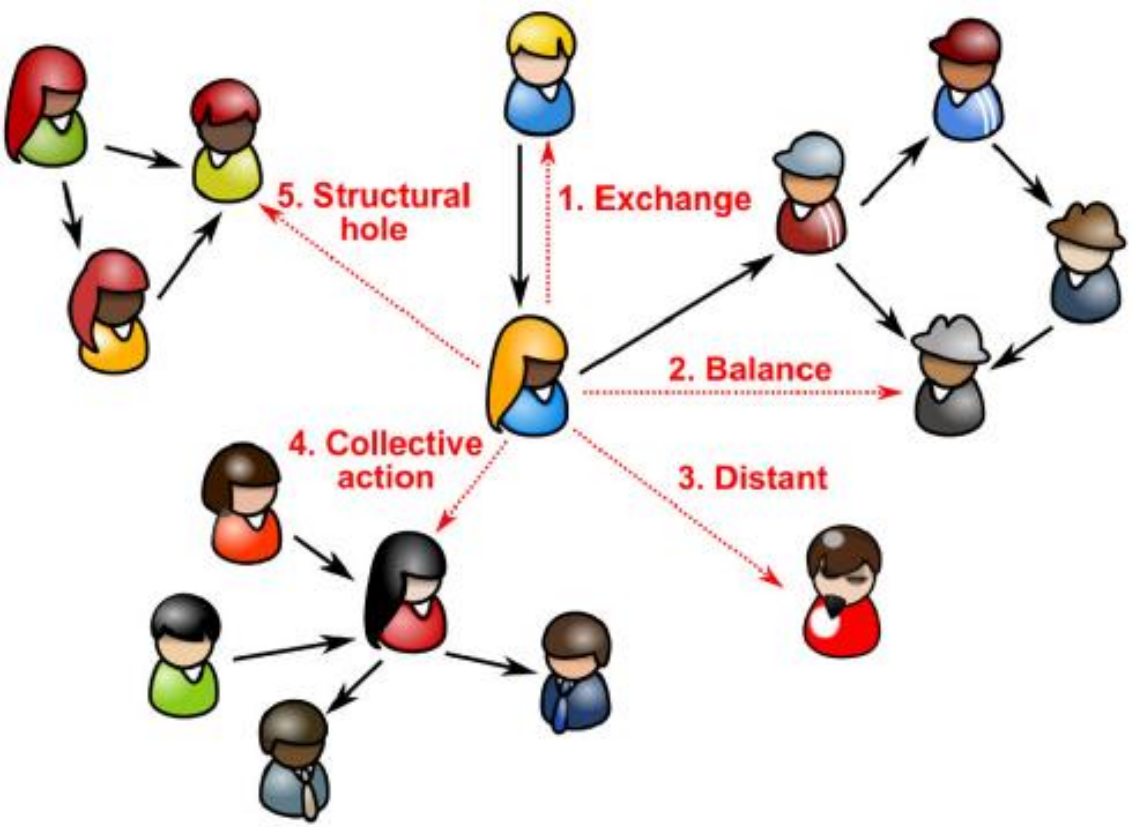
How to identify influential spreaders? **Kitsak et al Nature Phys. (2010)**

How opinions are formed? **Shao et al, PRL (2009)**

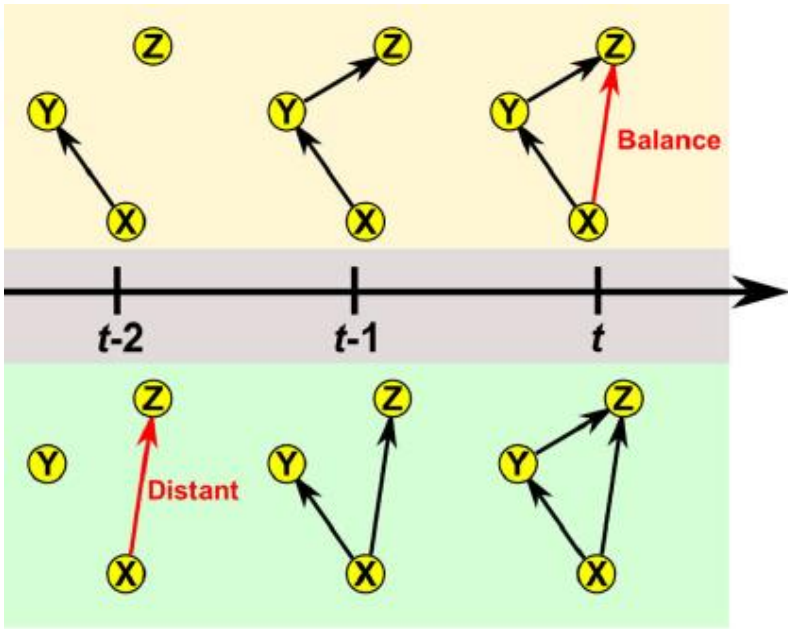
Qian Li et al J. Stat. Phys (2013)

How extreme opinions occur? **Makse et al preprint (2013)**

How People Interact in Online Networks?



