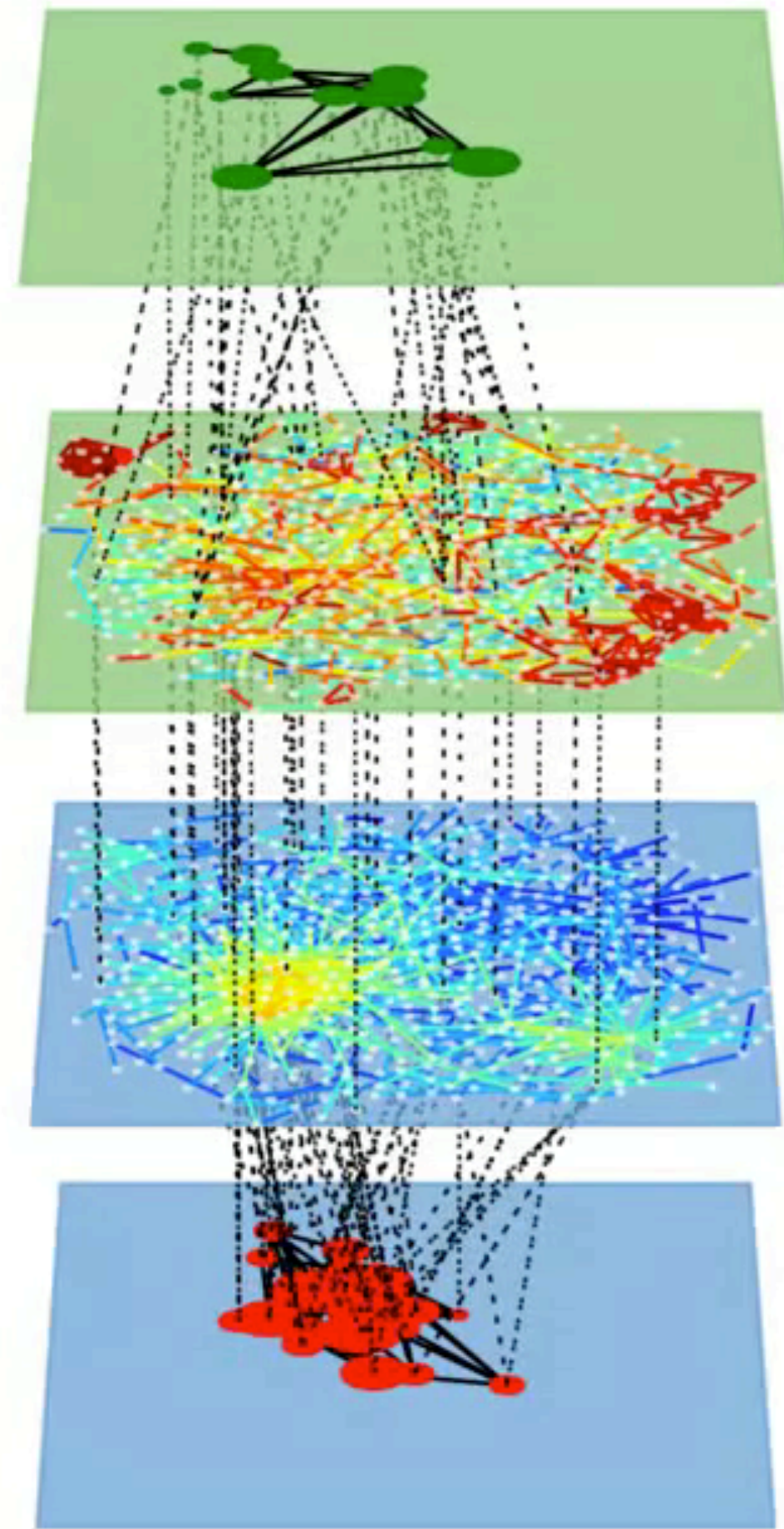


Polarisation, social groups, and multilayer networks



Mikko Kivela

Assistant professor

Academy of Finland research fellow

 @bolozna

www.mkivela.com



The white house



CC BY-NC-SA 2.0
Exit photo team



Alisdare Hickson
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Why are we in homogeneous groups?

The white house

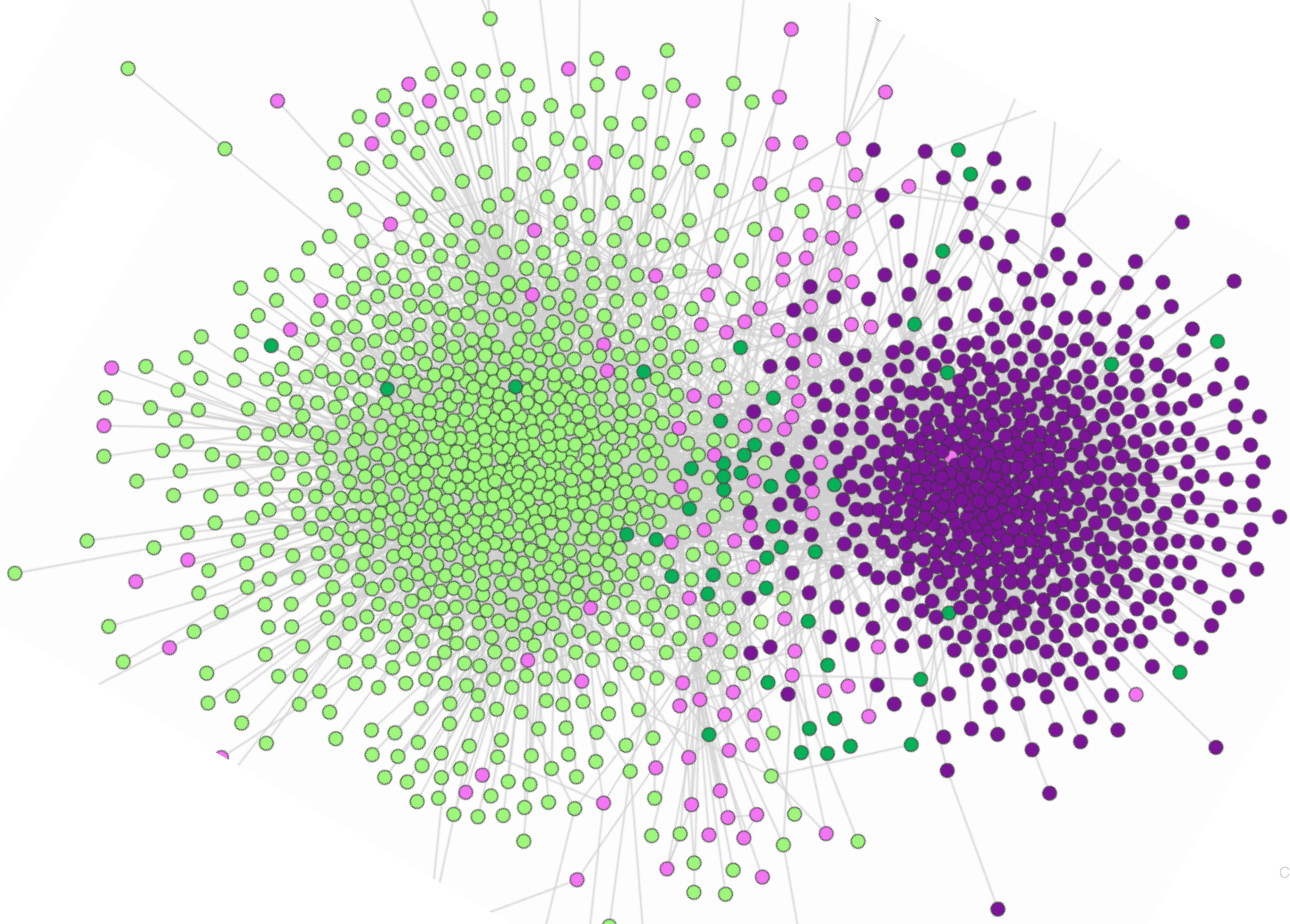


Is it only by choice?

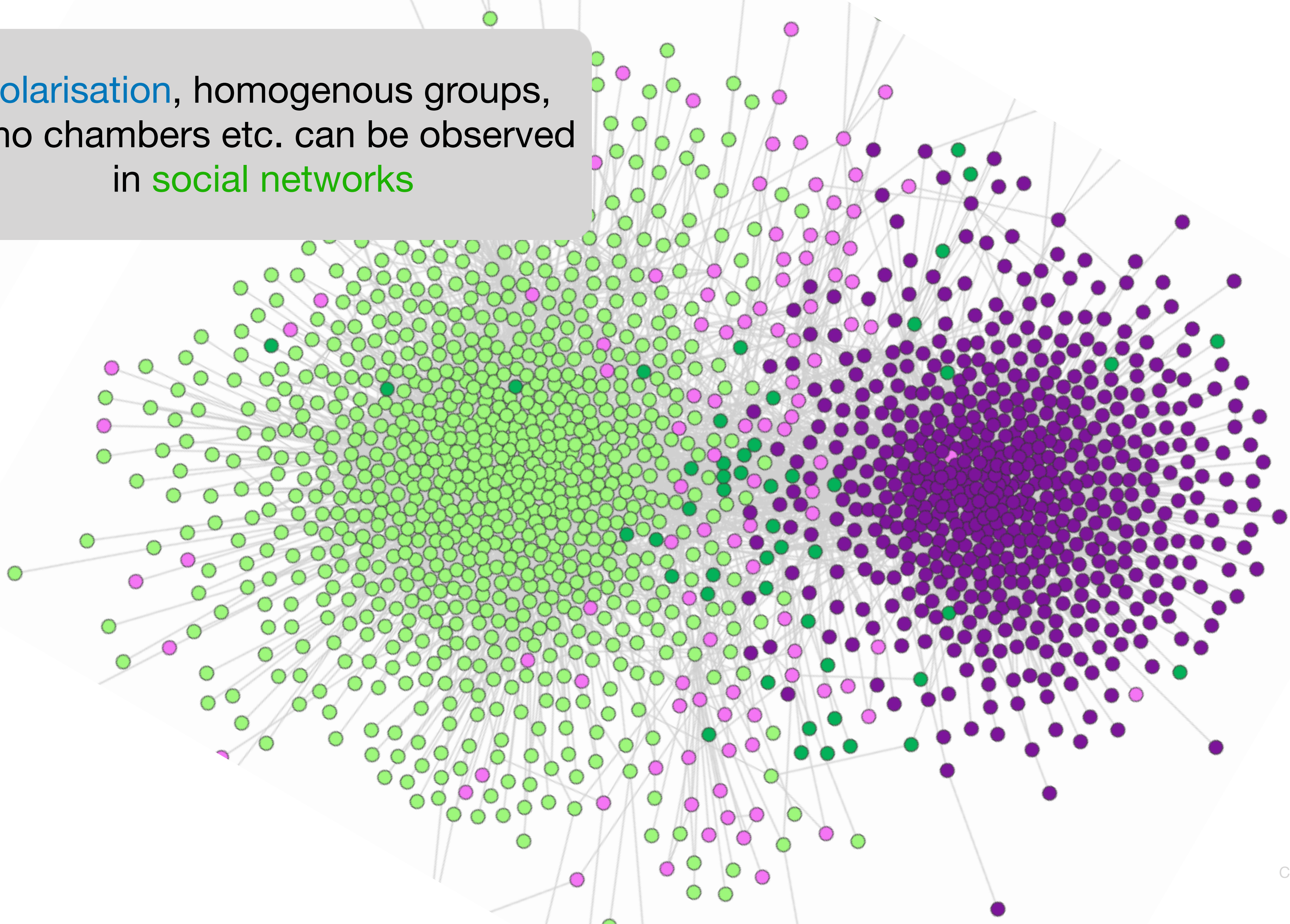


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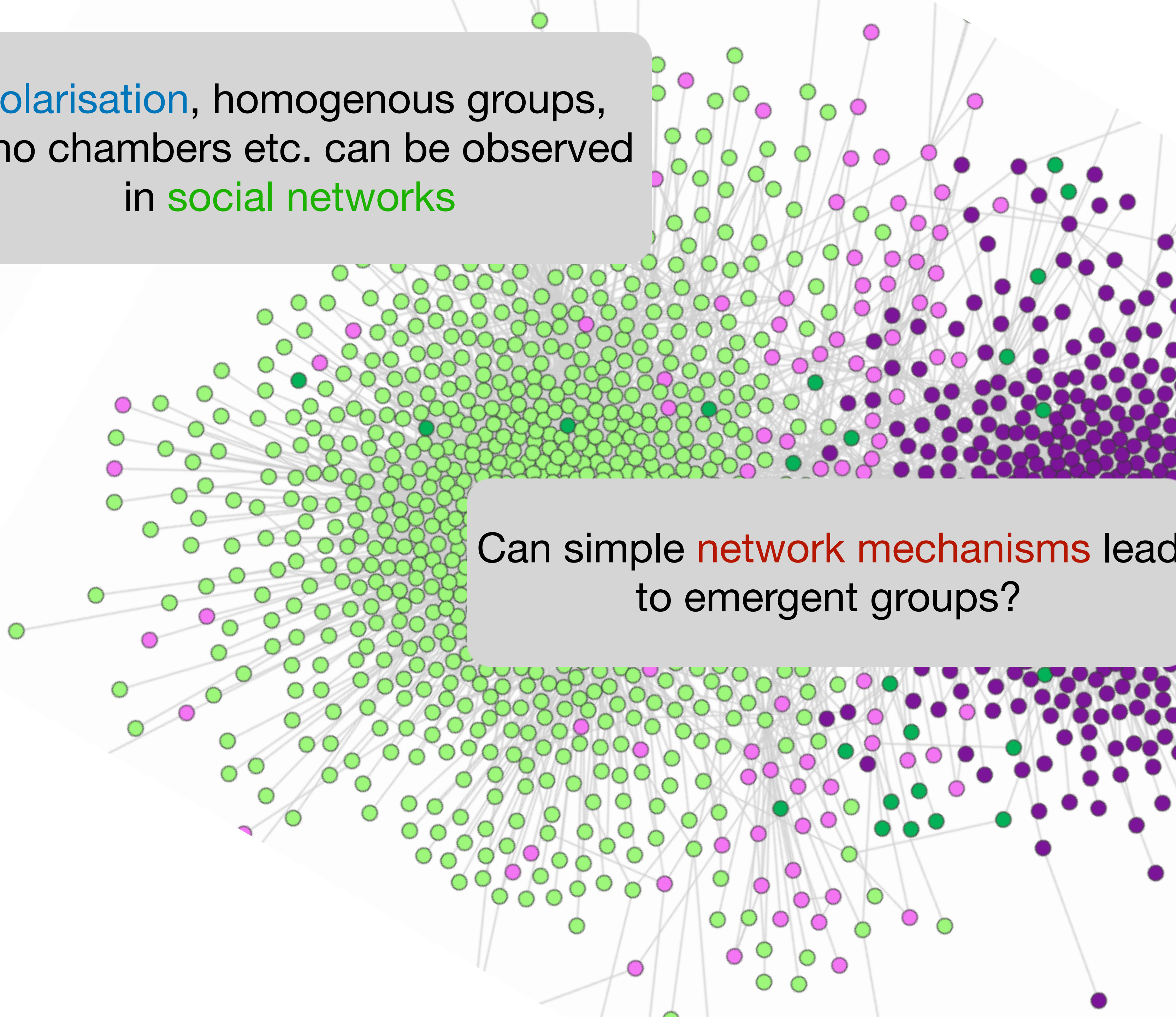
Alisdare Hickson
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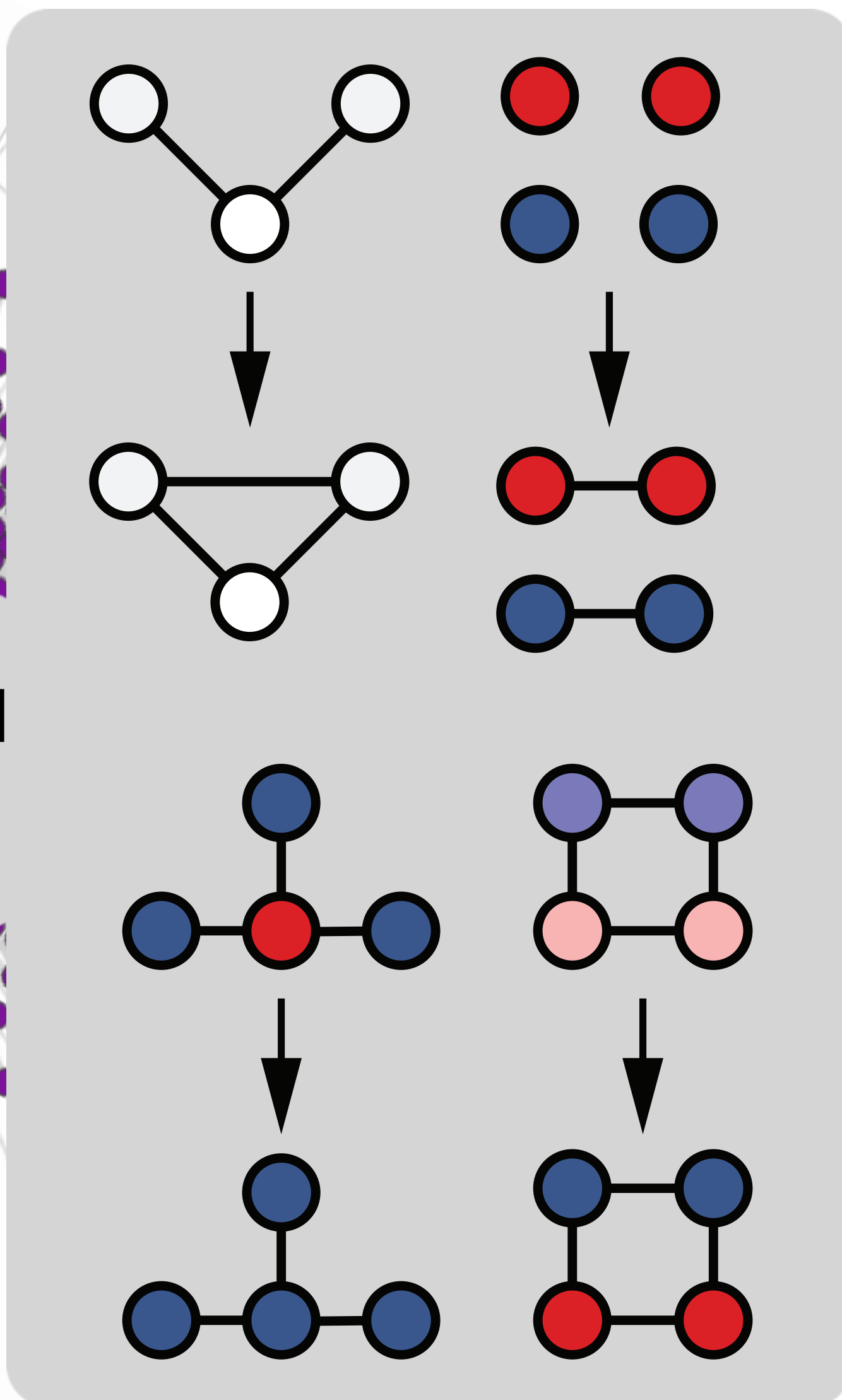
Polarisation, homogenous groups, echo chambers etc. can be observed in **social networks**



