

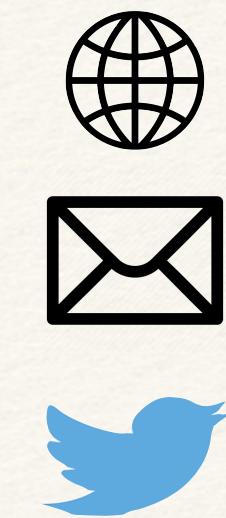
Giancarlo Ruffo - Università degli Studi di Torino (Italy)

# Divided we Stand

Torino, November 14th, 2019

<https://medium.com/mljcunito>

[http://www.di.unito.it/~ruffo/talks/2019\\_Nov\\_MLJ\\_Torino.pdf](http://www.di.unito.it/~ruffo/talks/2019_Nov_MLJ_Torino.pdf)



<http://www.di.unito.it/~ruffo>

[giancarlo.ruffo@unito.it](mailto:giancarlo.ruffo@unito.it)

@giaruffo



Methods and Tools to Represent,  
Understand, and Analyze a Digital Society

# or: How I Learned to Stop Worrying and Love Segregation and Polarization



# The strange case of Lajello

# Analyzing social network with a bot

- ❖ Anobii was a social networks for book lovers
- ❖ Scraping users' profiles from the Web was admitted
- ❖ Users' libraries and their links were collected periodically

The screenshot shows the Anobii website interface. At the top right is the Anobii logo with the tagline "together we find better books". Below the logo, there are links for "Shelf" (highlighted in blue), "Wish list", and "Reviews (2)". On the left, a user profile for "Clœudia" is displayed, showing a profile picture, the name "Clœudia", the gender "Female", age "38", status "Single", location "Torino, Italy", and a bio indicating taste compatibility is "UNKNOWN". Below the profile are buttons for "Follow" and "Message". A sidebar lists "Groups" such as "Wikicitazioni (Wikiquote)", "Sospesi tra cielo e terra", "Transpersonal Psychology and B...", "Herr Professor Carl G. Jung", and "Dillo ad aNobii (Tell aNobii)". At the bottom is a "Shoutbox" section with a "Leave a comment" input field. The main content area shows a wooden bookshelf titled "Books (126)" with a dropdown menu for sorting by "All books" or "Added (Newest)". The shelf displays 12 book covers, each with a star rating. To the right of the shelf are sections for "Friends" (listing "reyda", "Aglaja", "Walter", "bethulla", and "zeromeno") and "Neighbors" (listing "Simonetta", "\*MM\*", "Ste", "Moonray", and "virinthesky").

# Analyzing social network with a bot

- ❖ Anobii was a social networks for book lovers
- ❖ Scraping users' profiles from the Web was admitted
- ❖ Users' libraries and their links were collected periodically
- ❖ The bot “Lajello” used to silently navigate Anobii twice a month for one year



A screenshot of an Anobii user profile page for a user named "Lajello". The profile picture is a simple gray placeholder icon. The name "Lajello" is displayed in a large, bold, black font. Below the name are two buttons: "Follow" with a dropdown arrow and "Message". Underneath the name is a "Shoutbox" section with a "See all" link and a text input field containing "Leave a comment". To the right of the shoutbox is a "All books" section with a message stating "No items on this shelf yet". At the bottom of the page is a link "← Back to previous page" and an "RSS feeds" link with a small orange feed icon.

# Analyzing social network with a bot

- ❖ Anobii was a social networks for book lovers
- ❖ Scraping users' profiles from the Web was admitted
- ❖ Users' libraries and their links were collected periodically
- ❖ The bot “Lajello” used to silently navigate Anobii twice a month for one year
- ❖ homophily by selection and by influence analysed