Following dynamics



P. R. Monge and N. S. Contractor, Theories of Communication Networks (Oxford University Press, New York, 2003).

L. Gallos, D. Rybski, F.Liljeros, S. Havlin, H. Makse, PRX, 2, 031014 (2012)

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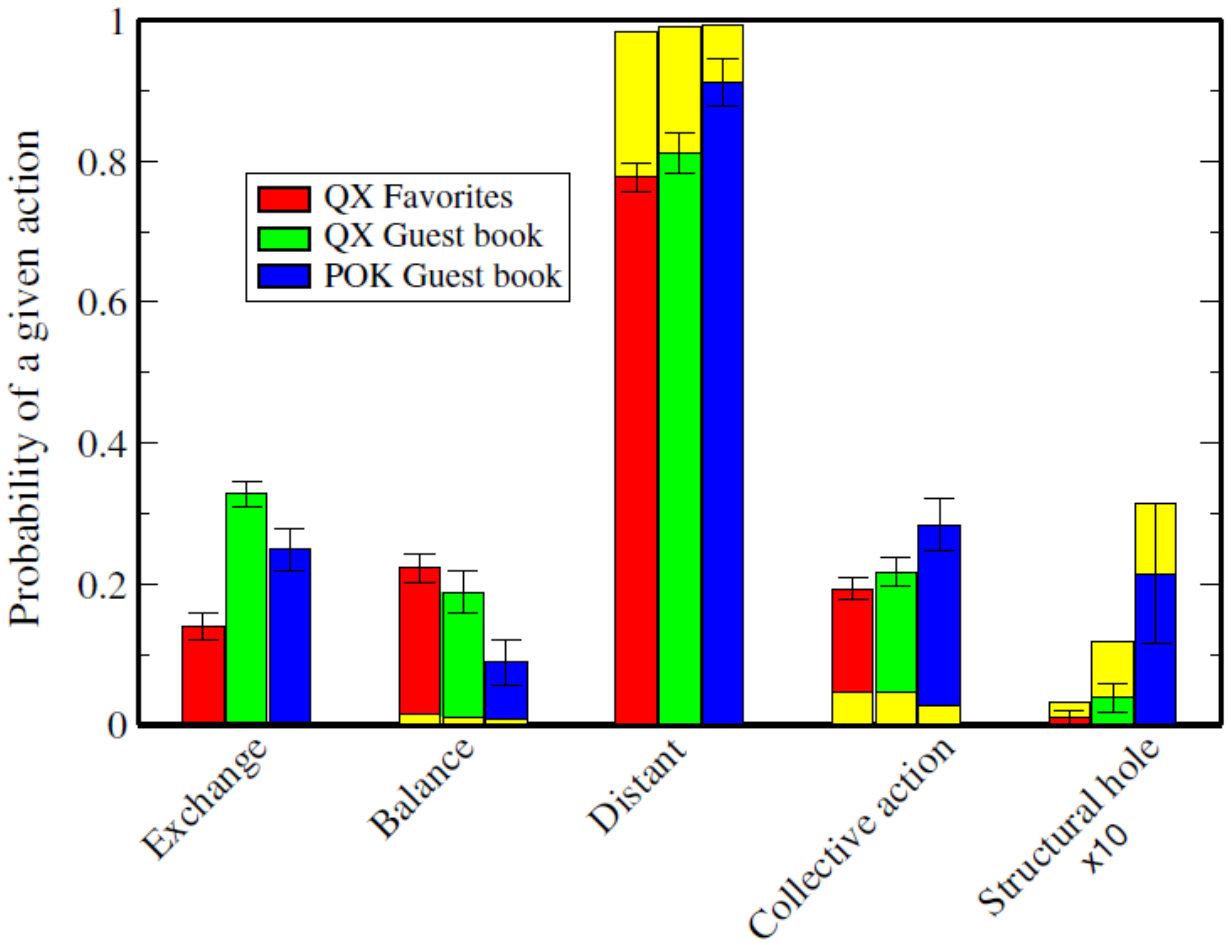

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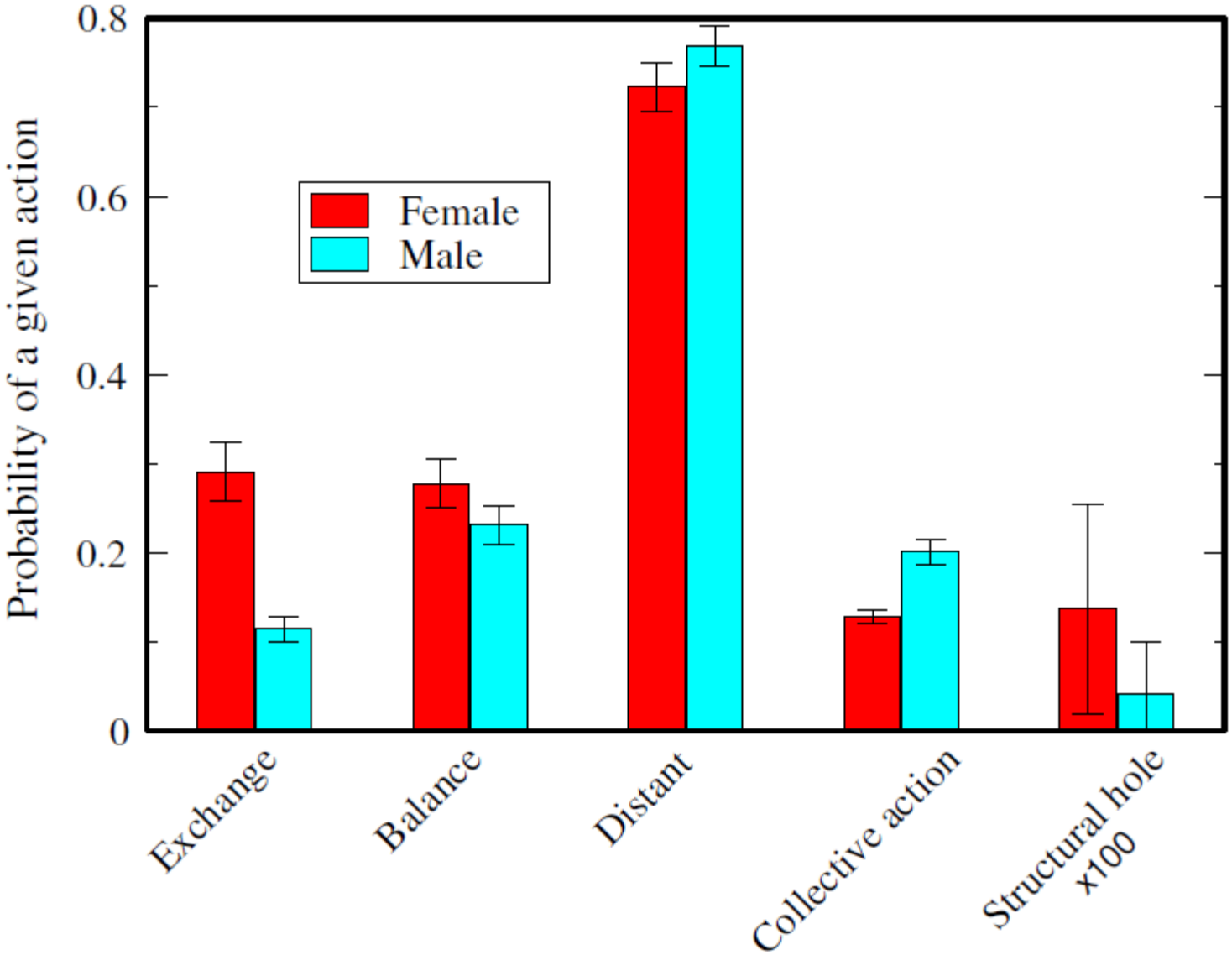