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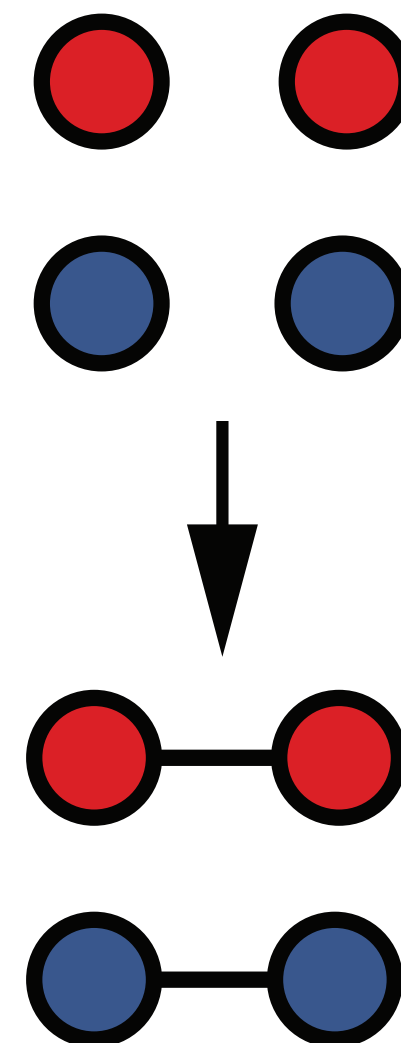
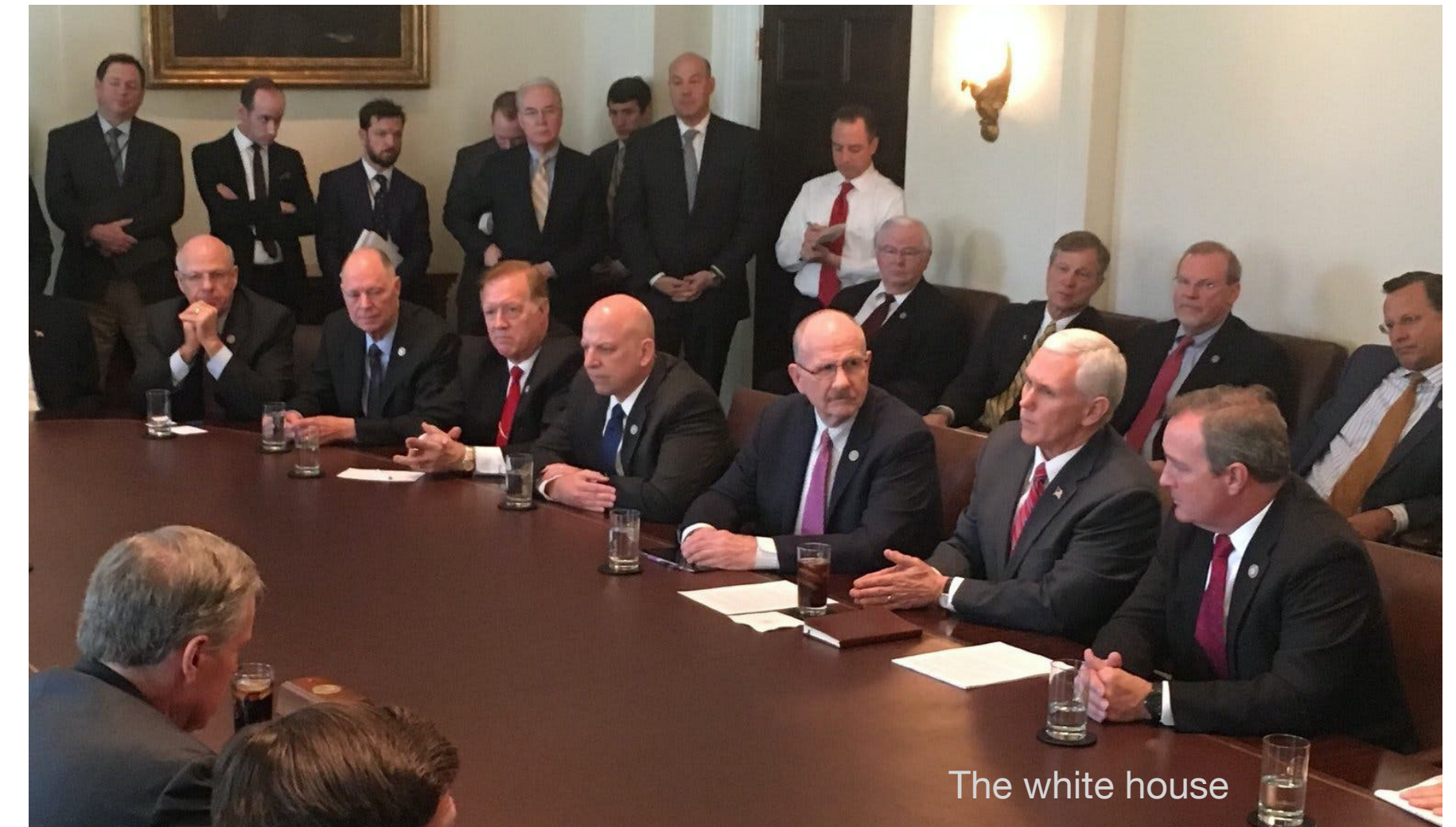
Can simple **network mechanisms** lead to emergent groups?



Why are we in homogenous groups?

(choice) **homophily**, we are more likely to connect to similar people

- *Is this enough? Are the massively homogeneous groups we see reflecting peoples tendencies?*



McPherson 1987
McPherson 2001

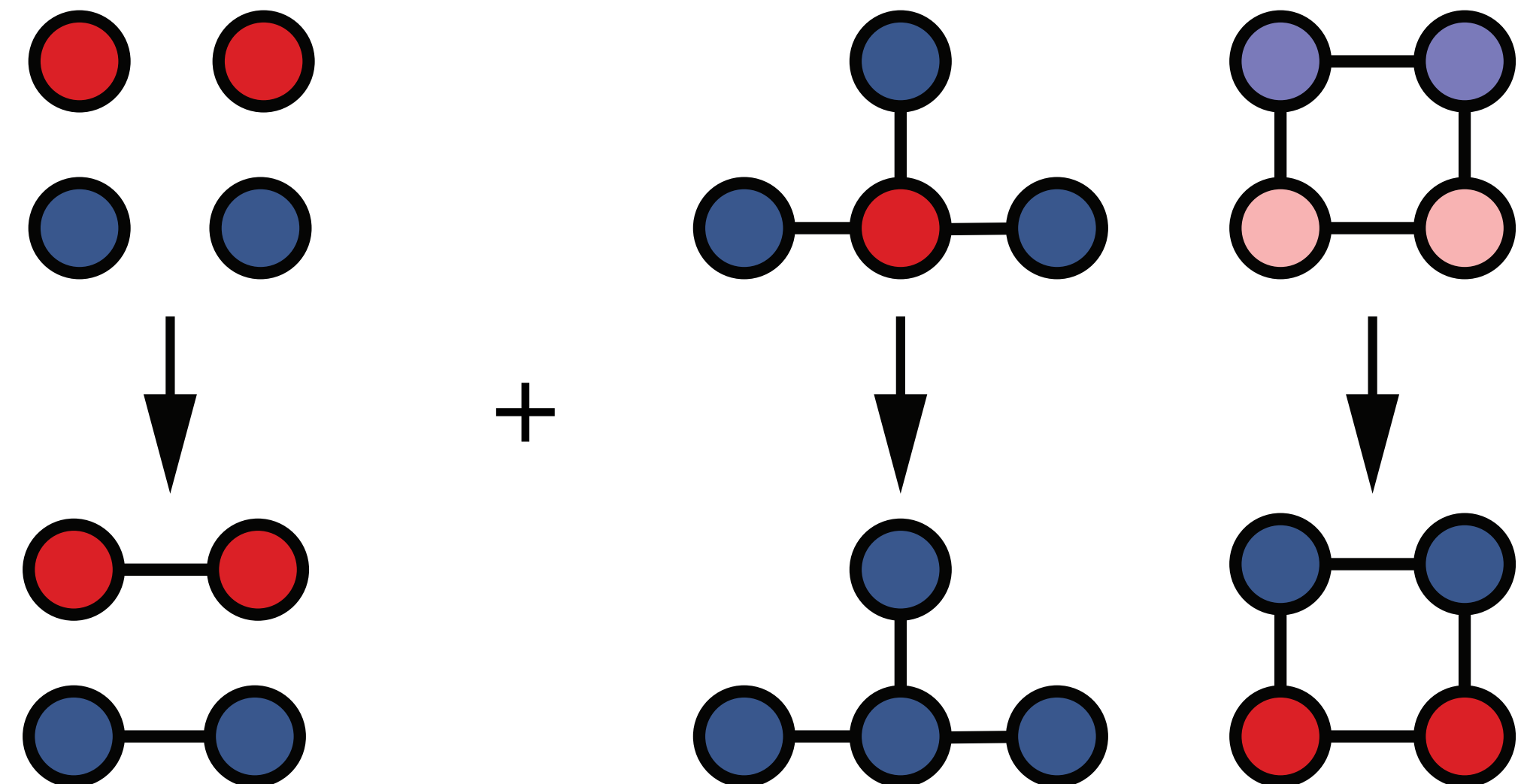
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Homophily + influence/adaption
(Axelrod's model, coevolution models)

- *What about features that are difficult/slow/impossible to change? Ethnicity, gender, social class, ...*



Axelrod 1997
Holme 2006
Vazquez 2007

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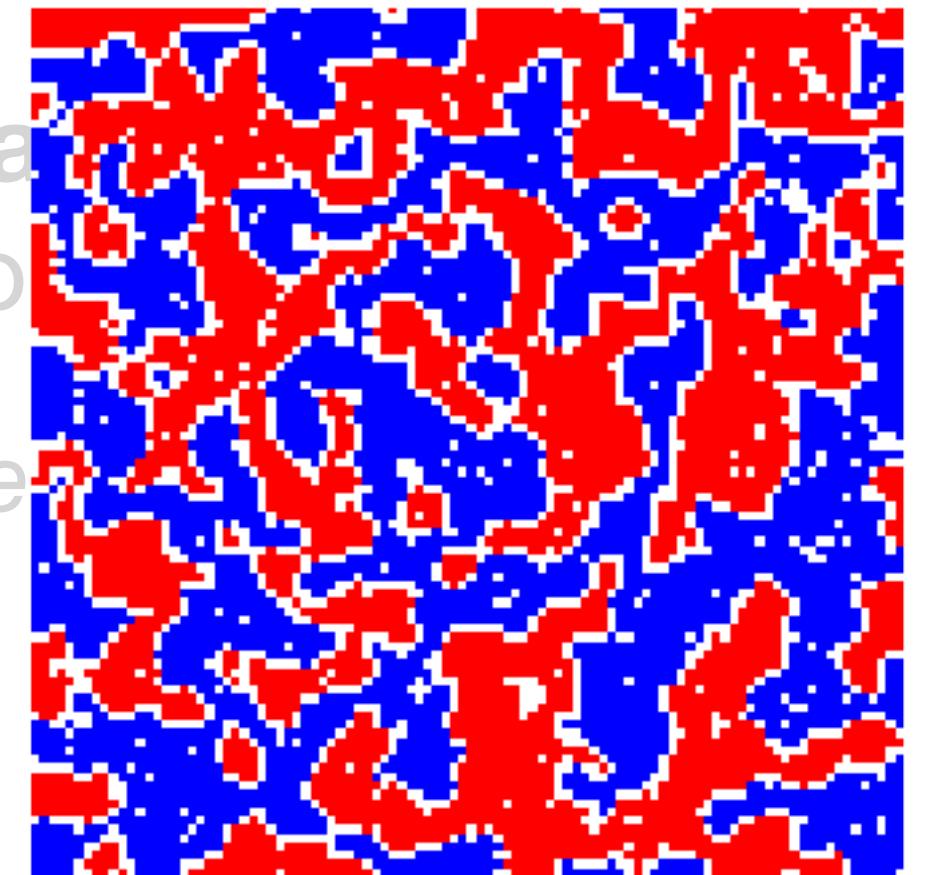
Homophily + spatial constraints \Rightarrow induced homophily (Schelling model)

- *But physical space has become less important. Our social space is our social networks.*

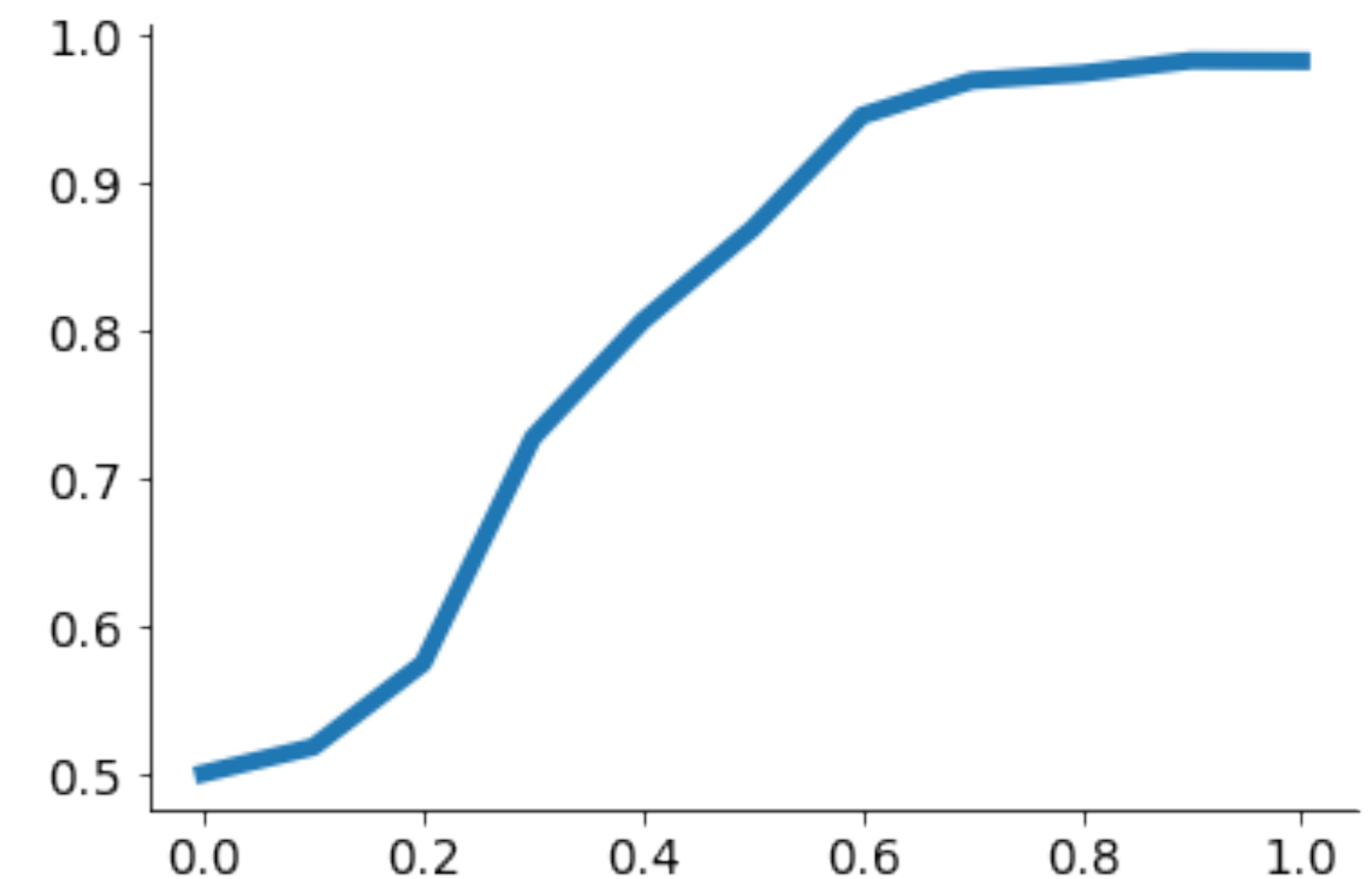
Schelling 1971

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Fraction of neighbors from the same groups



Preference for neighbors within group (choice homophily)

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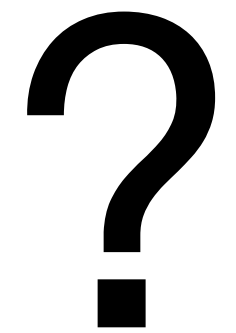
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⇒ induced homophily

- *What are the network constraints?*
- *"Schelling model" for networks?*



Why are we in homogenous groups?

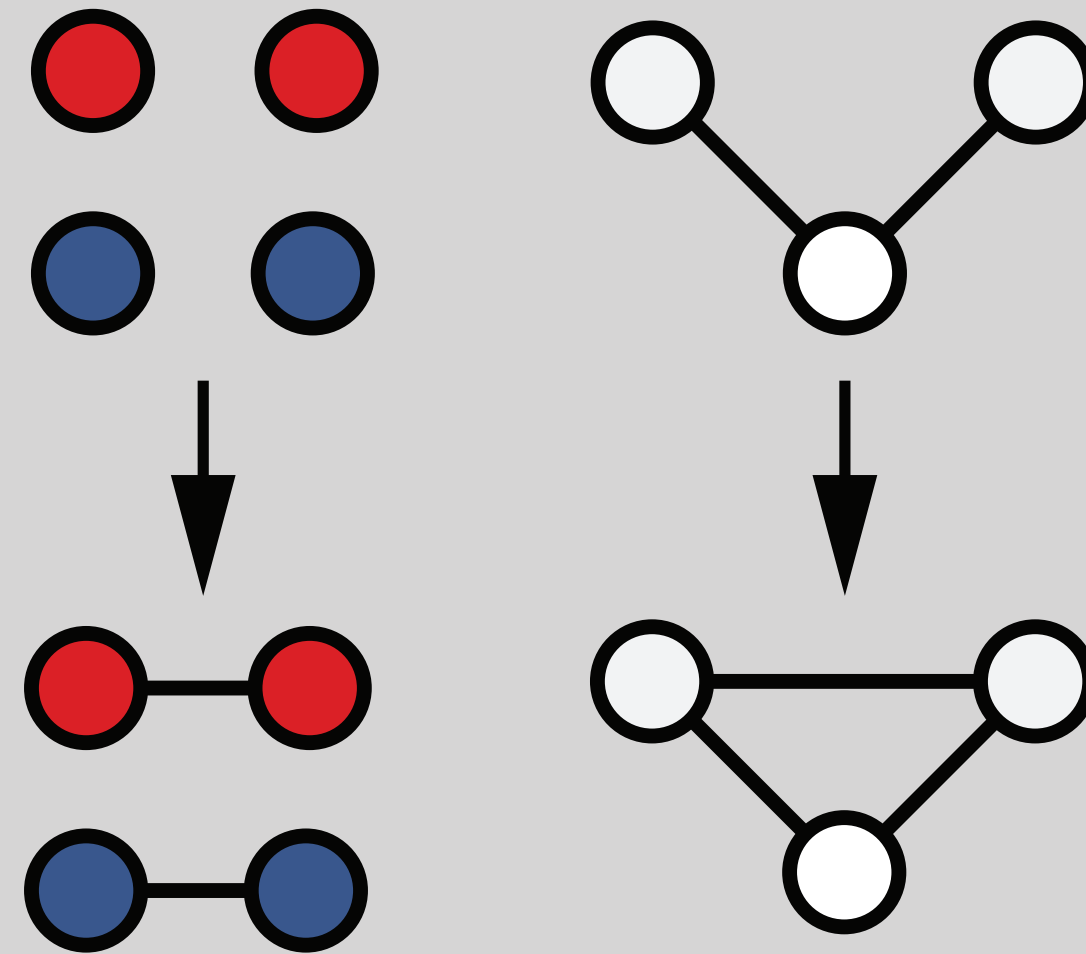
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homophily + triadic closure