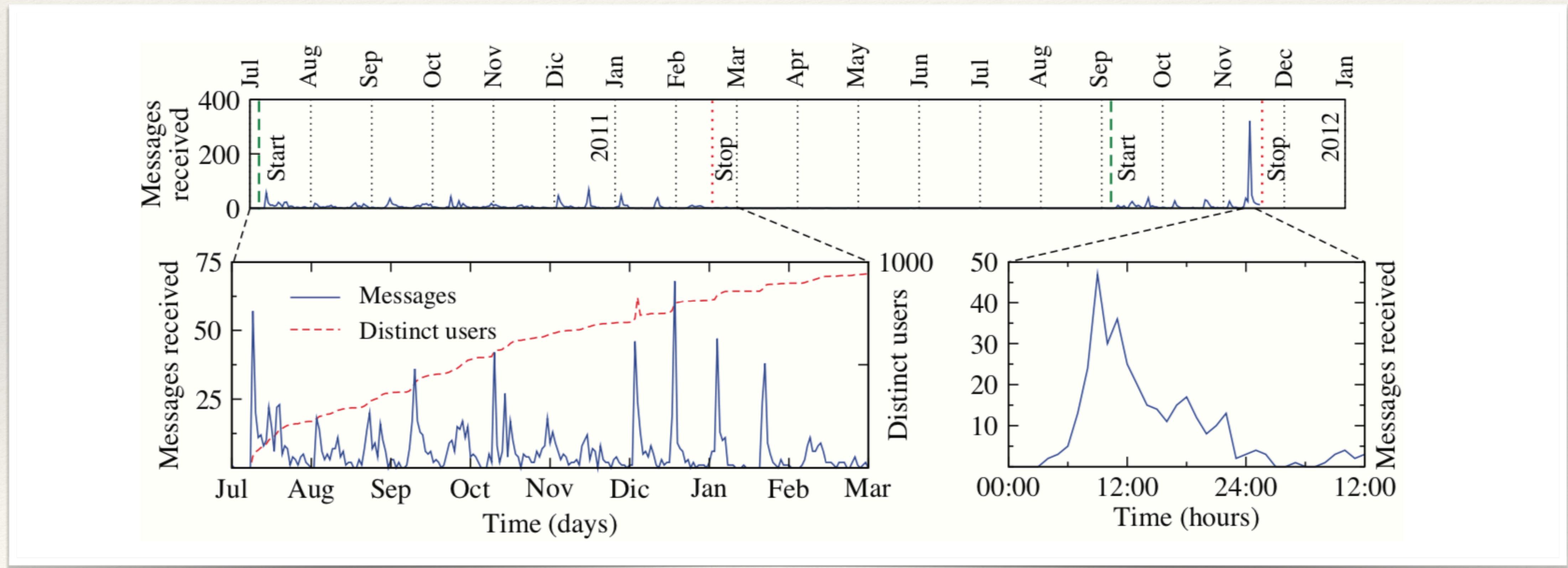
A screenshot of an Anobii user profile page for a user named "Lajello". At the top left is a placeholder profile picture icon. Next to it, the name "Lajello" is displayed in a large, bold, black sans-serif font. Below the name are two buttons: "Follow" with a dropdown arrow and "Message". Underneath these buttons is a "Shoutbox" section with a "See all" link. A text input field says "Leave a comment". To the right of the shoutbox is a "All books" section with a message stating "No items on this shelf yet". At the bottom right of the page is a link "← Back to previous page". At the very bottom center is a link "RSS feeds: subscribe to Lajello's shelf" with a small orange RSS icon.

LM Aiello, A Barrat, C Cattuto, G Ruffo, R Schifanella, [Link creation and profile alignment in the aNobii social network](#), 2010 IEEE 2nd Int.. Conf. on Social Computing, 249-256

LM Aiello, A Barrat, C Cattuto, G Ruffo, R Schifanella, [Link creation and information spreading over social and communication ties in interest based online social network](#), EPJ Data Science 1 (1), 12