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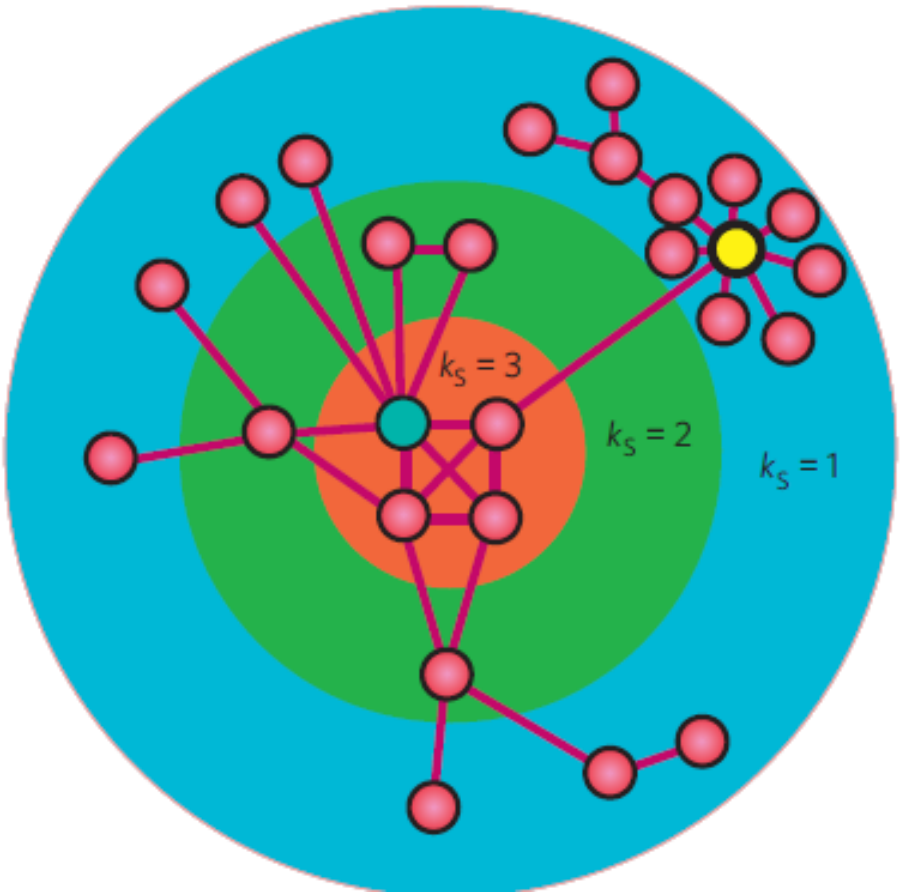
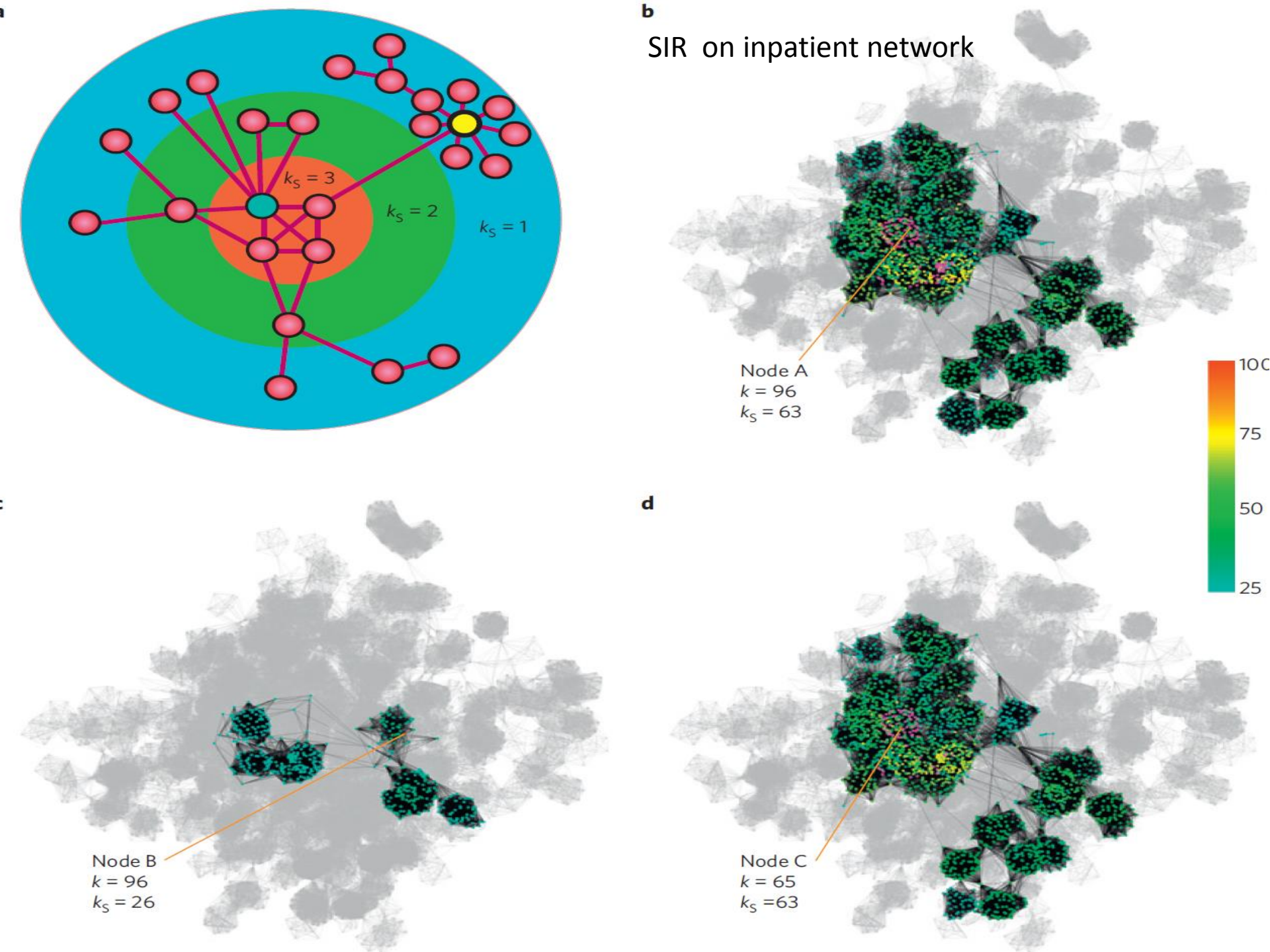
Identification of influential spreaders in complex networks