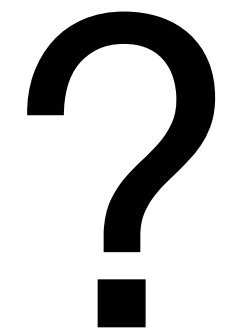


influence/adaption
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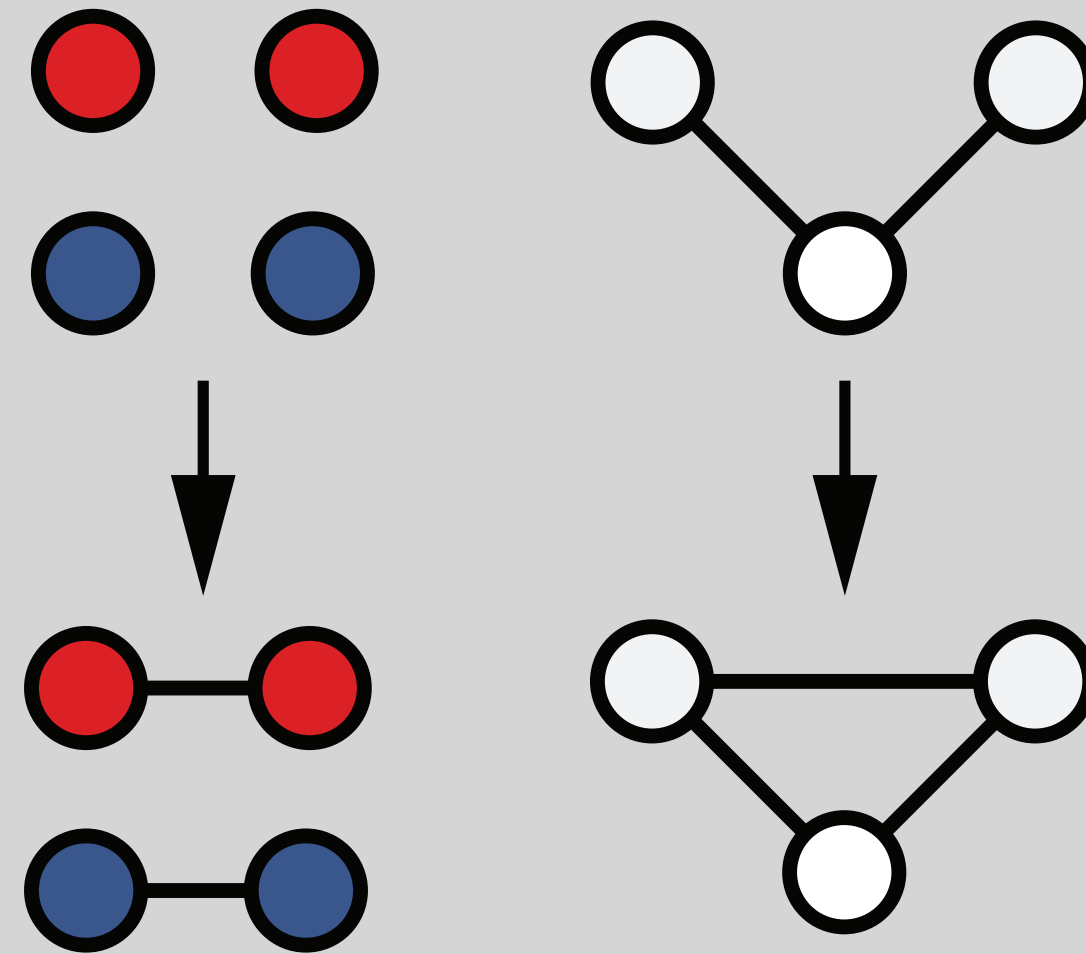
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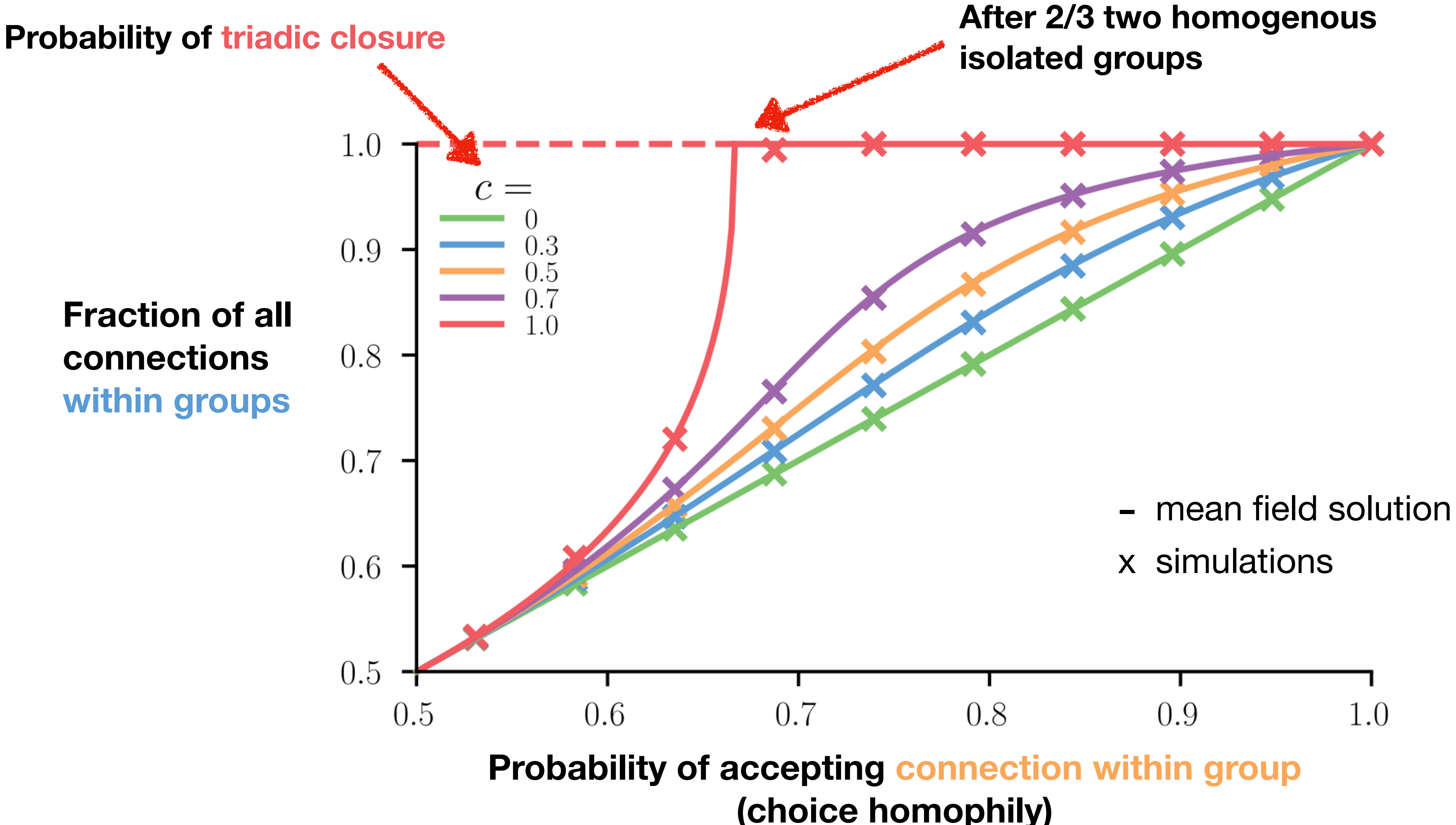


- Meet new people through
previous connections
- Empirically: the most common
structural mechanism
- Recommendation systems often
work via triadic closure

- What are the network constraints?
- "Schelling model" for networks?



Homophily amplification via triadic closure

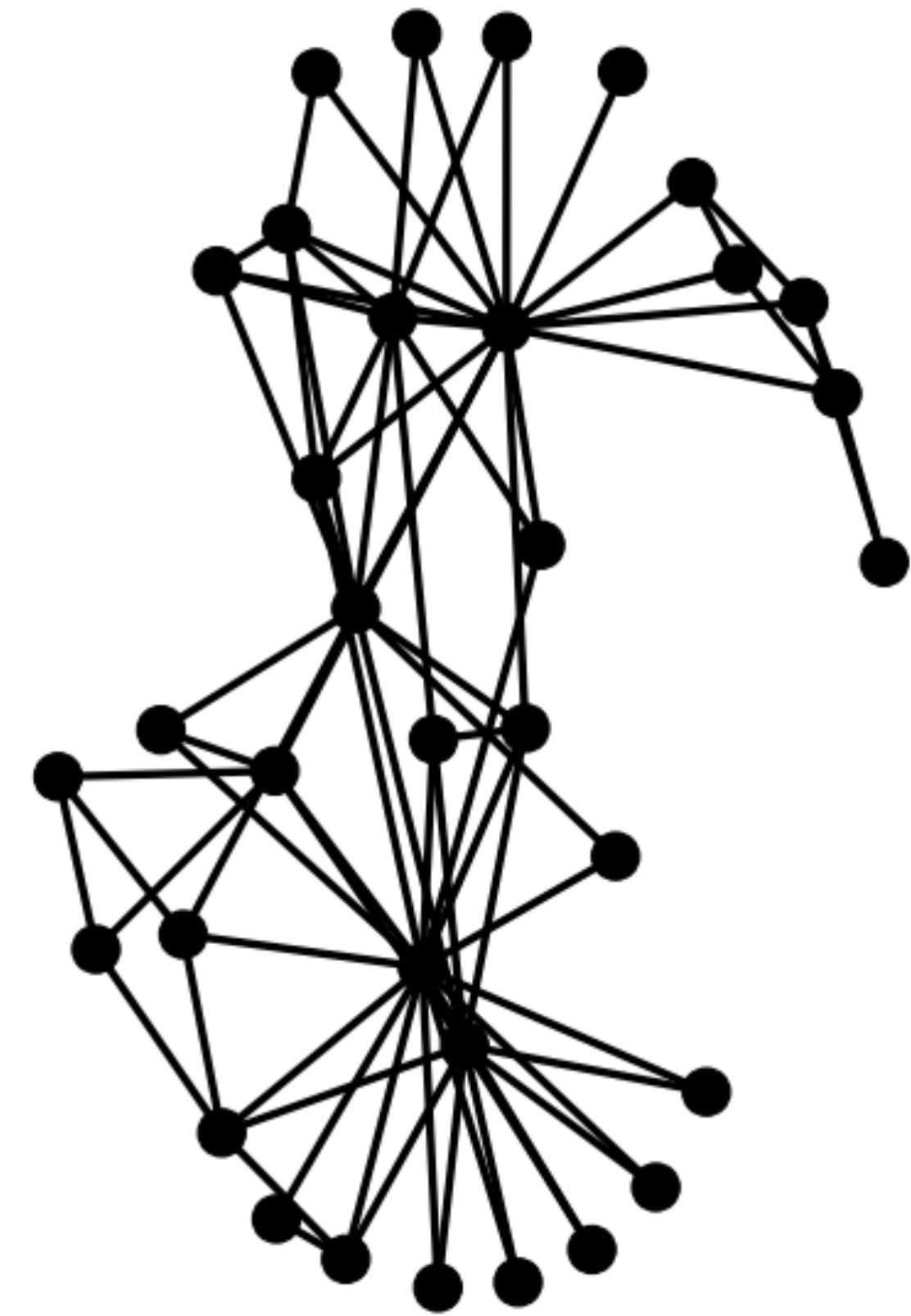


Network representations – are simple graphs enough?



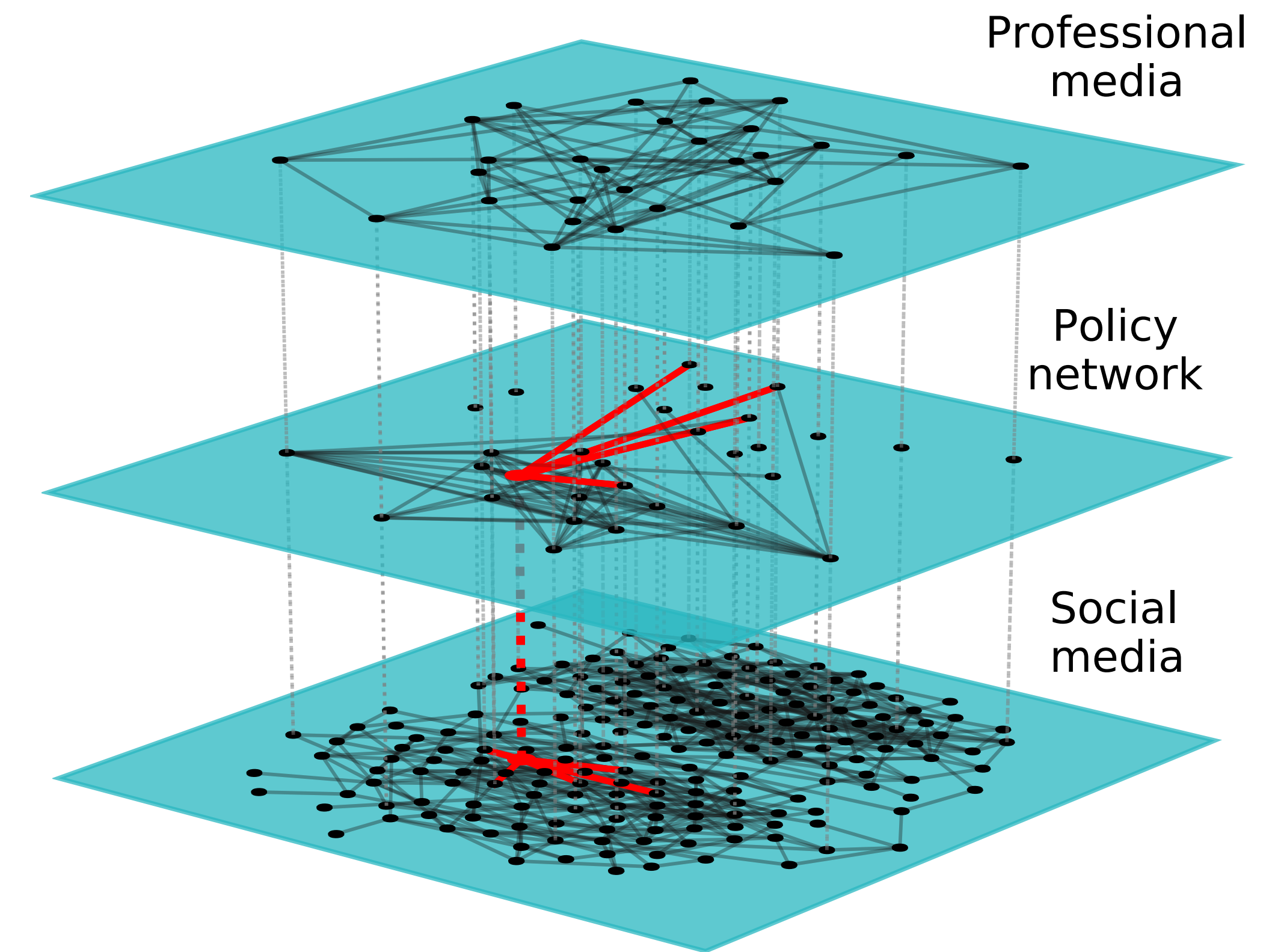
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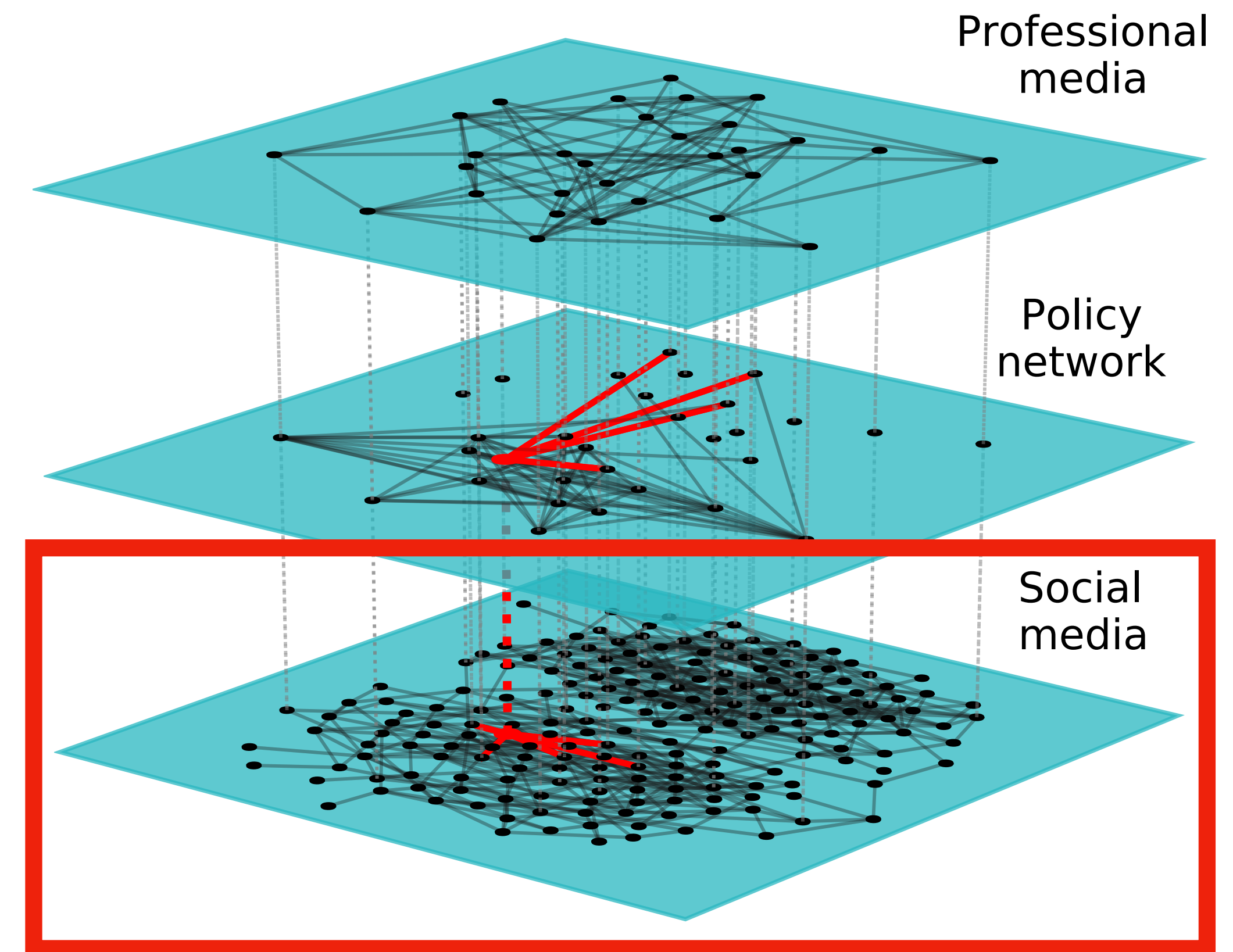
Multilayer networks of political communication