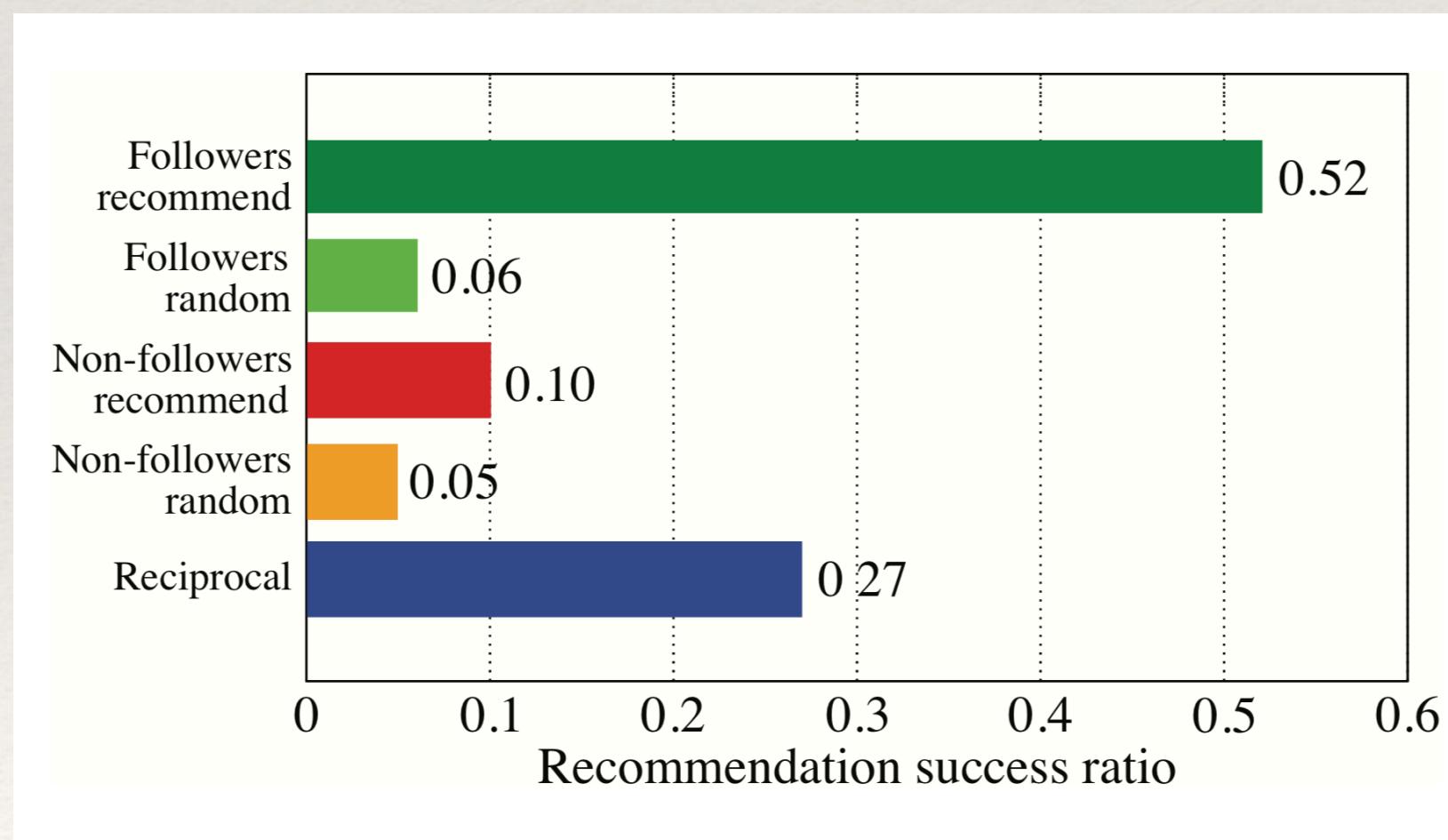
# What happened to Lajello?

Lajello, incidentally, became the second most popular user in Anobii in terms of messages from distinct users