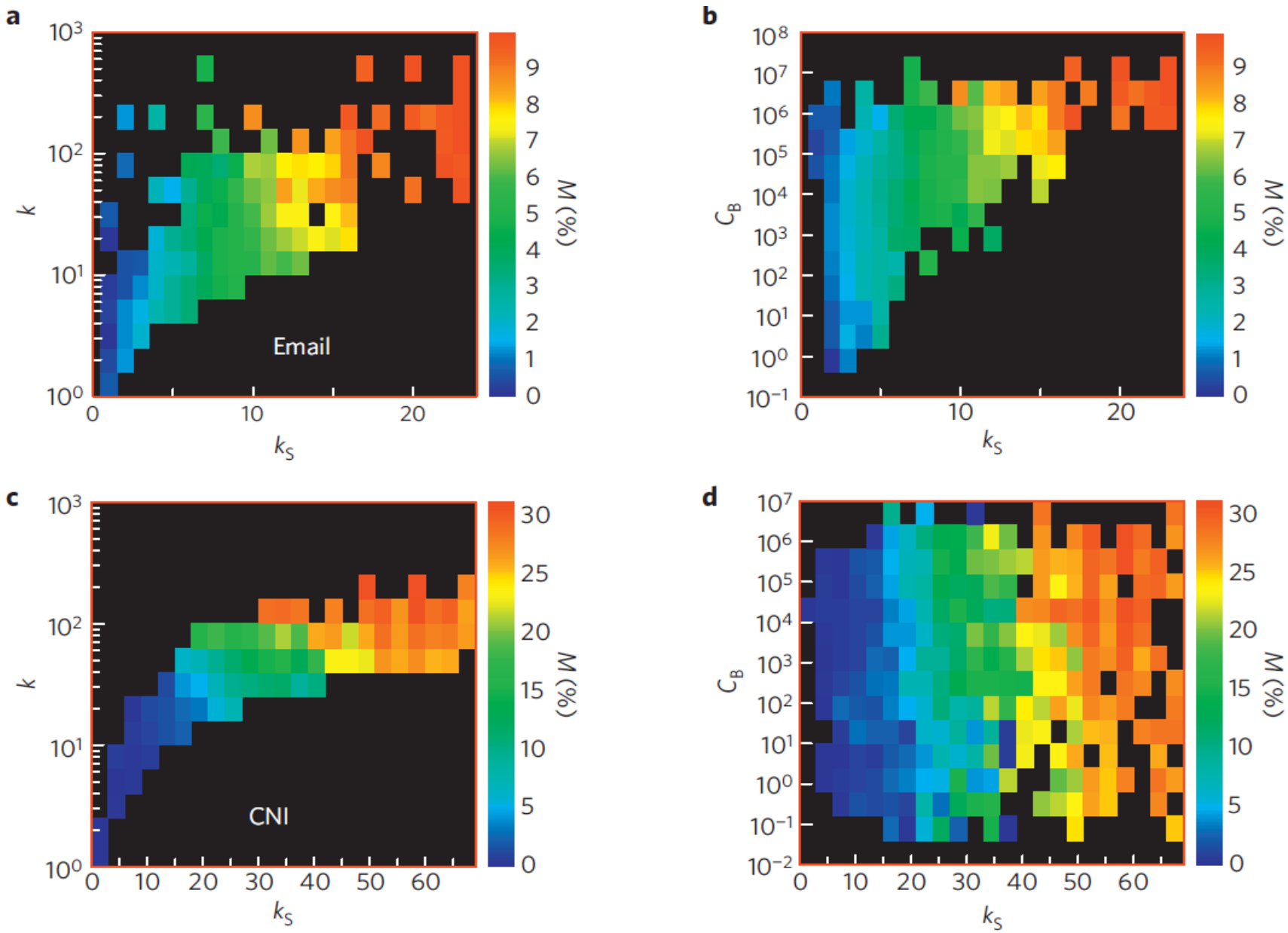
METHOD: k-shell decomposition analysis
Carmi et al: PNAS (2009)