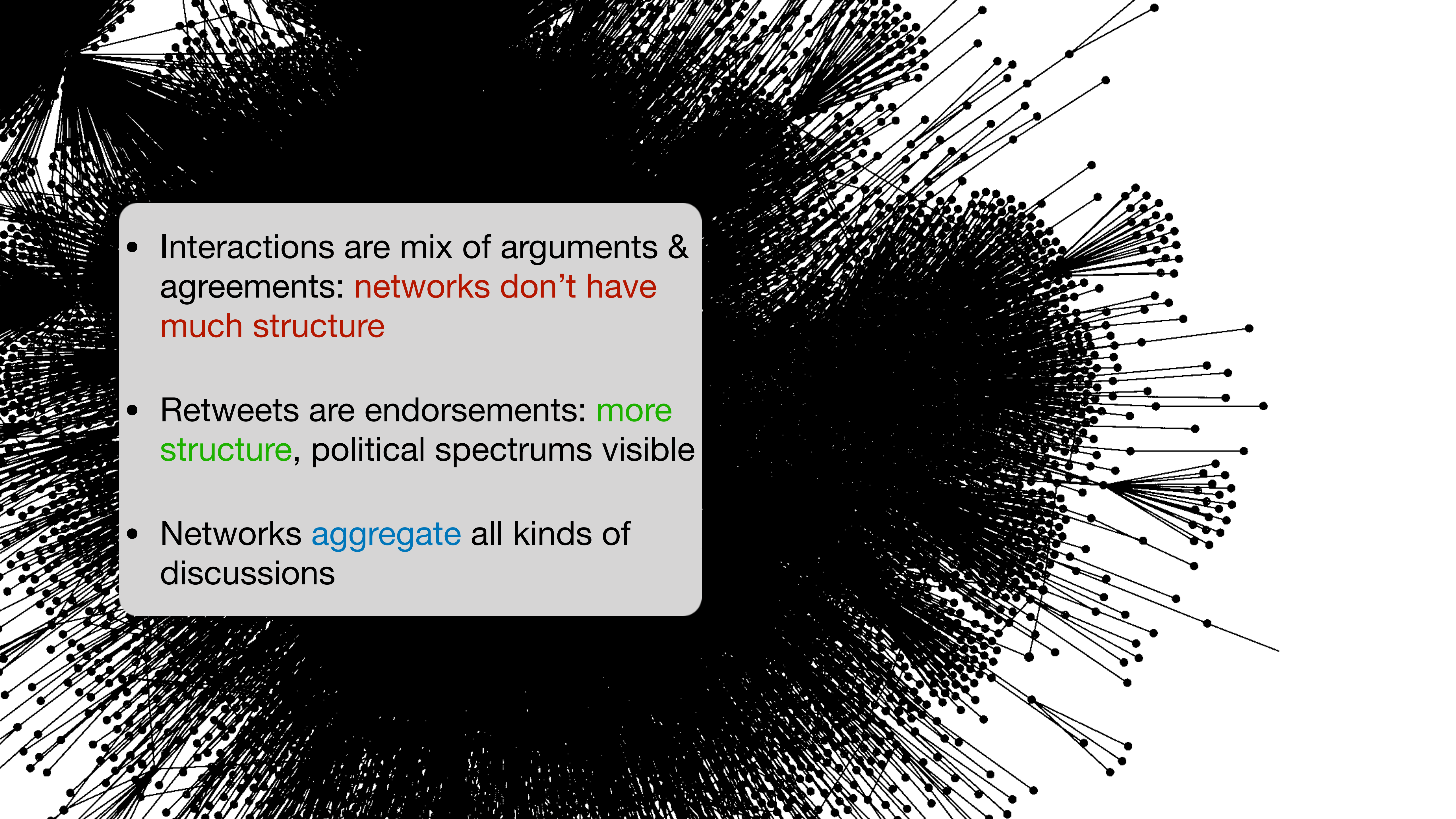
- Political communication **is not just a single system** which should be represented by a **single network**
- Two approaches:
 1. Networks are reflections of multiple (latent) networks
 2. Networks are part of a larger system (figure)



Multilayer networks of political communication

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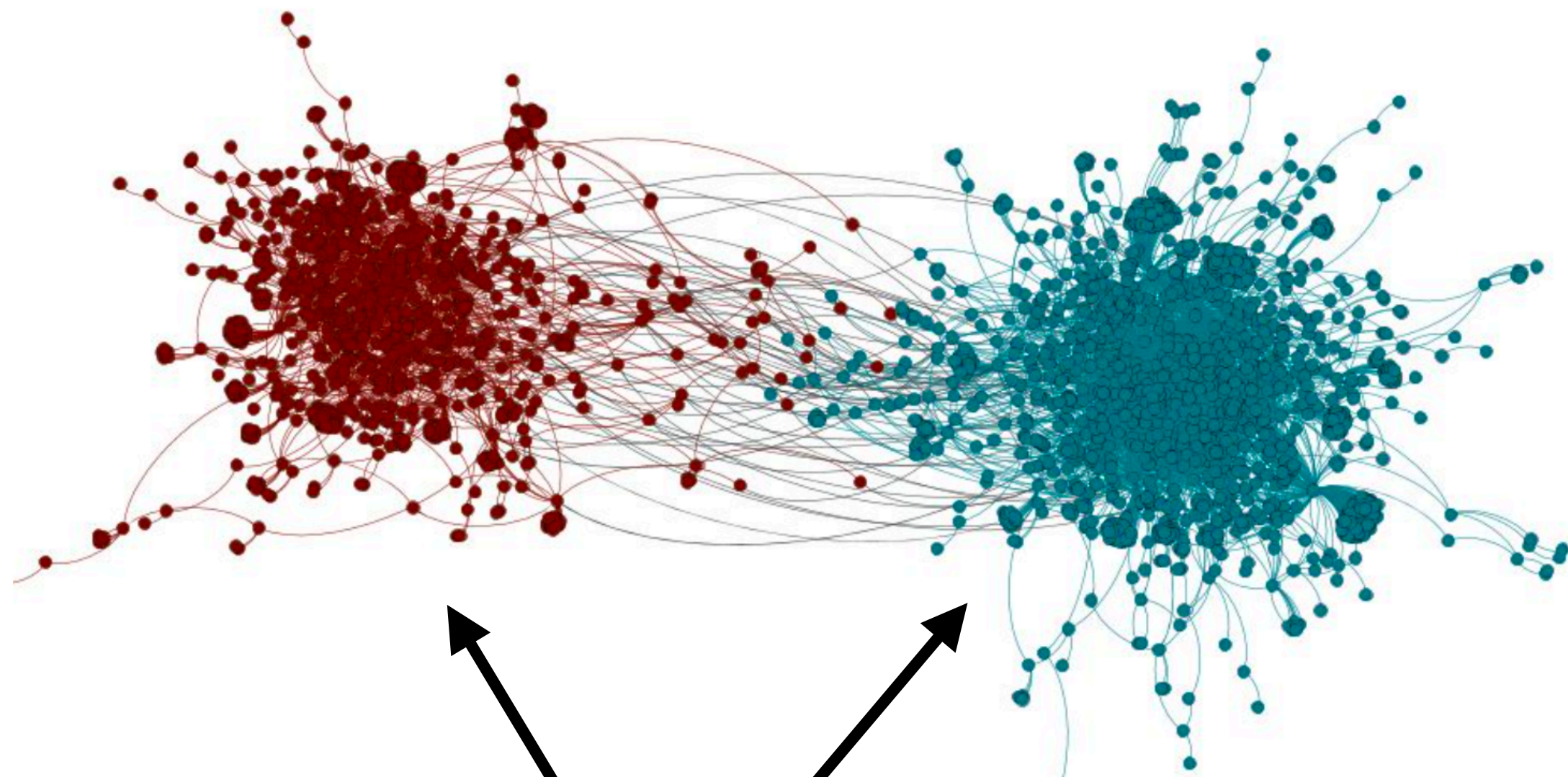


- 
- Interactions are mix of arguments & agreements: **networks don't have much structure**
 - Retweets are endorsements: **more structure**, political spectrums visible
 - Networks **aggregate** all kinds of discussions

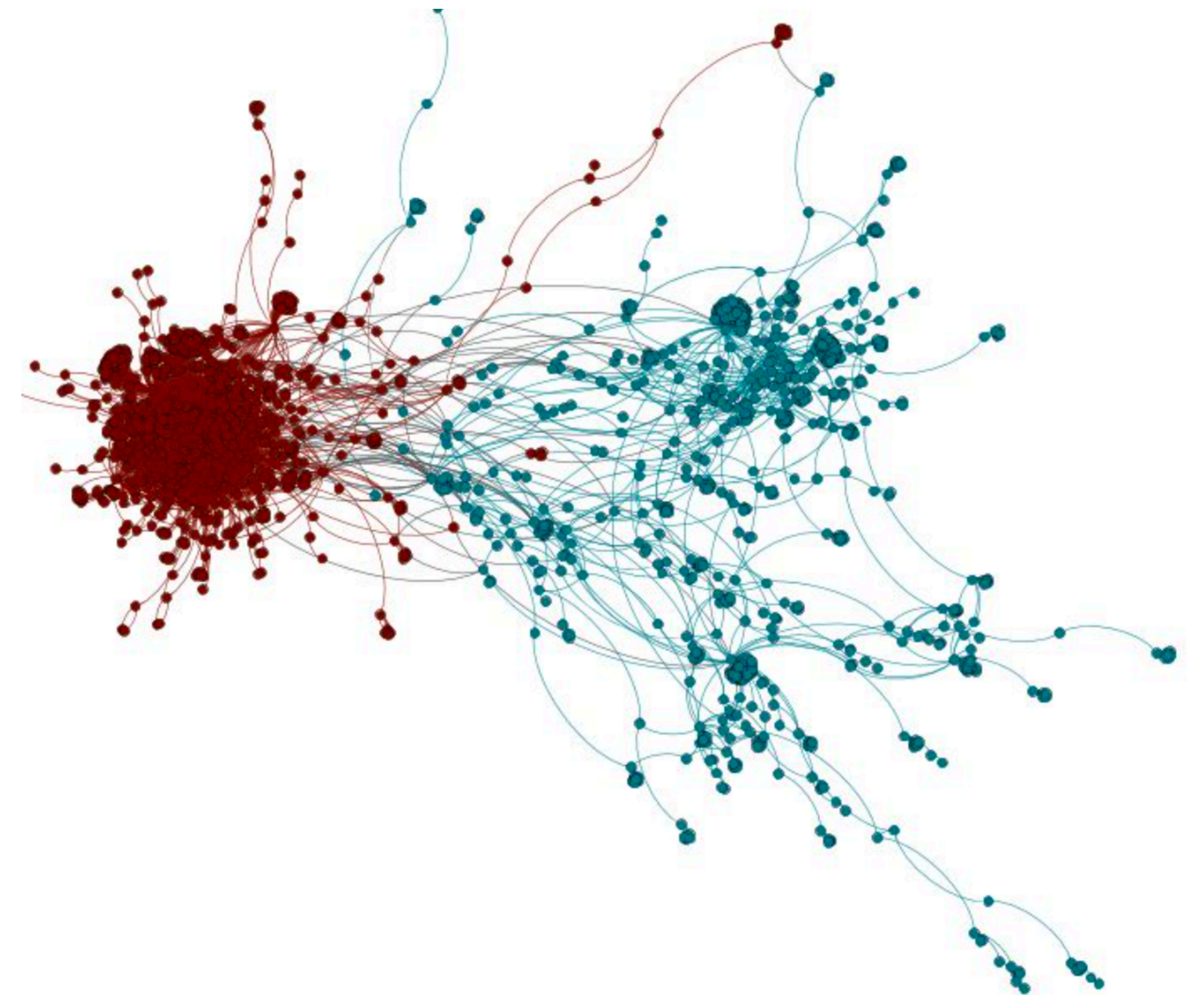


Many topic-based networks are clearly polarised

Green Party



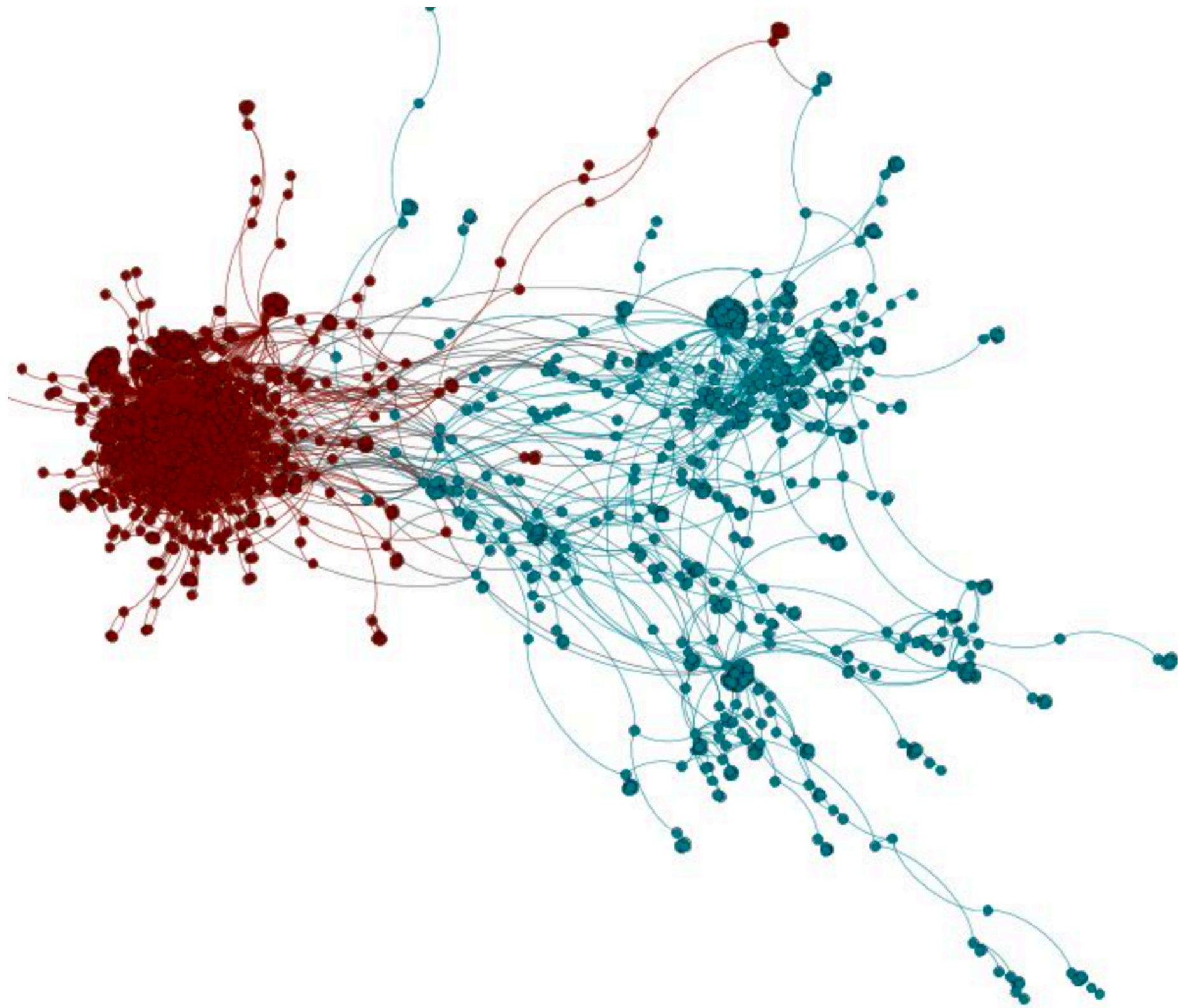
Immigration



Colors: groups found with a
graph clustering method

What about the content?

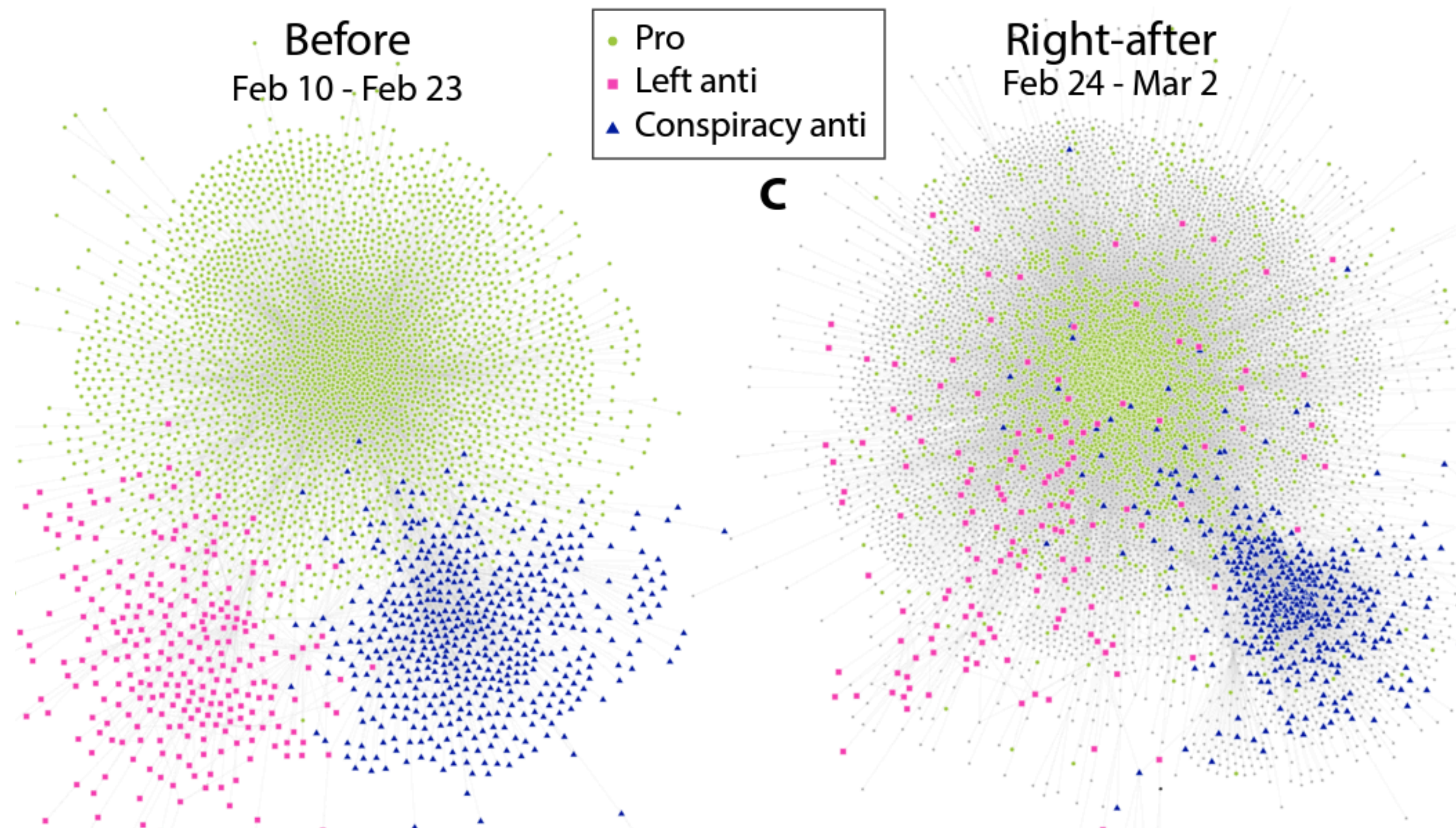
Immigration



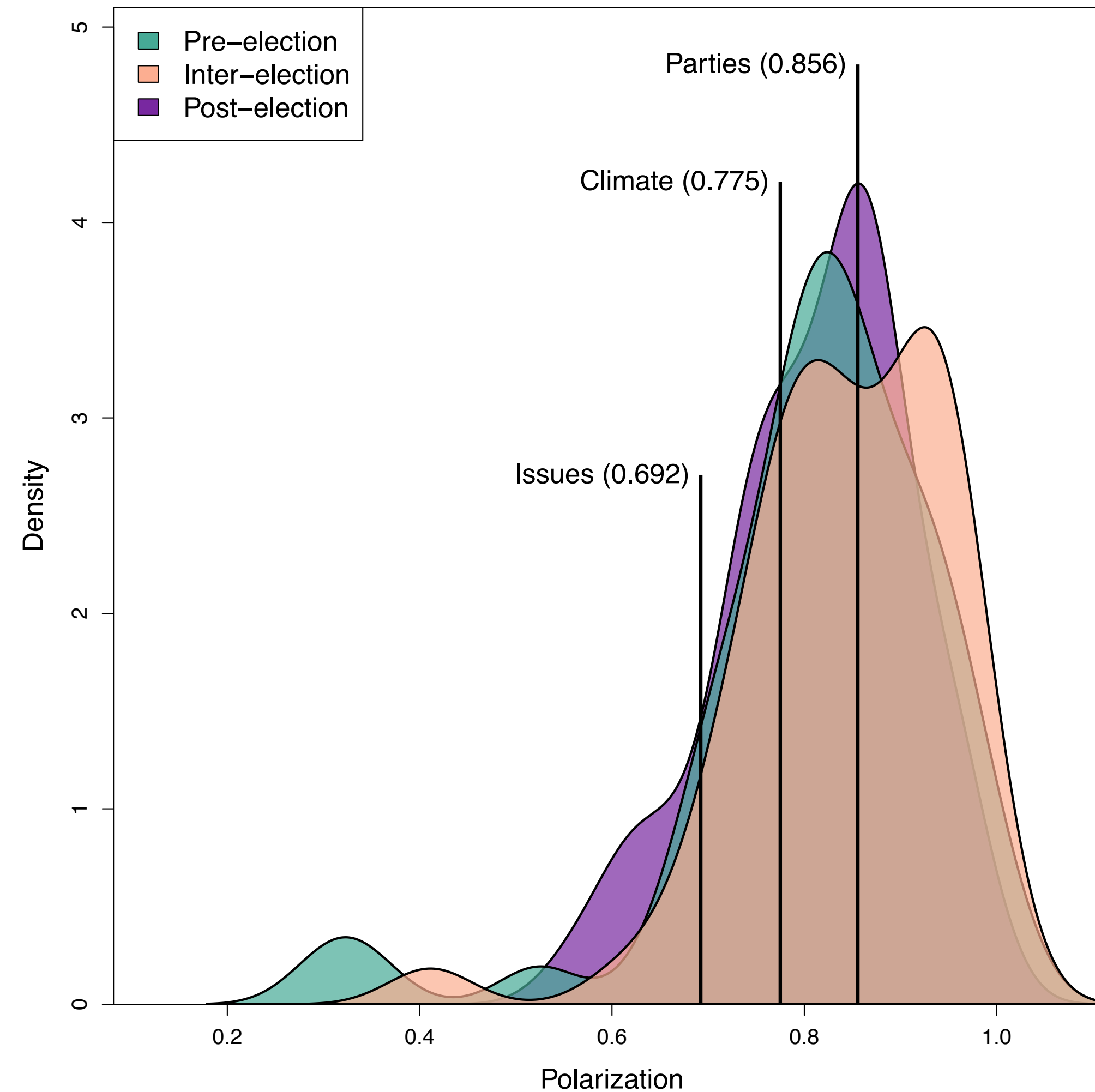
1. Our country's population grew by 370 people in January. The growth was maintained by immigration, because there were 1,331 more immigrants than emigrants. There were 961 less births than deaths. [url] #population #immigration #emigration [url]
2. We are losing our school's cleaner! He is going to work elsewhere: as an assistant professor of peace and conflict research in the University of California. He has lived in Finland 9 years with his family and didn't want to leave. Why is it like this? Read. #immigration [url]
3. The mistakes guided by the 2015 asylum policy program must be corrected in the government platform. Joining families must be made possible, asylum procedure and legal council system must be fixed. [url] #immigration #childrensrights