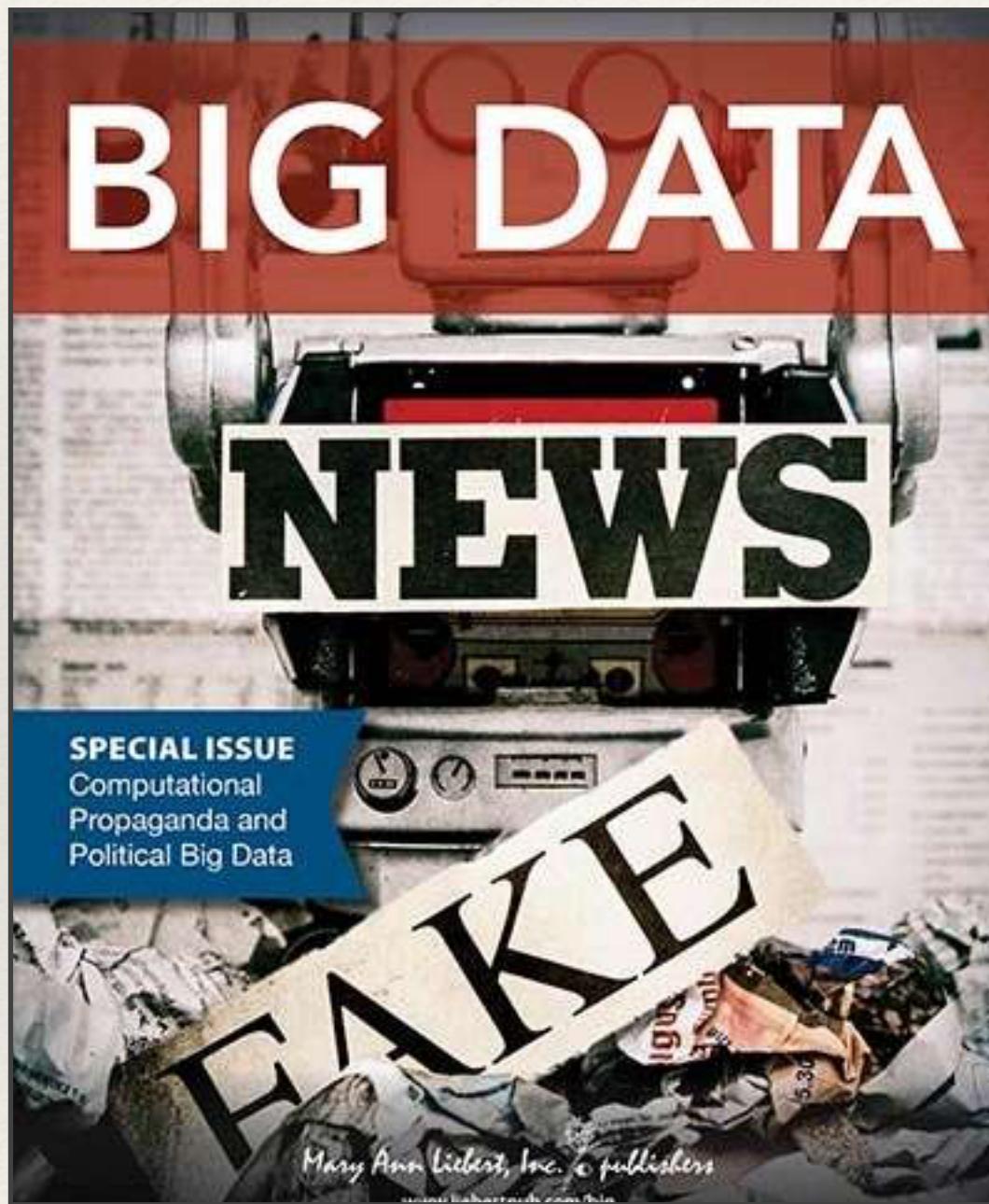


# Exploiting Lajello popularity

- ❖ Lajello started to introduce users to each other according our link recommendation algorithm
- ❖ First result: users acceptance of the recommendation skyrocketed if they previously wrote in Lajello's wall



# Influence of bots



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OF THE  
ACM**

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REVIEW ARTICLES

## The Rise of Social Bots

By Emilio Ferrara, Onur Varol, Clayton Davis, Filippo Menczer, Alessandro Flammini  
Communications of the ACM, Vol. 59 No. 7, Pages 96-104  
10.1145/2818717  
[Comments \(1\)](#)



**nature  
COMMUNICATIONS**

Article | Open Access | Published: 20 November 2018

## The spread of low-credibility content by social bots

Chengcheng Shao, Giovanni Luca Ciampaglia, Onur Varol, Kai-Cheng Yang, Alessandro Flammini & Filippo Menczer ✉

*Nature Communications* **9**, Article number: 4787 (2018) | [Download Citation ↓](#)



# Incidentally, we polarized Anobii users

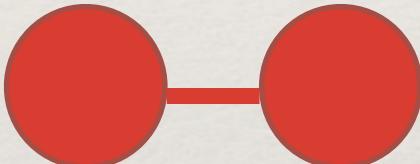
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- After our initial experiment, Lajello remained silent for one year and then he “talked”. The recommendations changed the net structure and lajello account was banned after 24 hours. This ignited a “war”
- Two polarized opinions emerged: Anobii users created immediately two thematic groups: “**the (not requested) suggestions of Lajello**” and “**Hands-off Lajello**”
- A large portion of users that were contacted by Lajello joined to one of these groups
- We observed a strong interplay between the existing relationships in the social network and the opinion that emerged from the users at the end of the links: “**echo chamber**” effect?