M. Kitsak, L. Gallos, S. Havlin, F. Liljeros, L. Muchnik, H. E. Stanley and H. Makse, Nature Phys. 6 (2010)

SIR on inpatient network



Test: SIR on real networks: email (β=0.08) and **inpatient** networks (β =0.04)

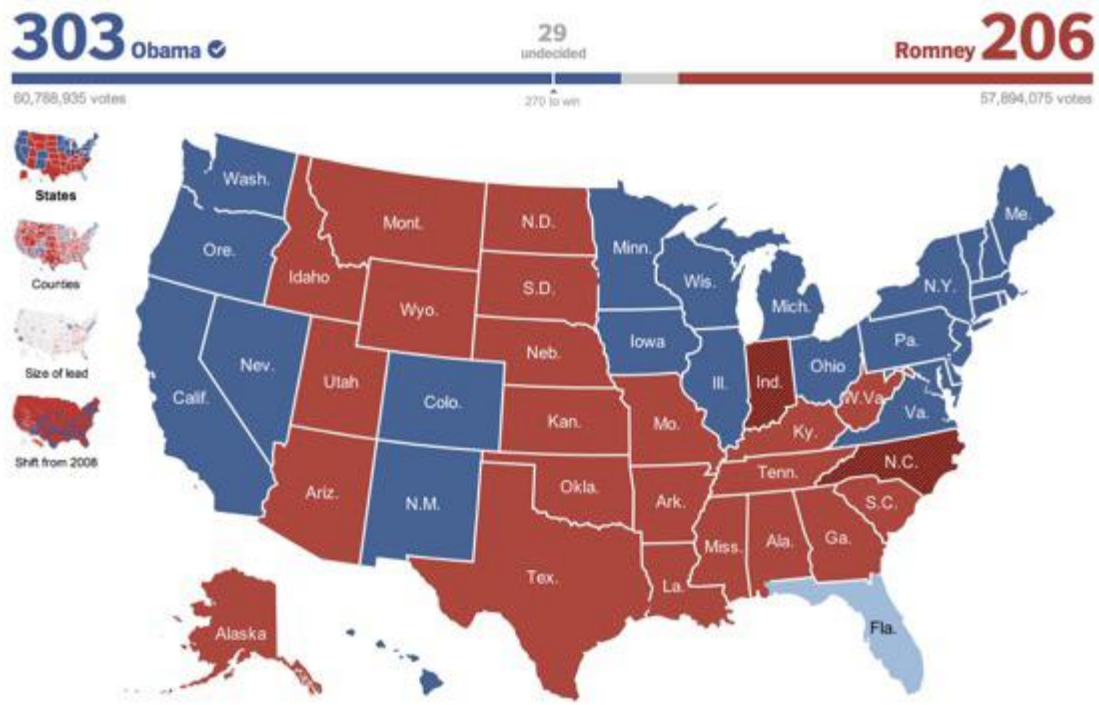


Kitsak et al Nature Phys. (2010)

How opinions are formed?

Consensus Opinion Models

- Voter Model (Holley and Liggett 1975, Redner 2005): The agents imitate their neighbors
- Majority Rule Model (S. Galam et. al, 2002, P. L. Krapivsky et. Al 2003) : Agents follow the majority opinion of their friends