1. #closetheborders is the only valid #immigration policy. Everything else is insanity and betrayal. #elections2019 #parliamentelections
2. New report: The percentage of sex offences that are made by immigrants is even larger than presented before. 100% in the rapes in public places. "Mismatch is enormous. It cannot be explained by random fluctuations." #sexoffences #immigration [url]
3. Paul Usvalampi (True Finns) urges that #finns could foster their on #identity, hold on to their territories and live there with their own people. Without being force fed multiculturalism. Great article! #immigration [url]

Depolarisation of NATO discussion immediately after the attack



Polarisation measures



Problems with polarisation measures

- Methods work by **first** clustering networks, **then** quantifying how good the clusters are
- **Problem:** One can find very good clusters even in **random** sparse networks
- Likely that these methods will give **high scores** even for **random networks!**

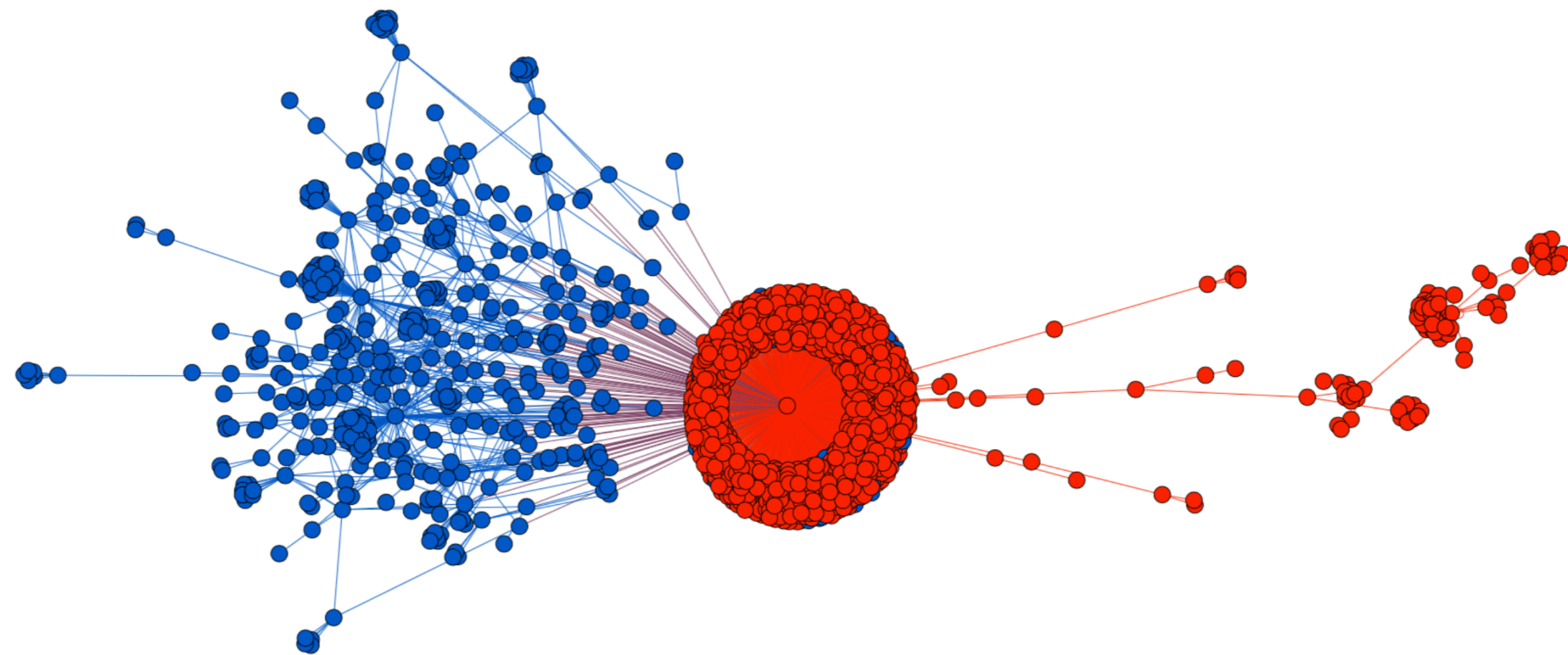


Problems with polarisation measures

Topic: **#translaw**

Original network

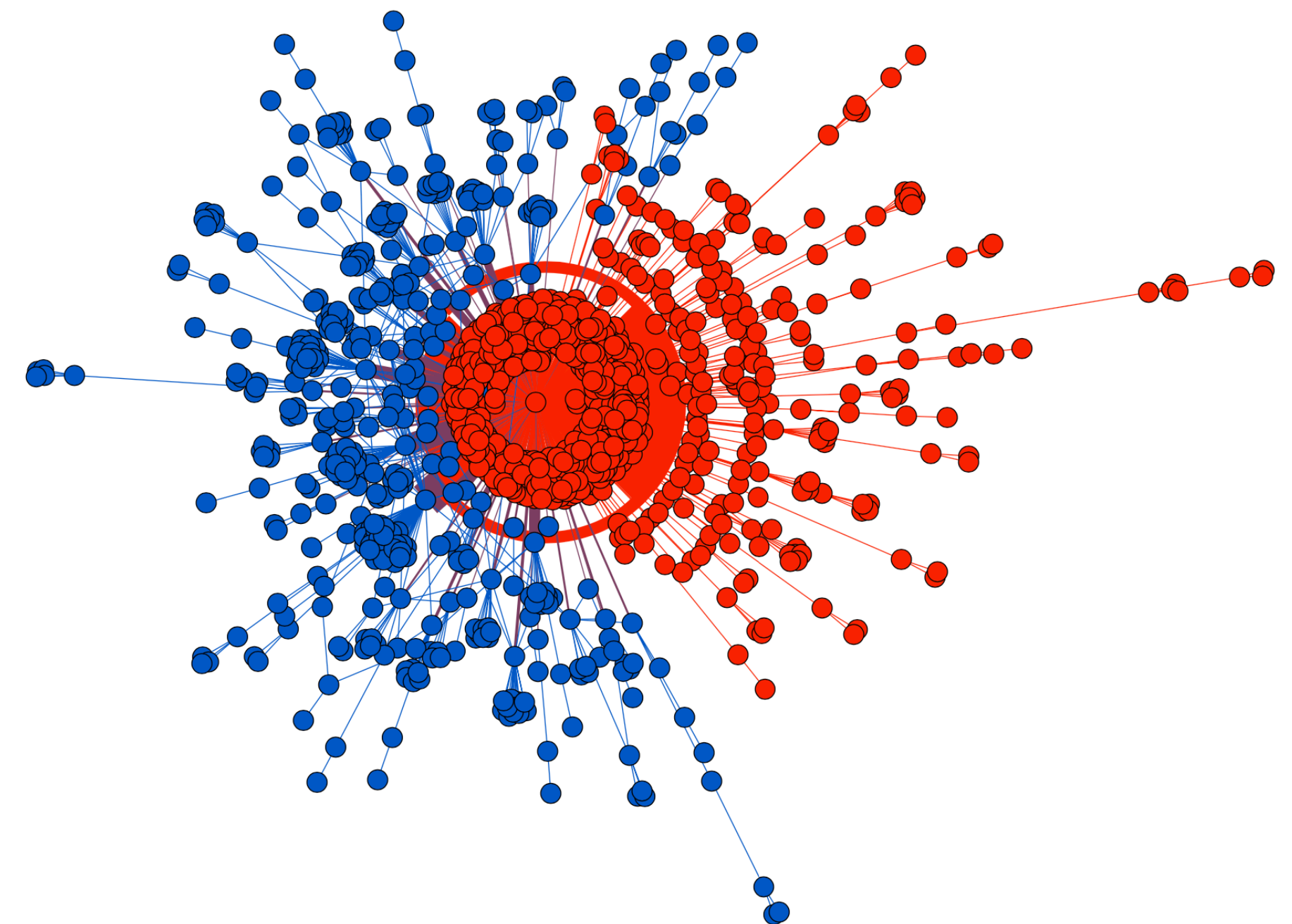
Random walk controversy score: **0.681**



Topic: **#translaw**

Randomised network

Random walk controversy score: **0.736**

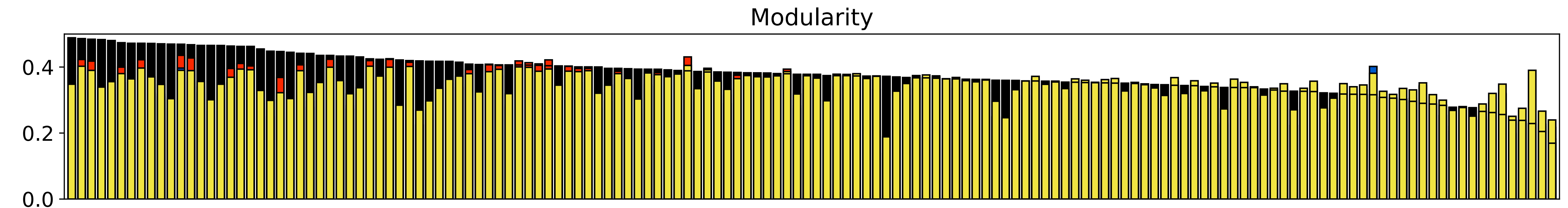
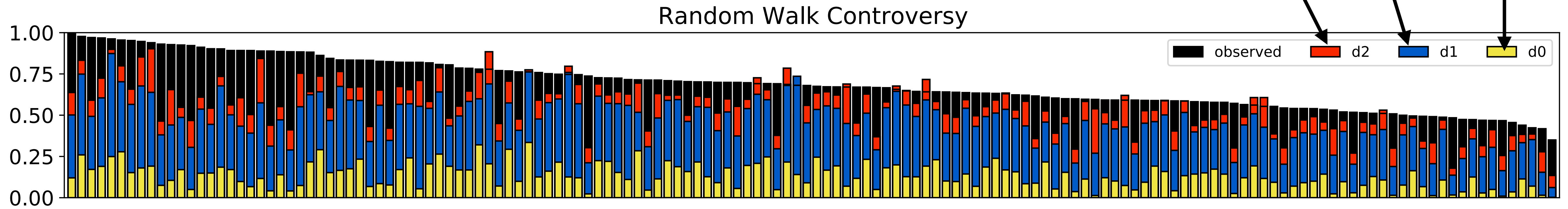


Problems with polarisation measures

Erdős-Rényi model:
keep *number of links*

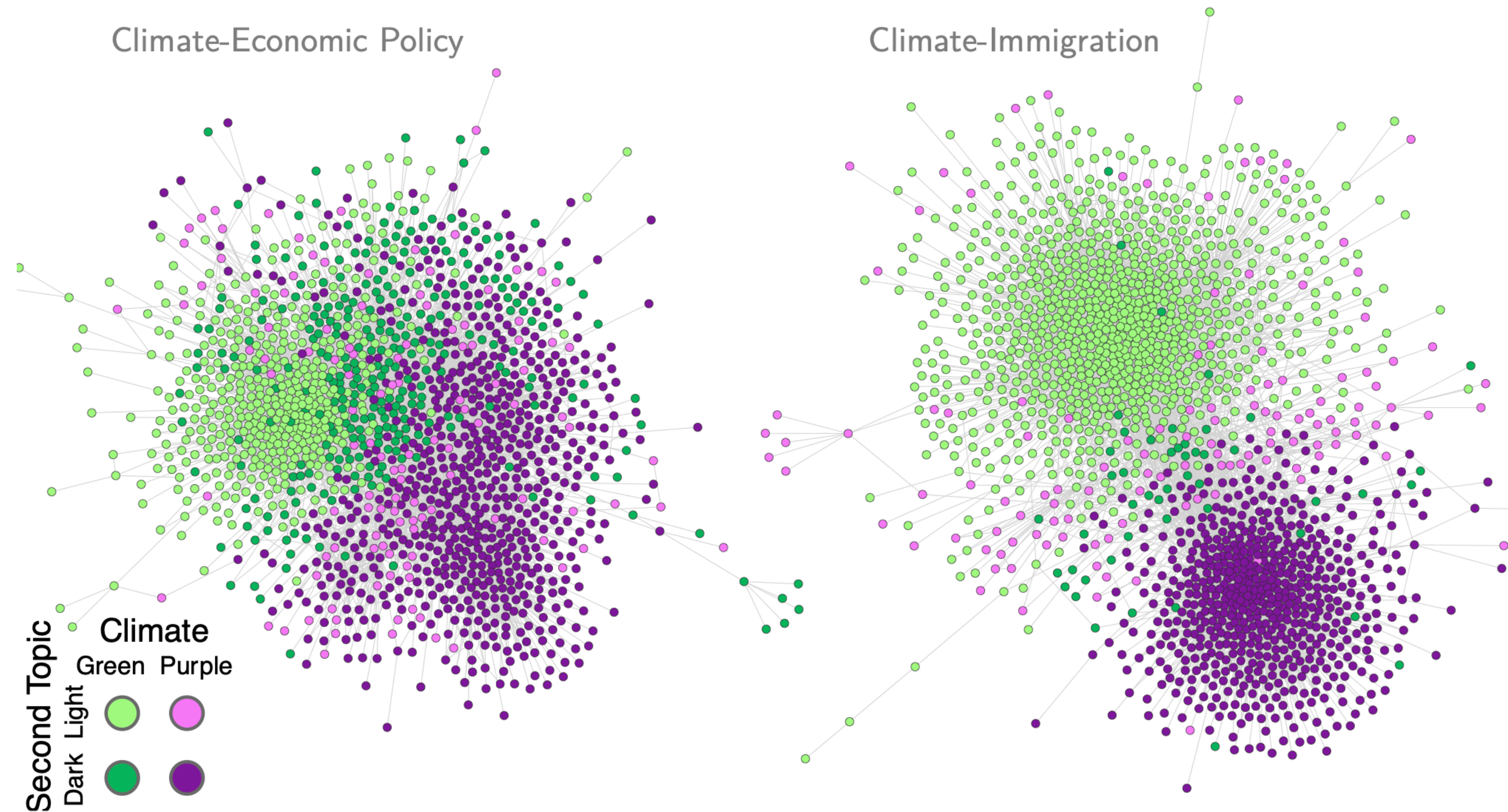
Configuration model:
keep *degrees of nodes*

Dk-2 model:
keep *degree correlations*

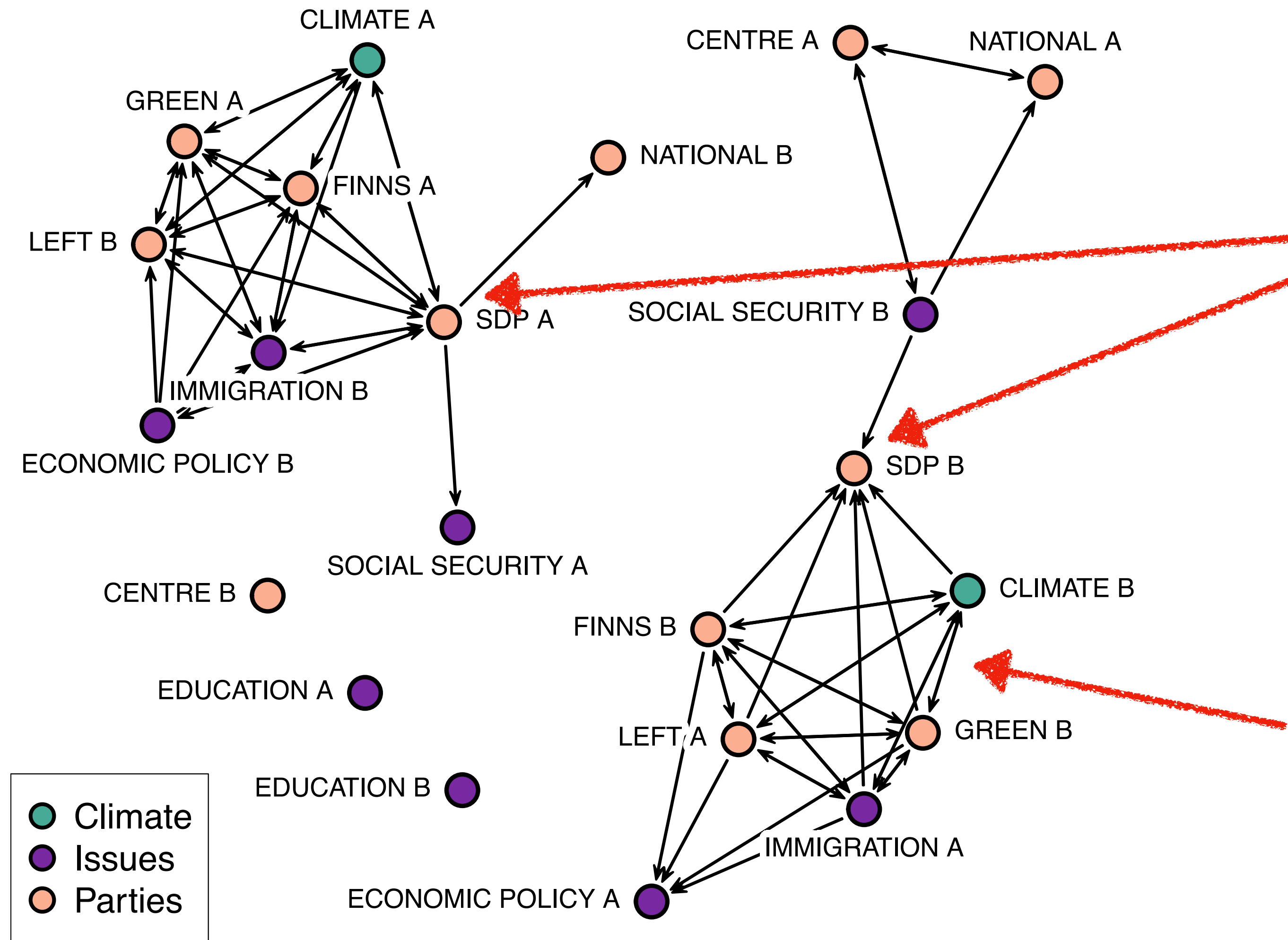


Alignment of polarised topics

- Endorsement networks are **naturally polarised on debated topics**
- Polarisation **problematic** if topics are **aligned**: same people consistently on opposing sides
- Alignment has previously been observed in **questionnaire studies**