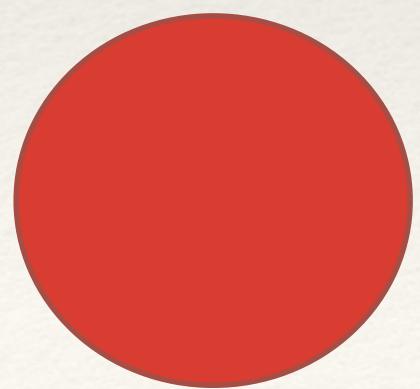
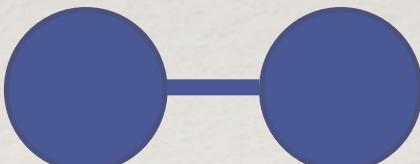
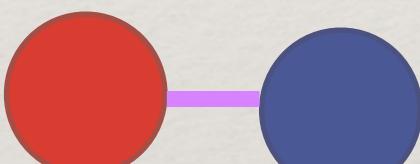
# Social polarization and emotional reaction

red dots are lajello supporters

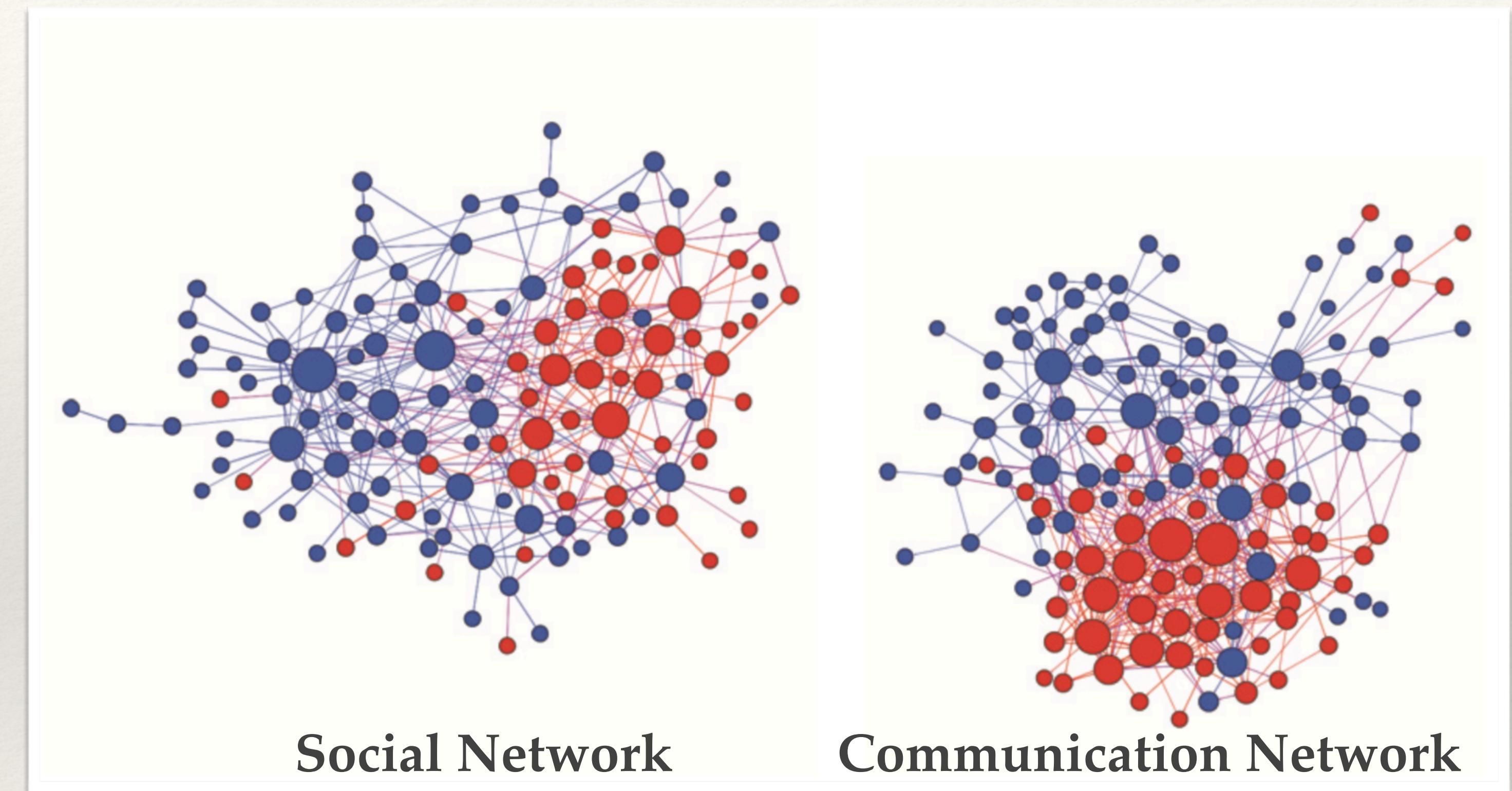
blu dots are lajello haters



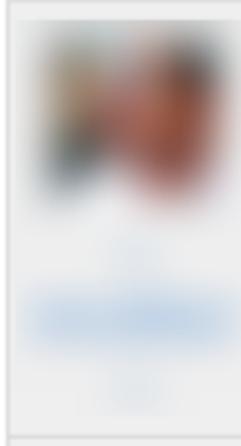
links are existing  
**social connections**  
or **direct messages**  
(graph is directed)



bigger dots are  
users with more links

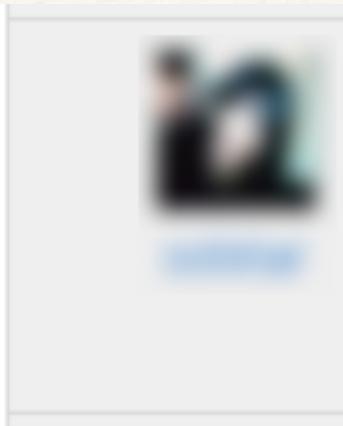


Automatic network-based **community detection** algorithm (OSLOM) accurately finds clusters (80% - Social network, 72% - Communication