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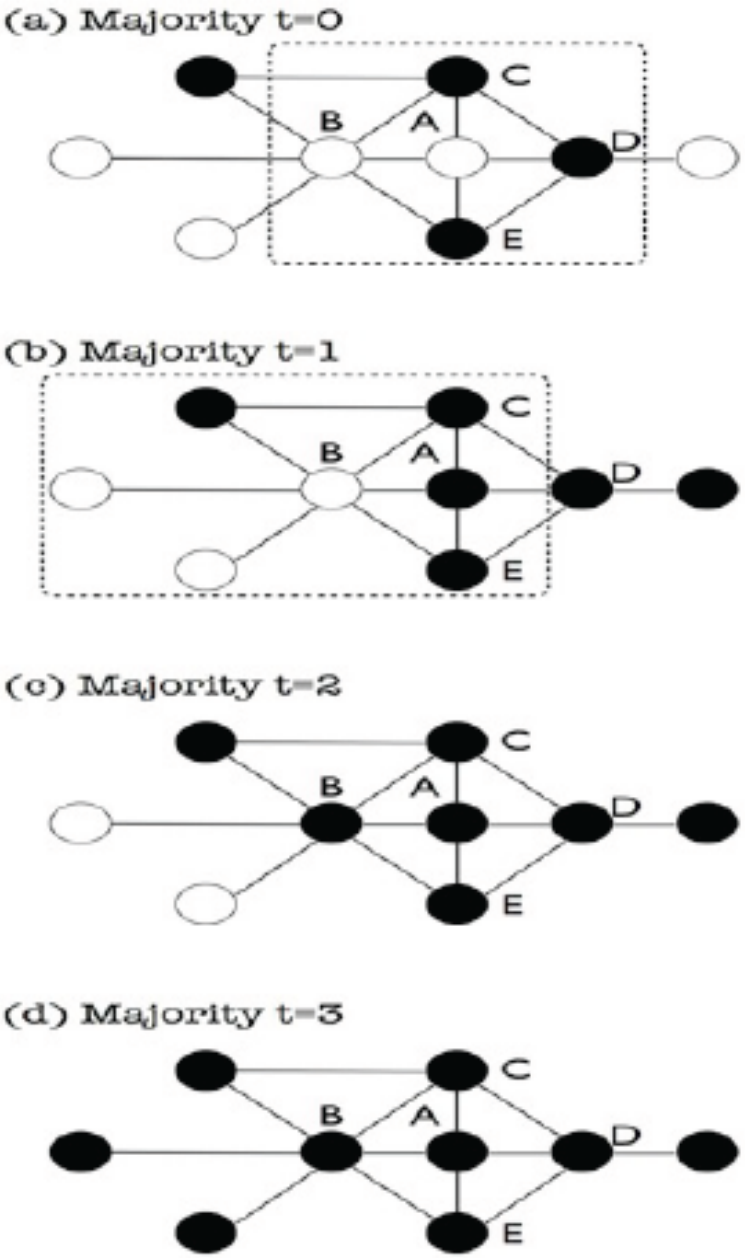
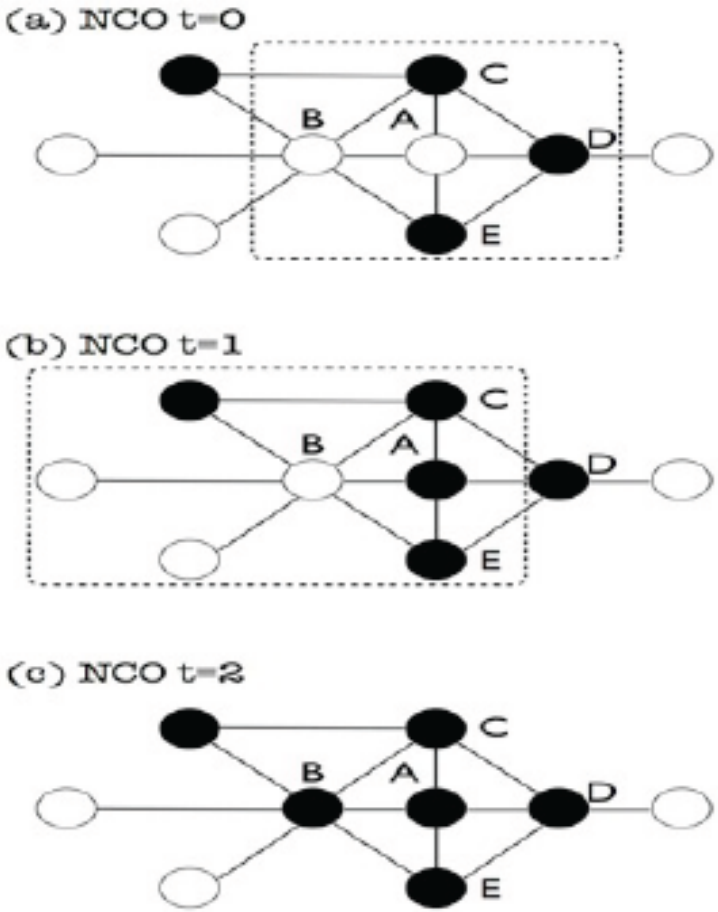
Non-Consensus Opinion (NCO) Models (J. Shao et.al, 2009):

- Agent's opinion is influenced by both its own current opinion and the opinions of his friends
- Agent follows the majority opinion of his local community, which include agent's friends and itself

Similar model (independently) by **F. Schweitzer and L. Behera,** Eur. Phys. J. B 67, 301(2009)