Alignment of polarised topics

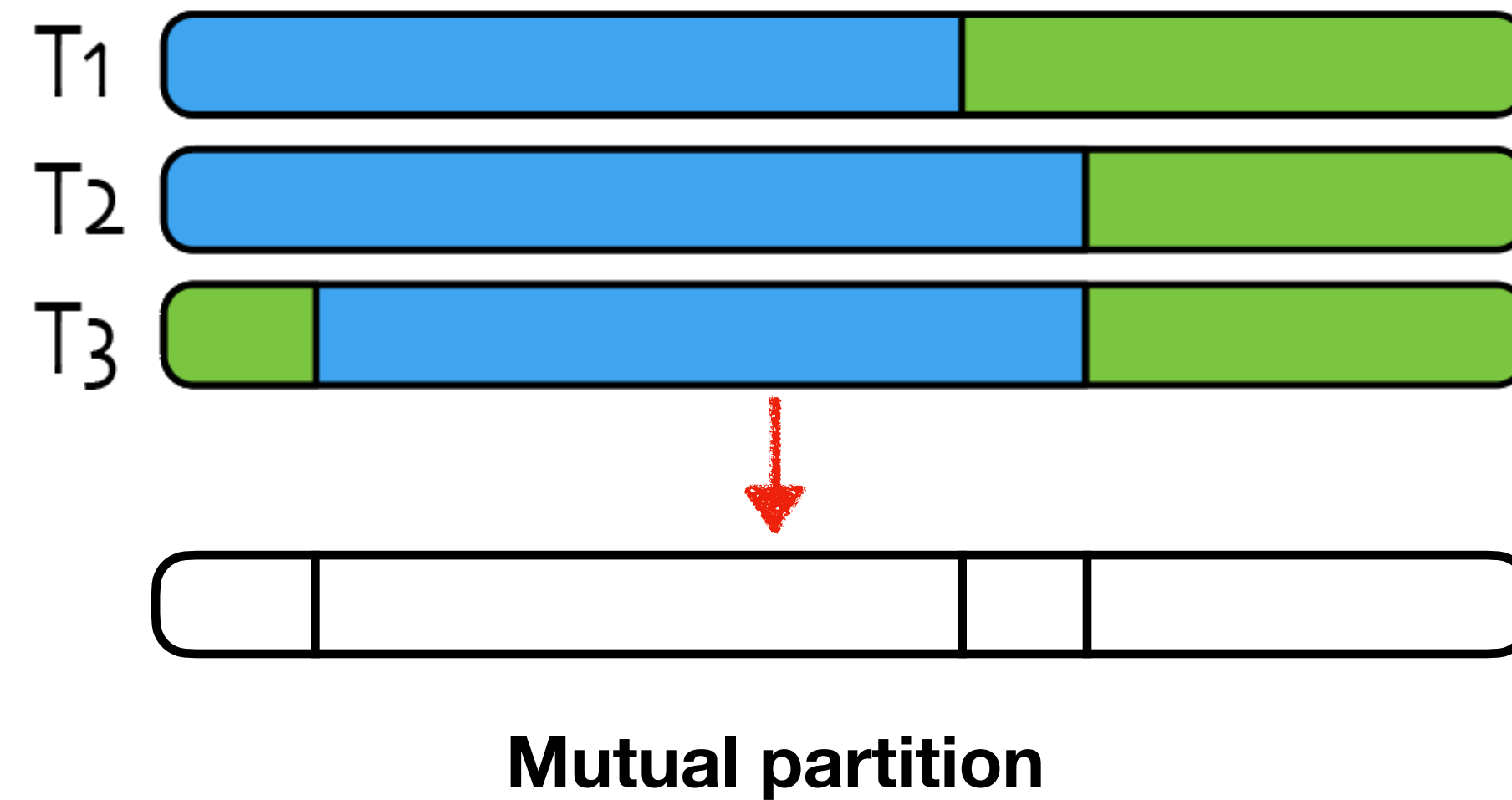


2 groups per topic, usually pro and against

Link A to B = more than 70% of people in group A are also in group B

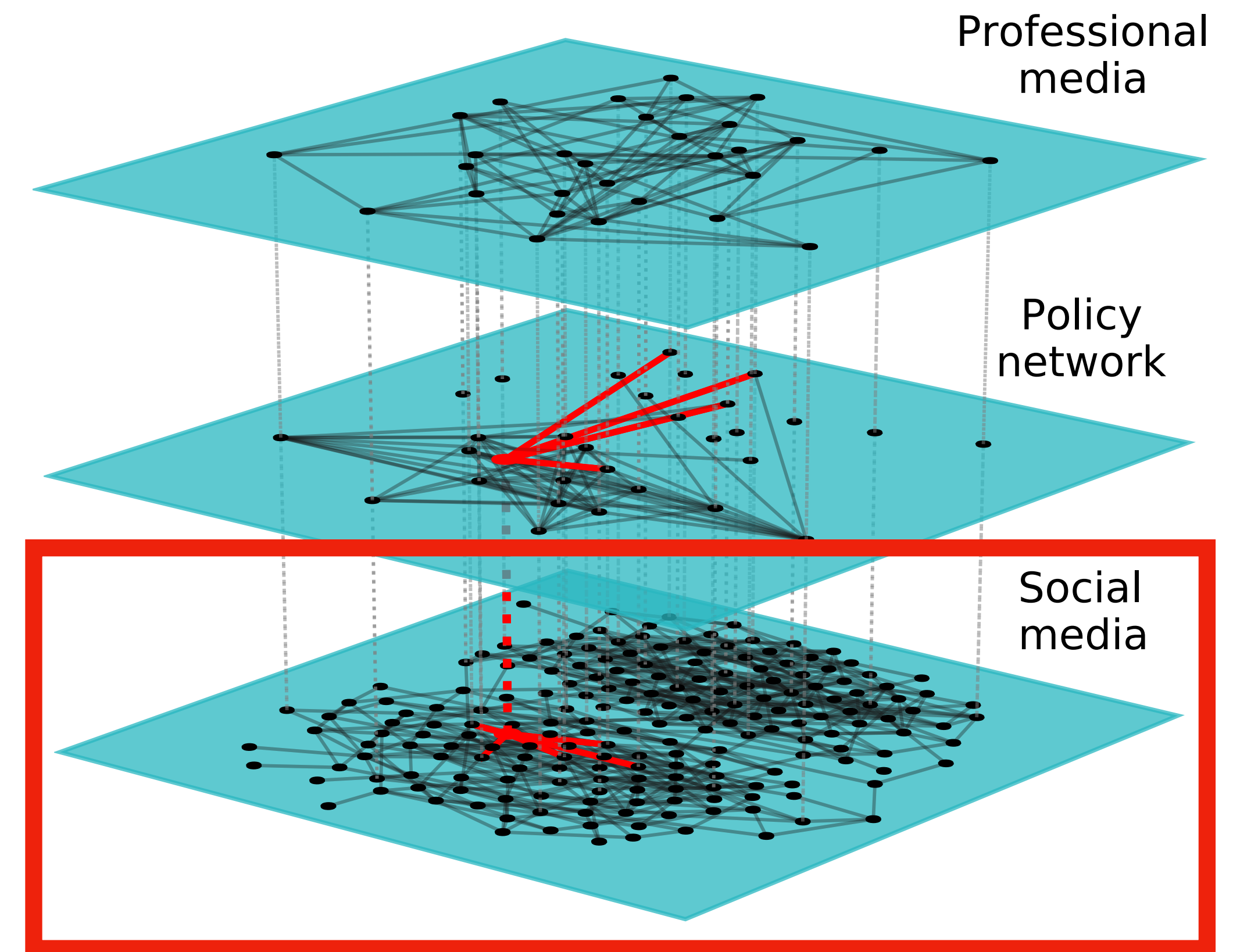
Higher order alignment of topics?

- Is it always the same people who are aligned across all topics?
- = can a single partition explain all of the other partitions?



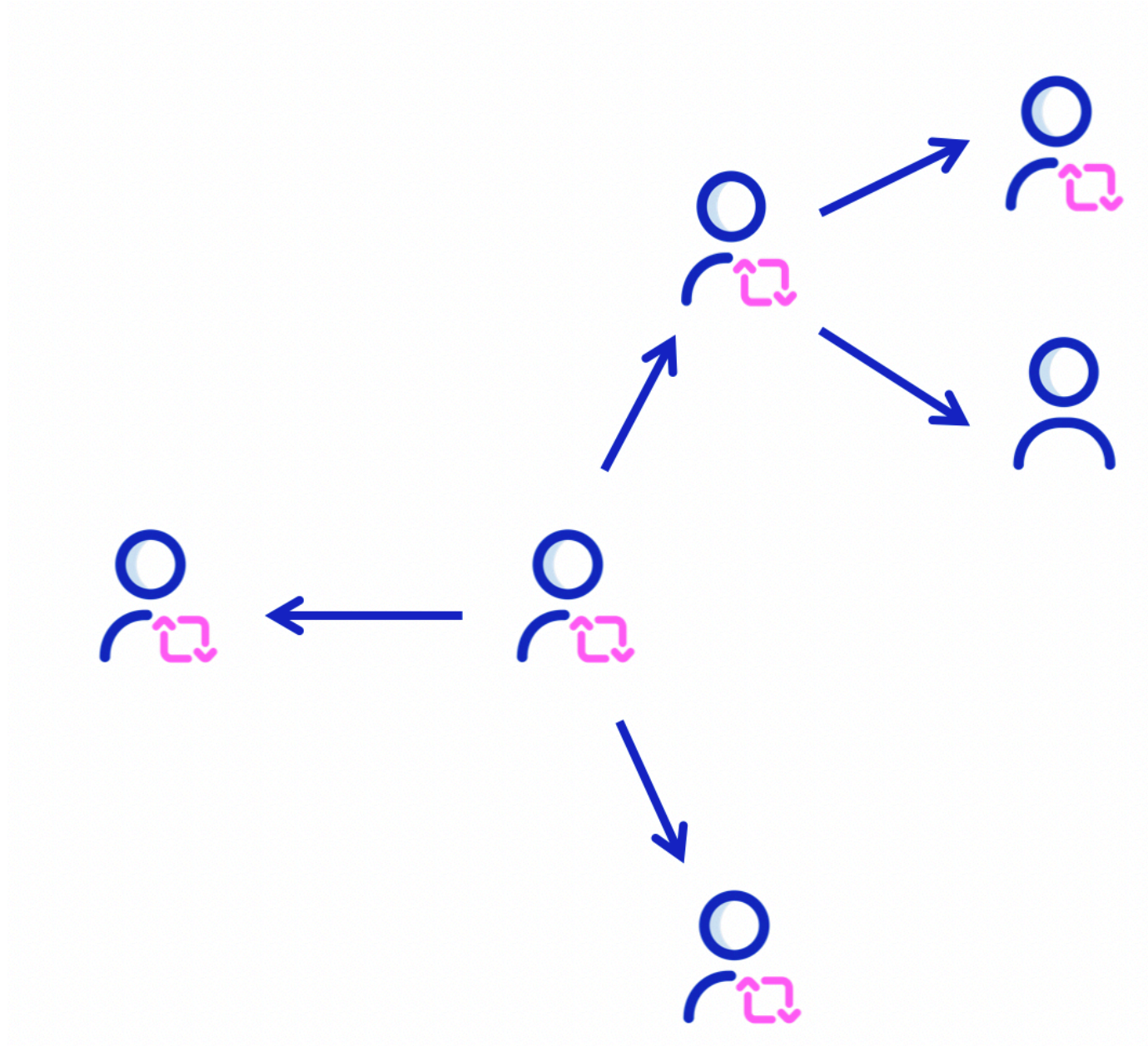
Multilayer networks of political communication

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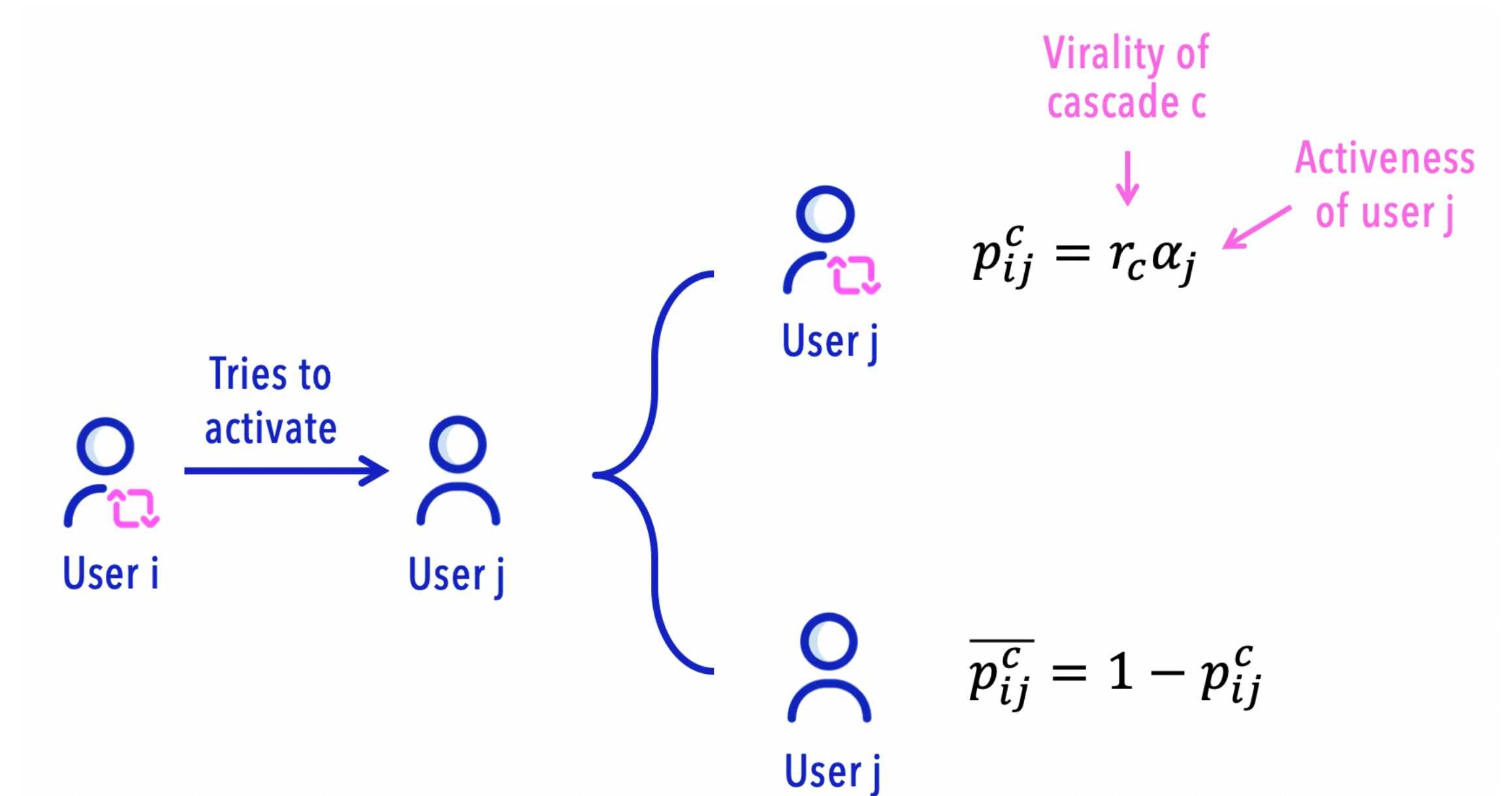


Layer inference from cascades

- The retweet networks can be built out of **cascades** of a tweet being retweeted:

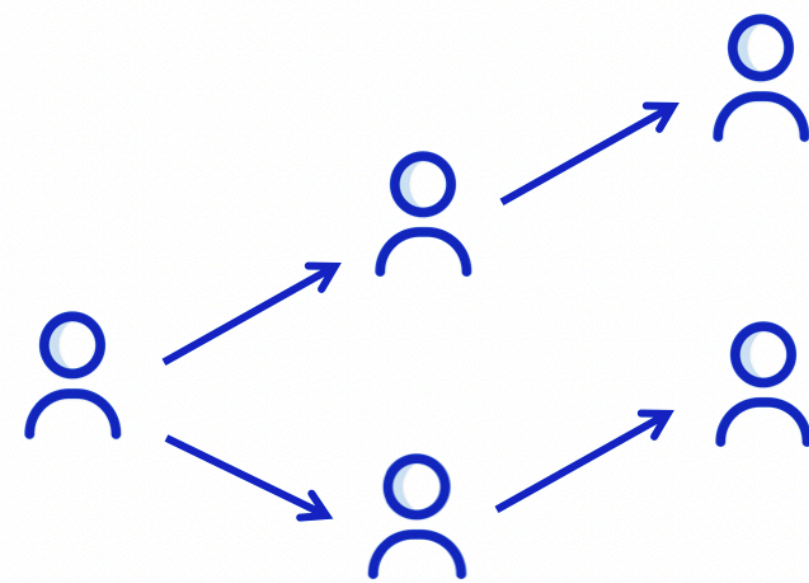


- The spreading model can include details on the dynamics
- Building the network is an **inference problem**