network), confirming a signal of **segregation** between the two groups before link recommendations



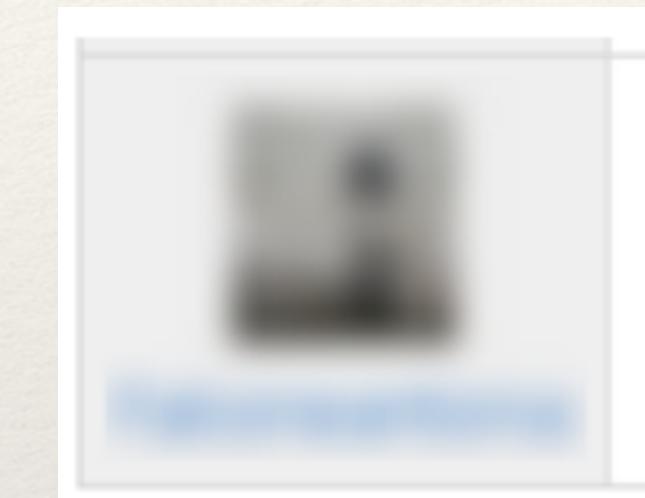
LAJELLO... HAI STUFATO..NON SE NE PUO' PIU'...STA ATTENTO/A CHE SONO CAPACE DI ASSOLDARE UN HACKER PER VEDERE CHI SEI..E PO' SONO C...TUOI

Tre settimane fa 



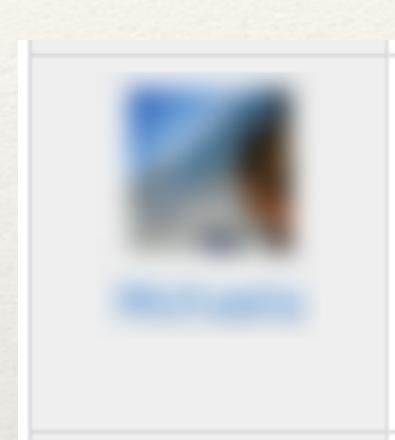
ahahahahahaha tu sei un genio!!!! sei davvero un genio!!! insomma ma quante visualizzazioni hai???? sei un grande!!!! riesci a farti visitare e a farti scrivere pur non avendo libri!!! ti adoro sei grandissimo :P

Aug 13, 2010 



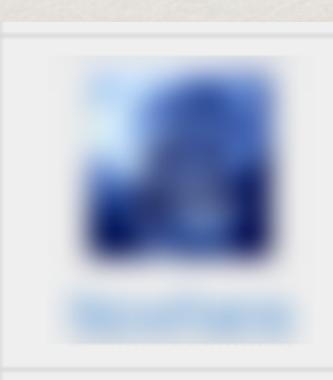
chi sei?