Majority Model VS NCO Model

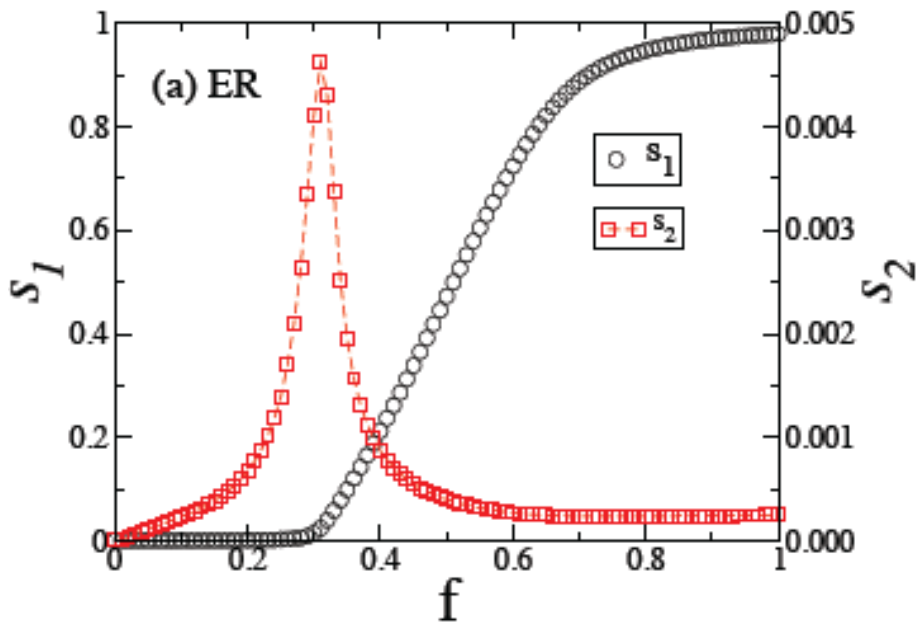


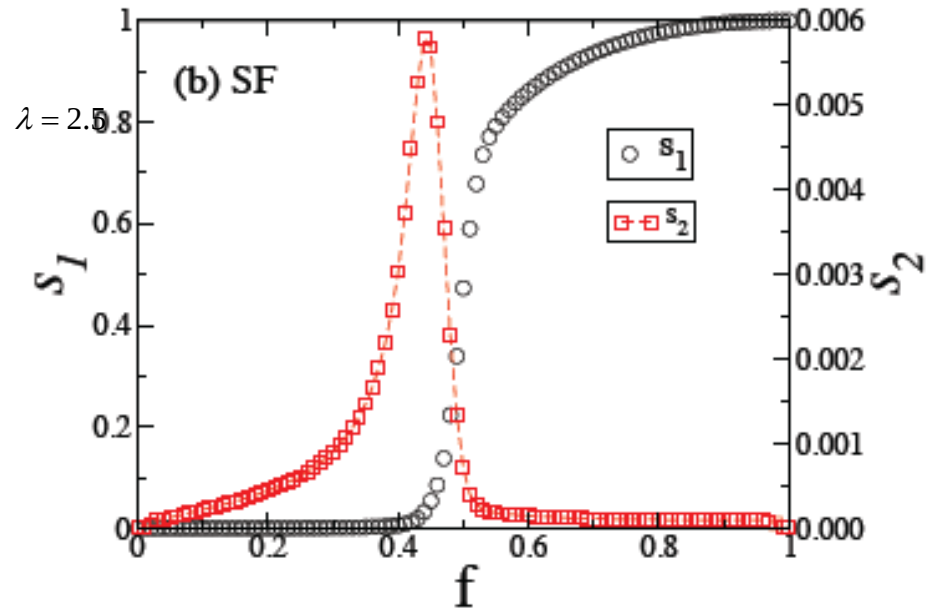


Considering the agent's own opinion leads to non-consensus state

NCO Model on Single Networks

f : Initial fraction of one of the opinions



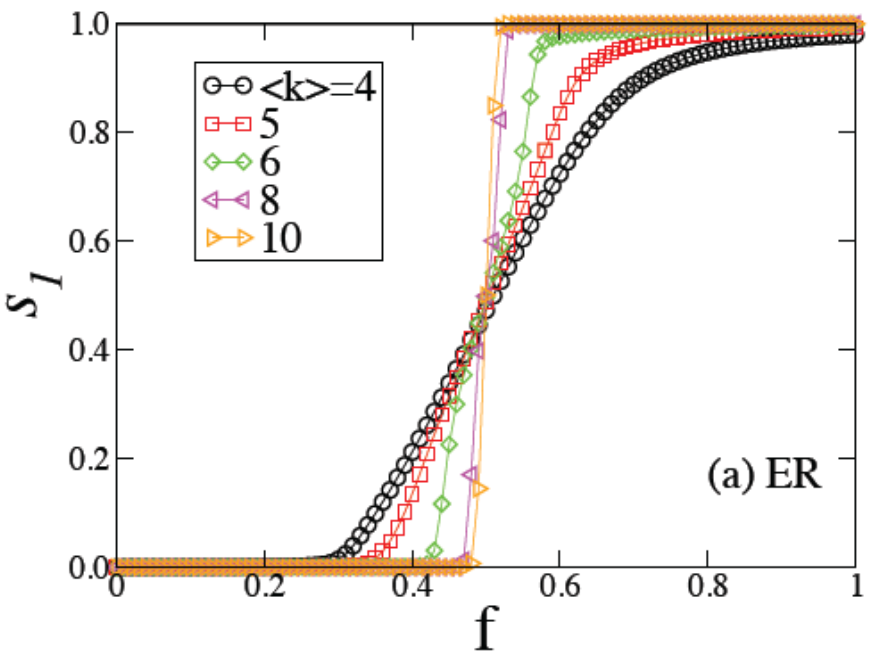


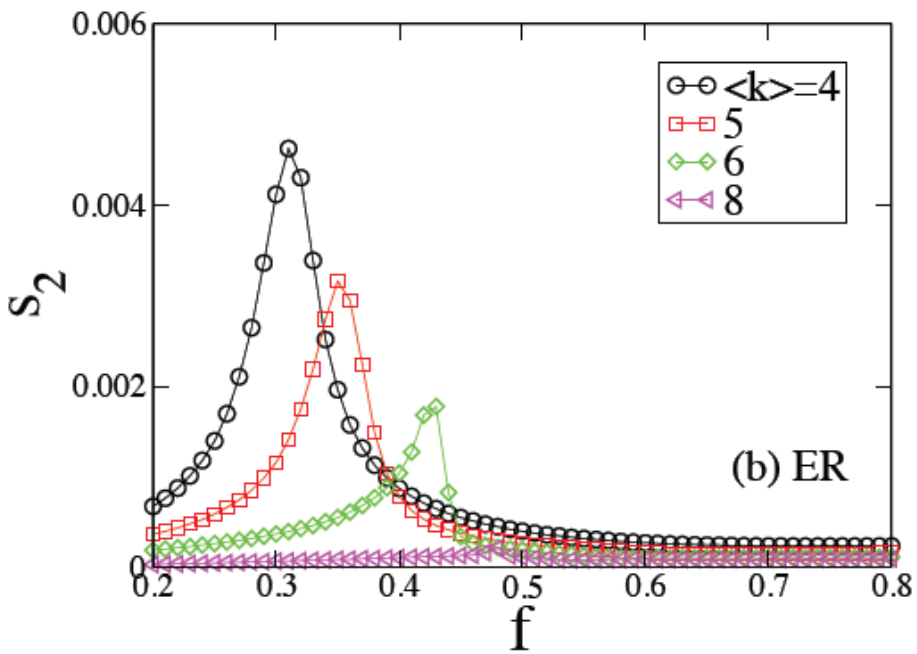
ER networks with average degree=4

SF networks with

Consensus Opinion Models ? **Non-Consensus Opinion Models**

- Increase The Average Degree of the Networks

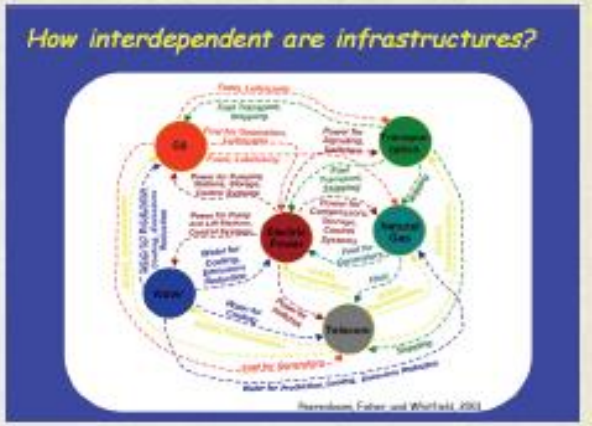




When the average degree of the networks increases, the importance of one's own opinion decreases and the NCO model converges to the Majority Rule model

NCO on Coupled Networks

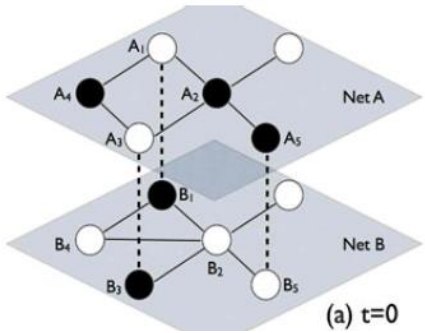
Why Coupled Networks ?

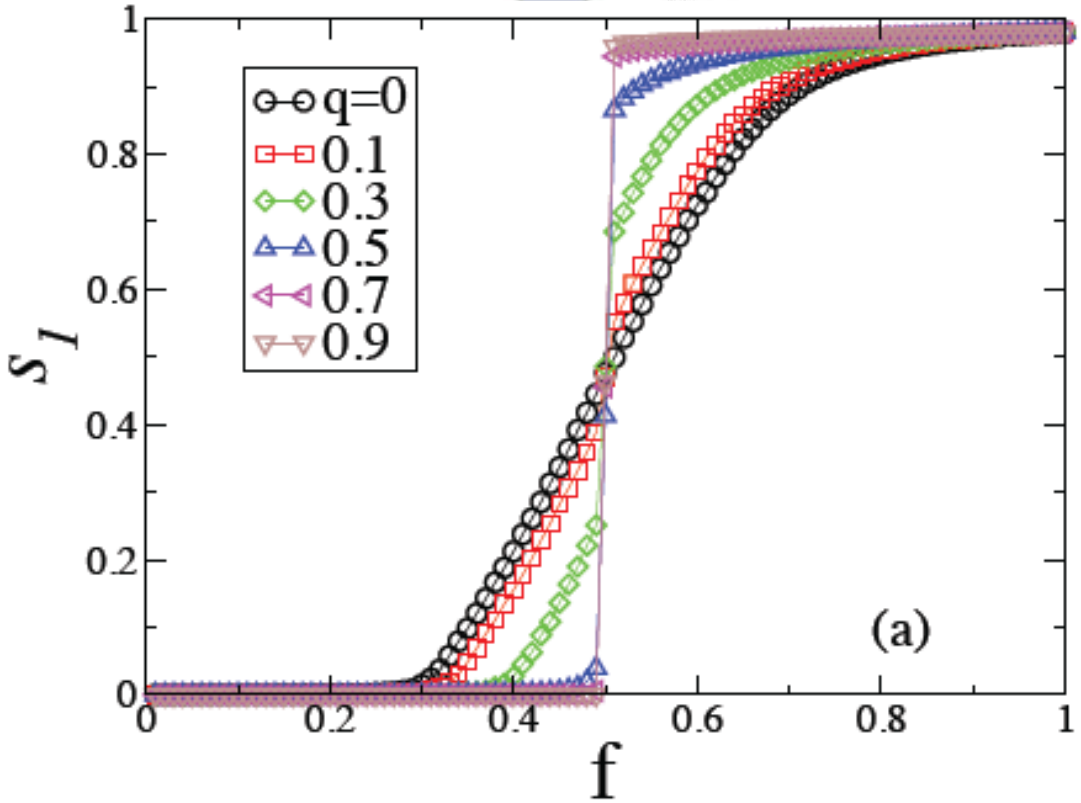


Almost All Real Networks are Inter-connected

Interdependent networks model: S. V. Buldyrev, R. Parshani, G. Paul, H. E. Stanley, and S. Havlin, Nature (2010)

NCO Model on Coupled Networks





Second Order Transition (NCO on Single Network)

↓

Hybrid Transition

(Abrupt Transition Dominate)

Similar to percolation in interdependent networks Buldyrev et al , Nature (2010)

Qian Li, L.A. Braunstein, H. Wang, J. Shao, H.E. Stanley, S. Havlin, J. Stat. Phys. 151, 92 (2013)

FOUR QUESTION ON SOCIAL NETWORKS---PARTIAL ANSWERS

MAIN MESSAGES:

How social networks are created? **Gallos et al PRX (2012)**

Motifs occur significantly in social interactions

How to identify influential spreaders? **Kitsak et al Nature Phys. (2010)**

In many cases K-shell better than degree or betweeness

How opinions are formed? **Shao et al, PRL (2009)**

Qian Li et al J. Stat. Phys (2013)

Agent's own opinion should be considered

How extreme opinions occur? **Makse et al preprint (2013)**

Agents surrounding by less extreme people are more stubborn