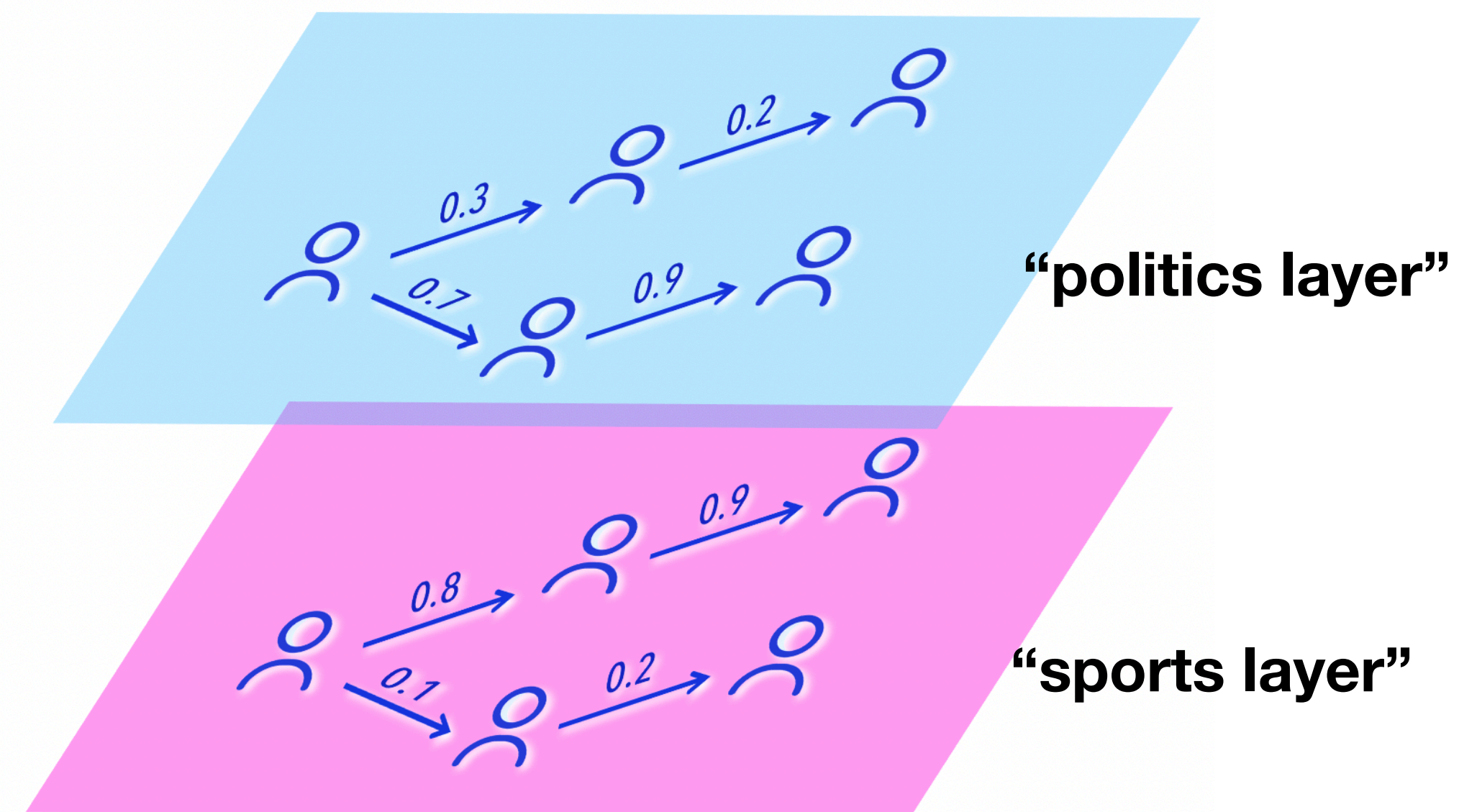


Layer inference from cascades

- You might trust someone for information on one topic but not on another
- Model: cascades happen on **latent networks/layers** depending on the topic



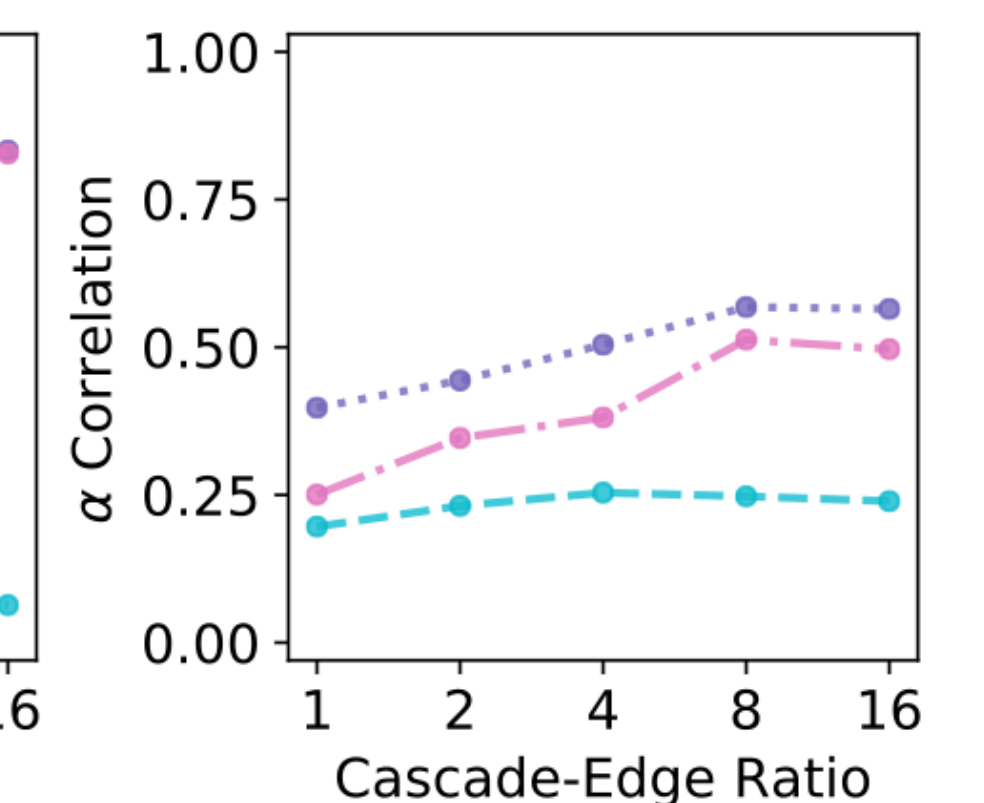
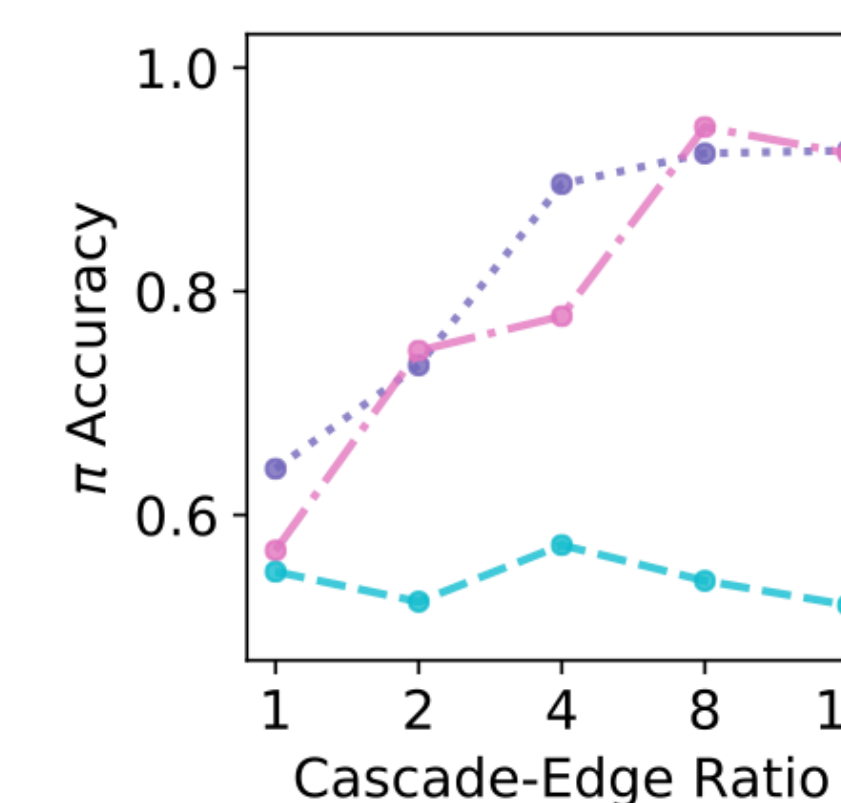
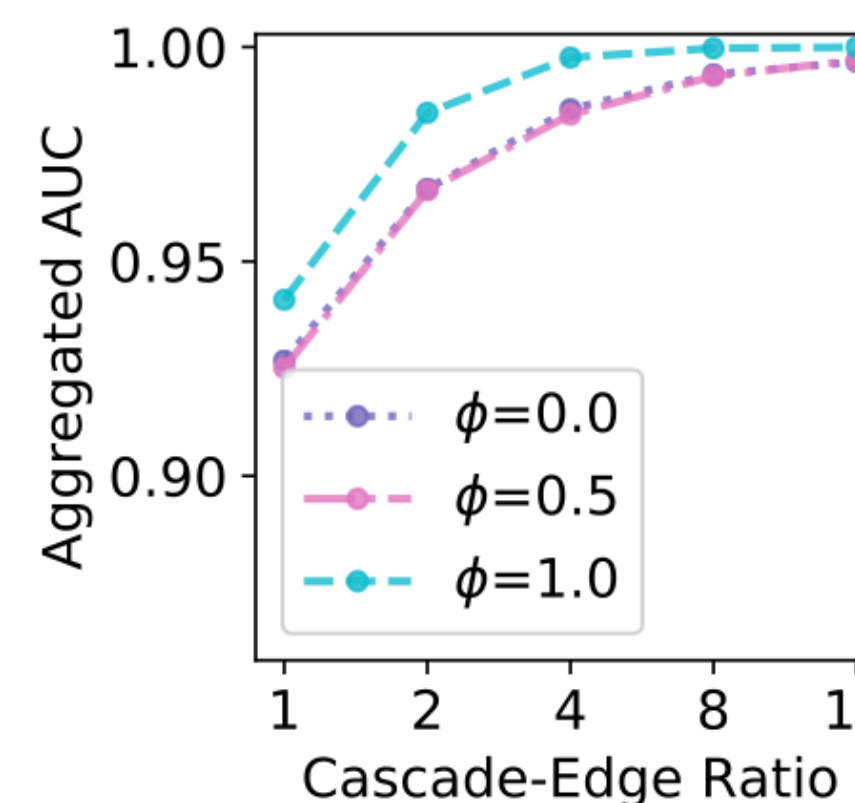
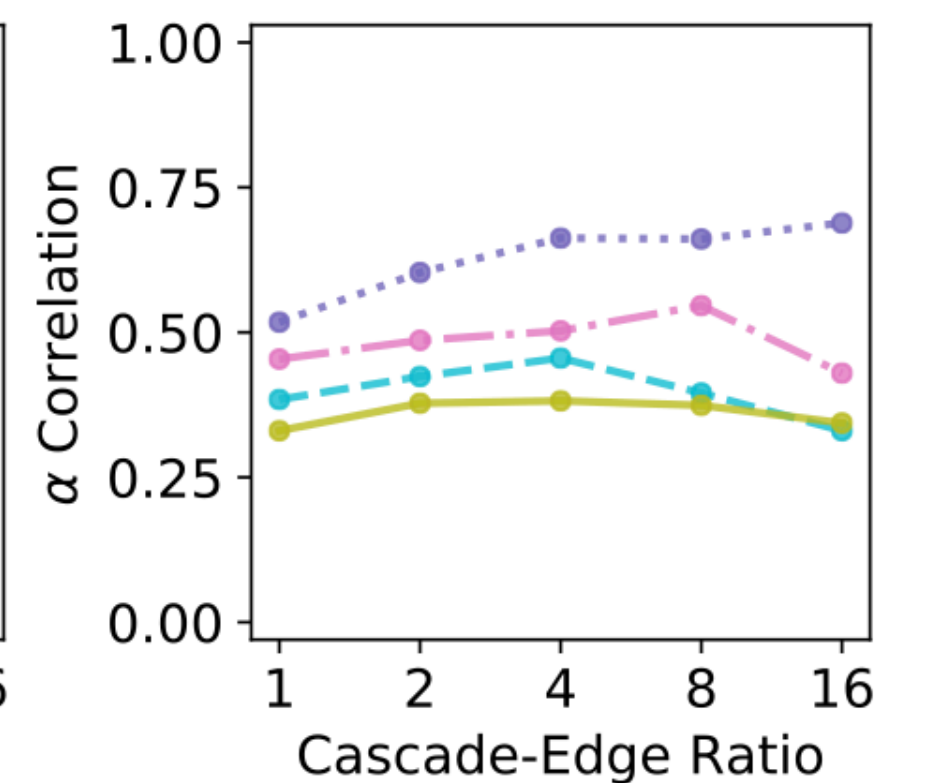
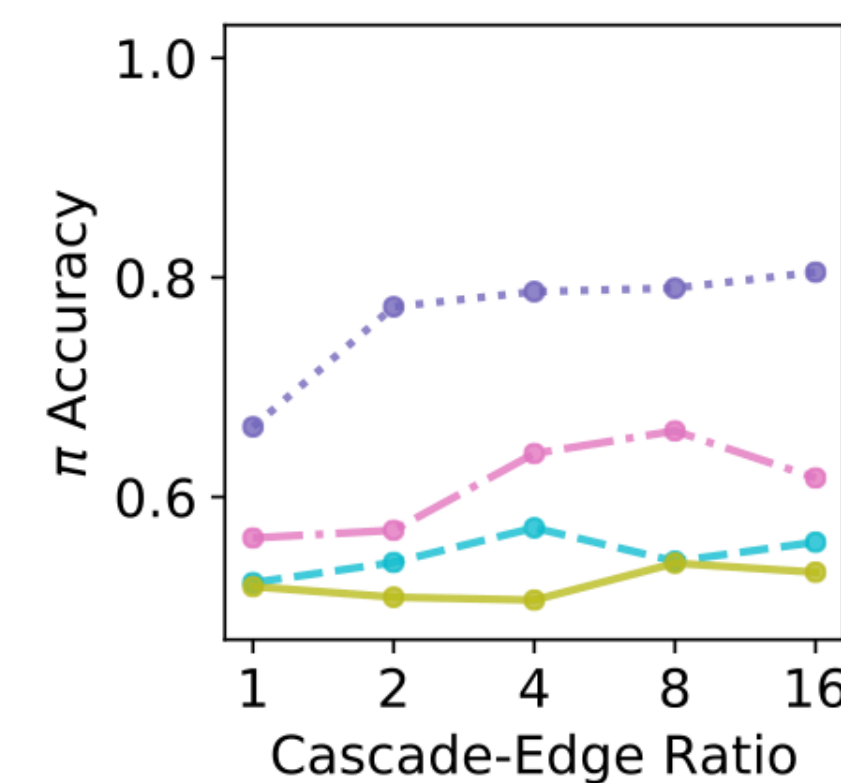
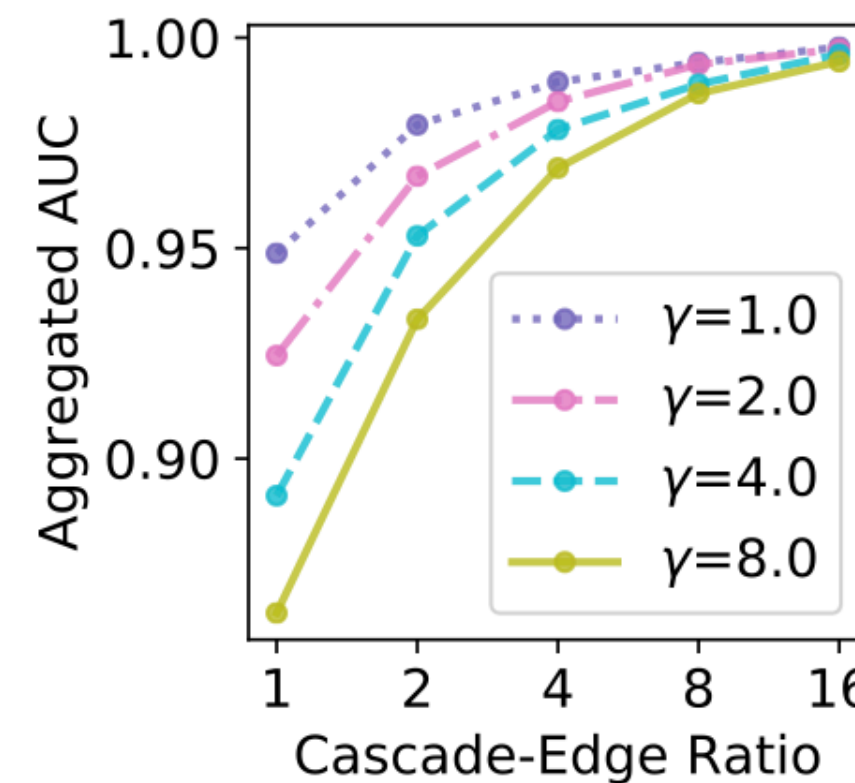
Follower network



Spreading network

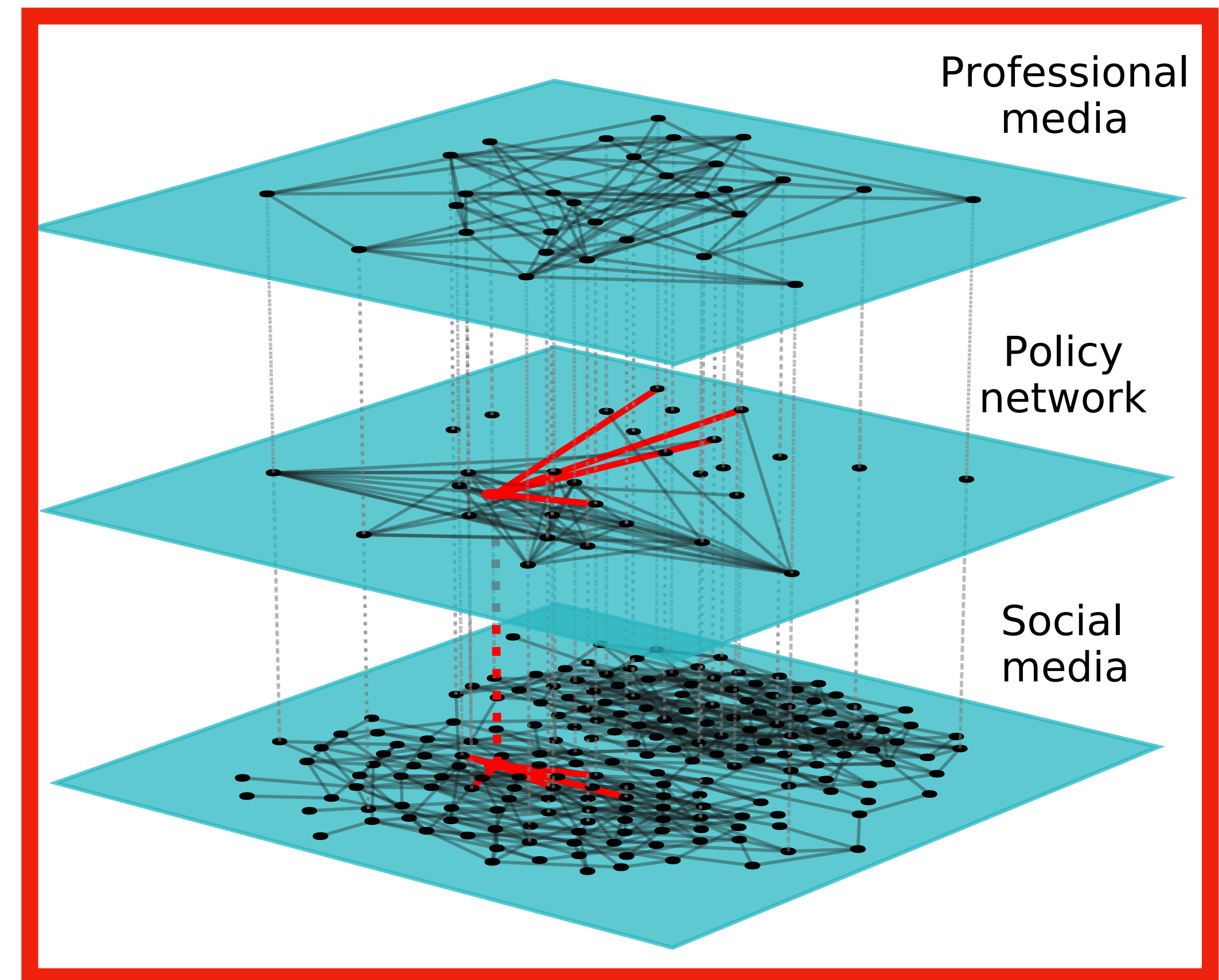
Limits of layer inference from cascades?