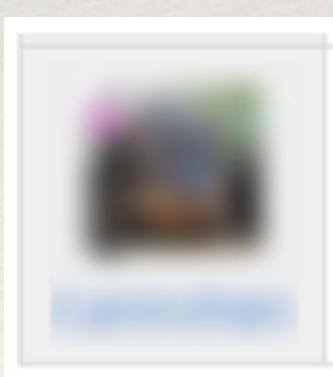
un grande.  
continua così. Grazie delle visite, si vede che ti sto simpatica....  
P.S: propongo di aprire un gruppo the Lajellos fans...

3 giorni fa 

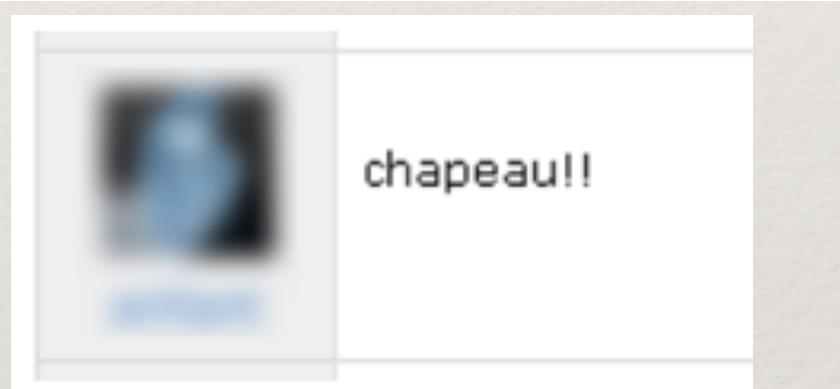


già che mi ritrovo qui mi faccio pubblicità! Venite a vedere la mia librerie è la più bella -del mondo-. (l'ultima parte andava sottolineata..)

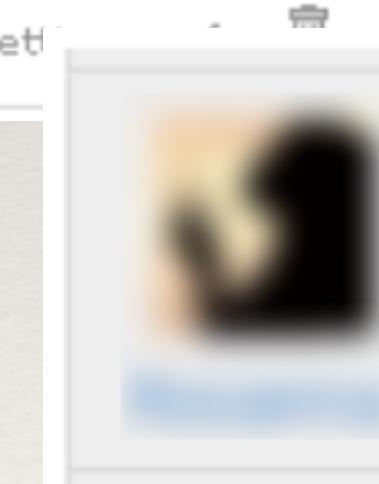
Due settimane fa 



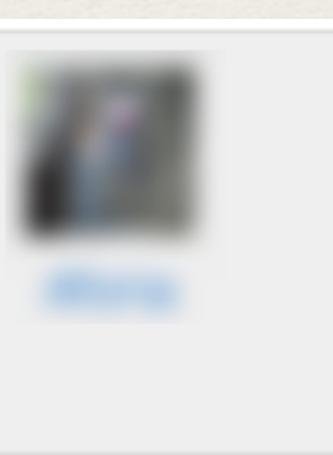
Le tue visite cominciano ad essere inquietanti....



chapeau!!



ahahahaahah tu sei un genio!!



Grazie Lajello, mi sono divertita un sacco a leggere i commenti degli altri anobiani. Sembra un esperimento di psicologia sociale, se non ti dispiace ti aggiungo come vicino! e resisti eh...non pubblicare un libro! ;)

Due settimane fa 

# Lessons learned and observations

- ❖ Handle experiments in social media with care :)
- ❖ A simple spambot can take power in a social network
- ❖ A seed of polarization found in pre-existing network structure
- ❖ Network and Sentiment analysis provide tools and measures, when we have data
- ❖ What if the real identity and motivations of Lajello were fact-checked?