- Is it even theoretically possible to infer layers, given data?
- Numerical results: depends highly on how the network (cascade sizes, edge overlaps etc)



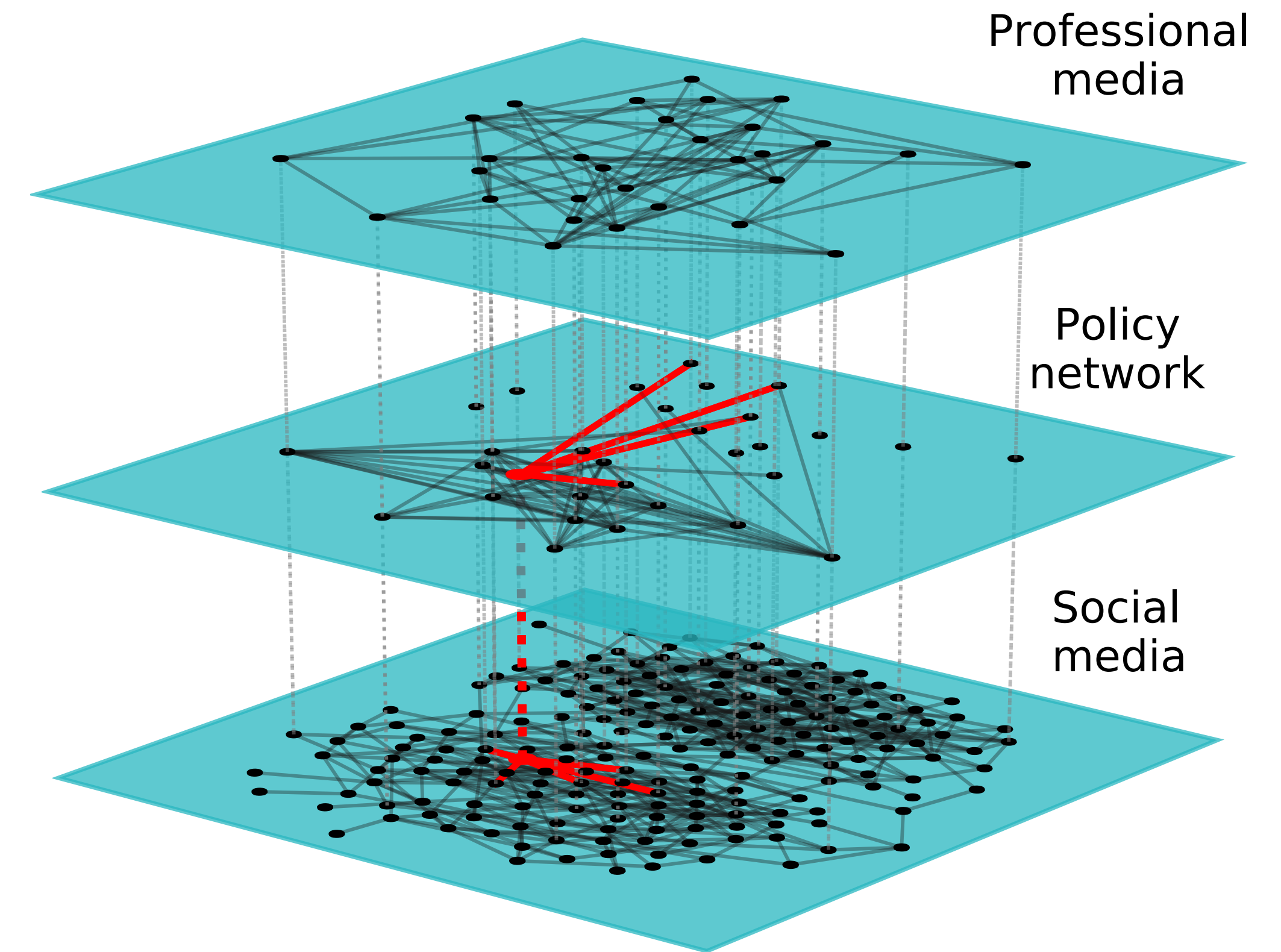
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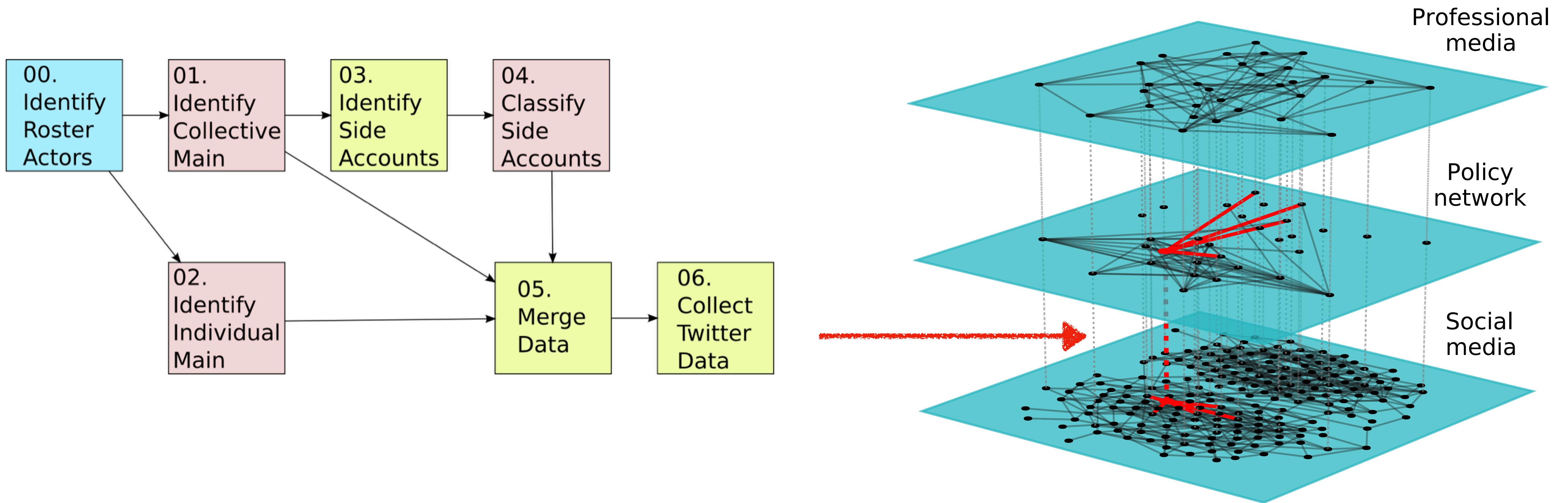


Building a multilayer political communication network

- **Professional media:** Network from organisations' opinions stated in **newspapers** (public opinion similarity)
- **Policy network:** **Questionnaire** to ~100 organisations active in climate change discussion (collaboration)
- **Social media:** **Twitter** accounts related organisations and discussion/retweets between them



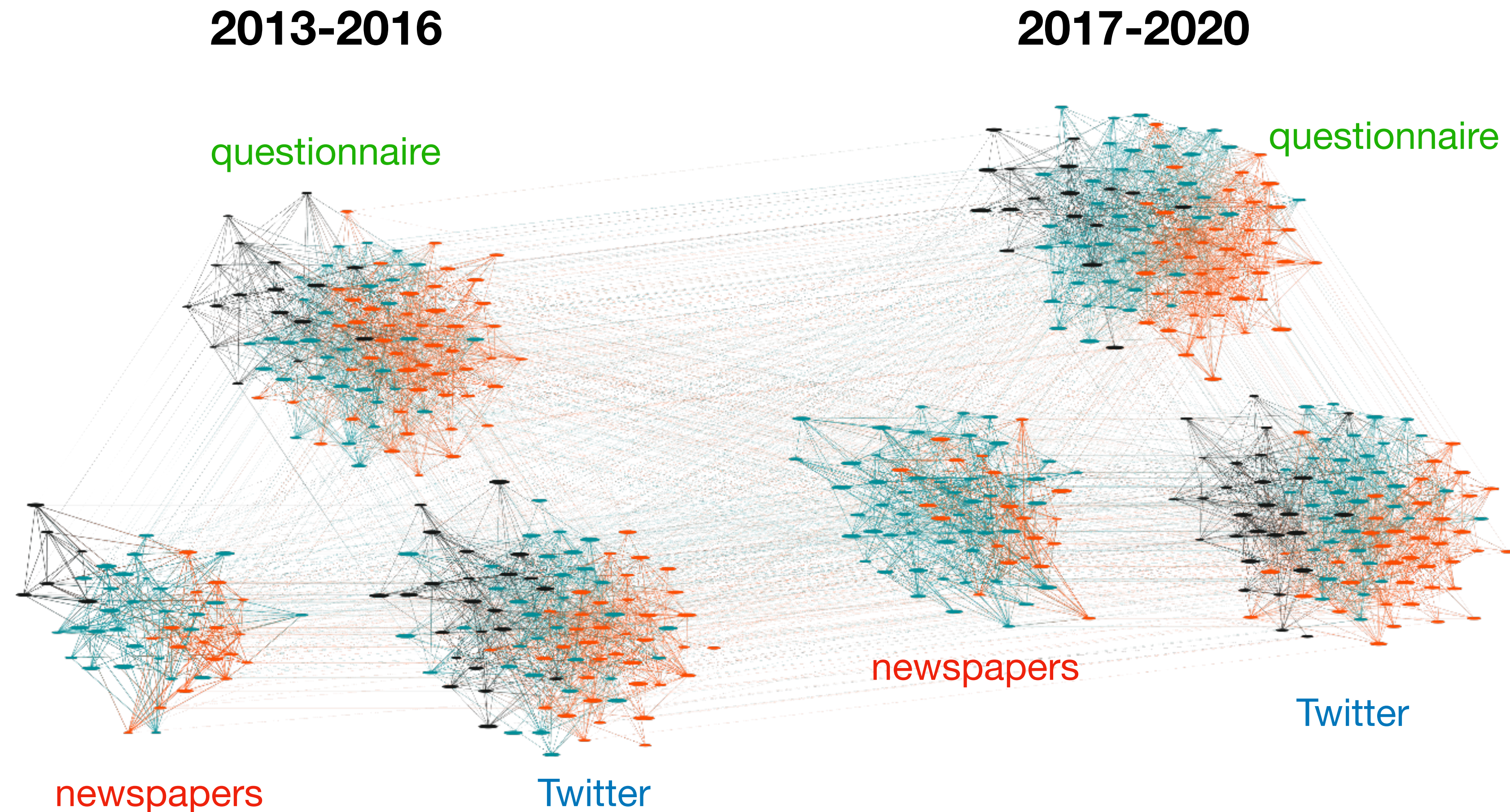
How to find the inter-layer links?



<https://github.com/tedhchen/componMultilayer>

Multilayer clustering

- **Multislice modularity:** clusters of node-layer pairs (co-clustering of nodes and layers)
- **Combining data** (with missing nodes in layers)
- Nodes can have **different roles** in different layers
- Results: “complex coalitions”



Pamfil, Howison, Lambiotte, Porter. 2019. “Relating Modularity Maximization and Stochastic Block Models in Multilayer Networks.” SIAM J Math Data Sci 1(4): 667–698

A Malkamäki et al. Complex coalitions: political alliances across relational contexts, arXiv:2308.14422

Conclusion and summary

- **Structural polarisation** can be measured and explained by analysing social networks
- Most social systems are not properly characterised by a **single social** network
 - They consist of subnetworks
 - They are part of larger systems of networks

Thank you!

Team

Aili Asikainen
Dr. Ted Chen
Dr. Ali Faqeeh
Dr. Arash-Badie Modiri
Ali Salloum
Javier Ureña-Carrion
Yan Xia

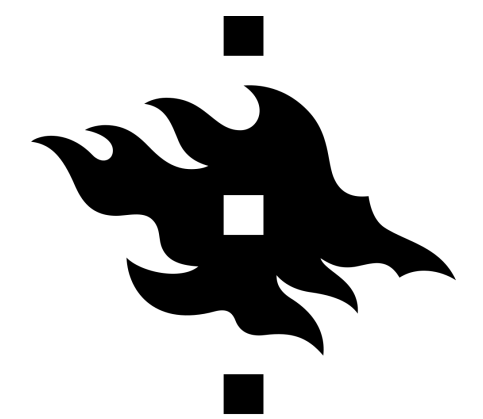


Funding

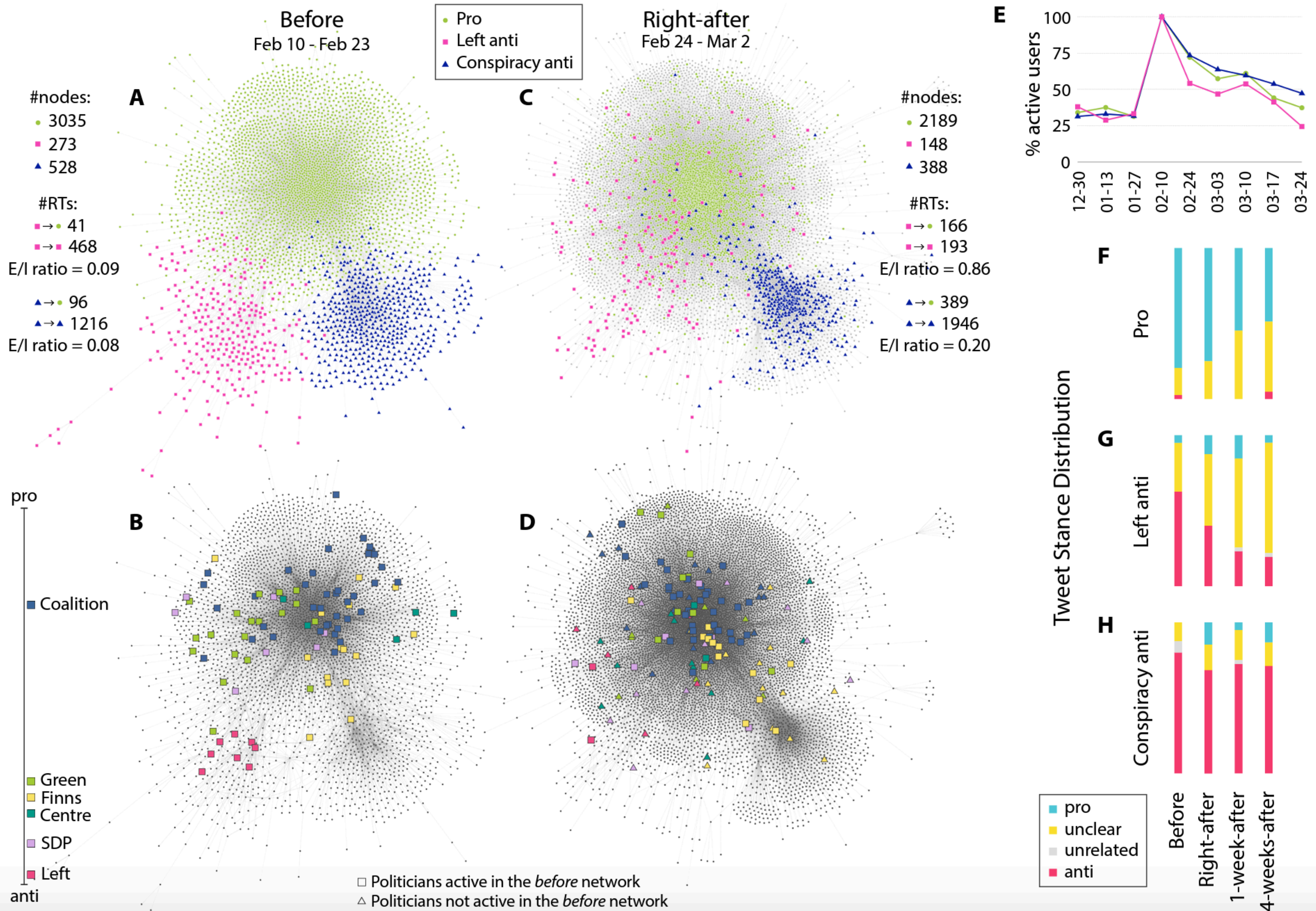


Collaborators

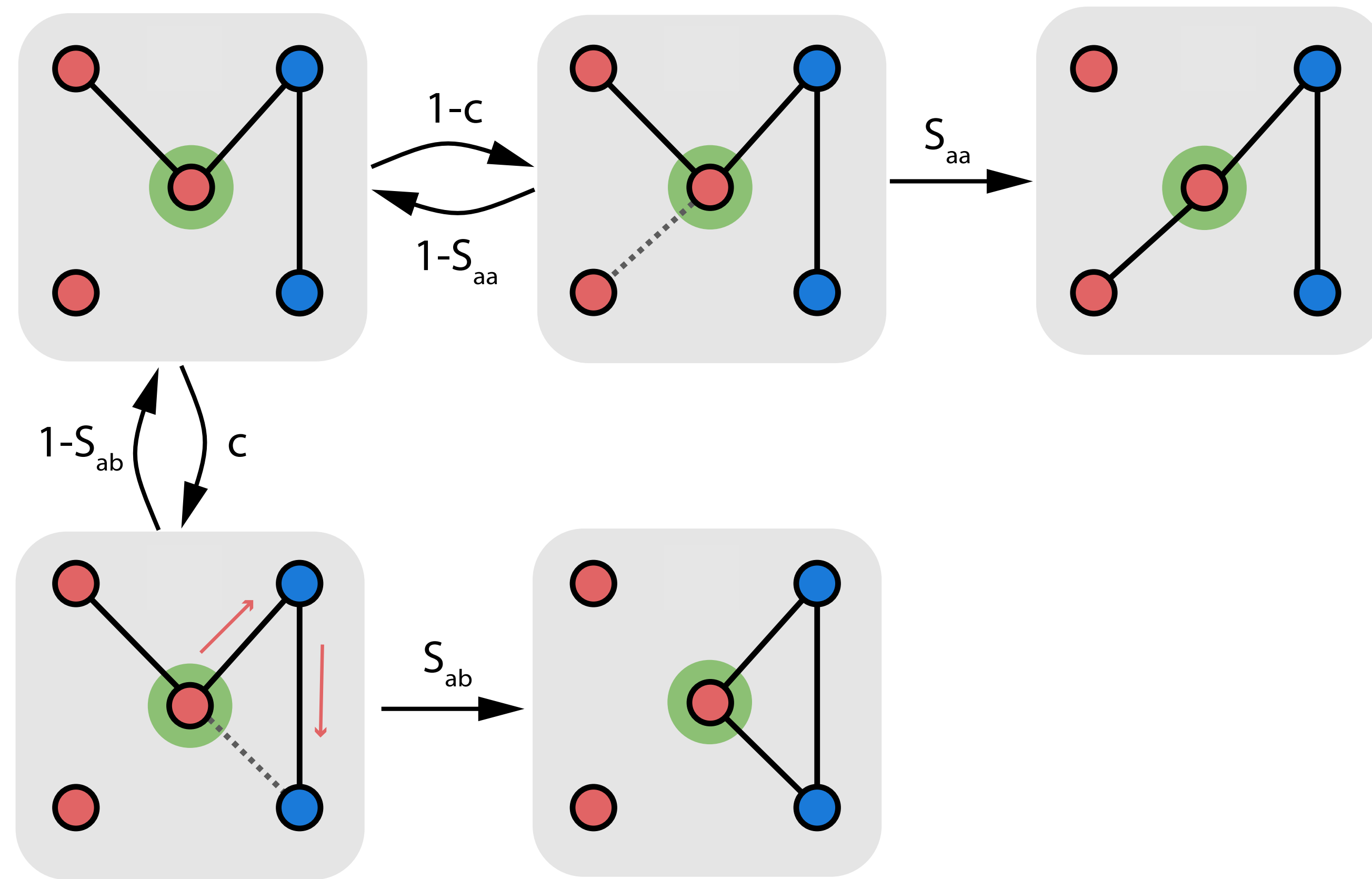
Prof. Gerardo Iñiguez
Prof. Kimmo Kaski
Prof. Tuomas Ylä-Anttila
Dr. Antti Gronow
Dr. Arttu Malkamäki



HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI



Triadic closure + homophily model



Parameters:

s : choice homophily ($S_{aa}=S_{bb}=s$, $S_{ab}=S_{ba}=1-s$)
 c : probability of triadic closure

We measure:

T_{aa} : probability of node in group a to link to the same group (observed homophily)