MIT  
Technology  
Review

Connectivity

## How a Simple Spambot Became the Second Most Powerful Member of an Italian Social Network

The surprising story of how an experiment to automate the creation of popularity and influence became successful beyond all expectation.

by Emerging Technology from the arXiv

Aug 5, 2014

# Modeling the spread of misinformation

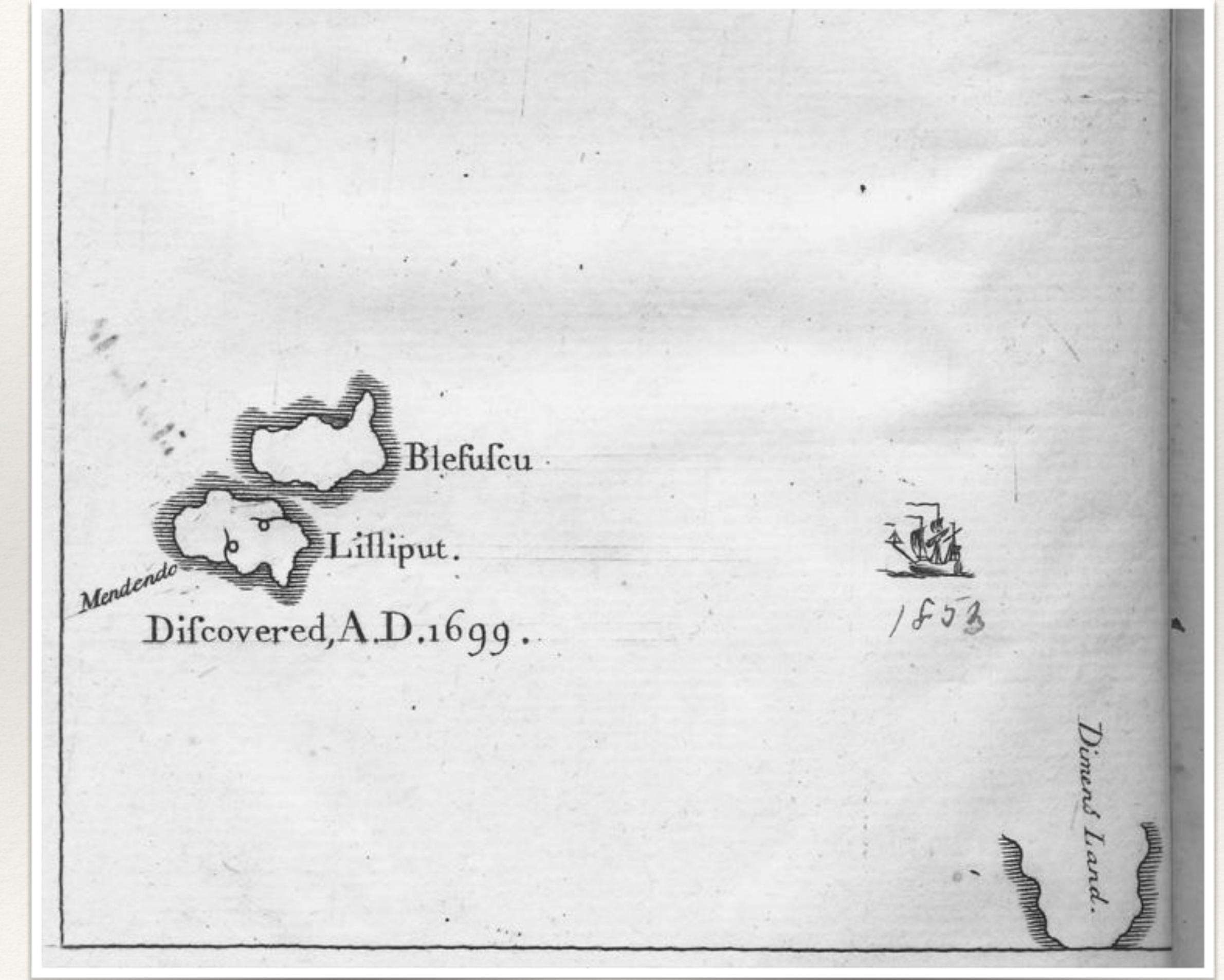


# Questions

- ❖ Is fact-checking effective against the diffusion of fake-news?

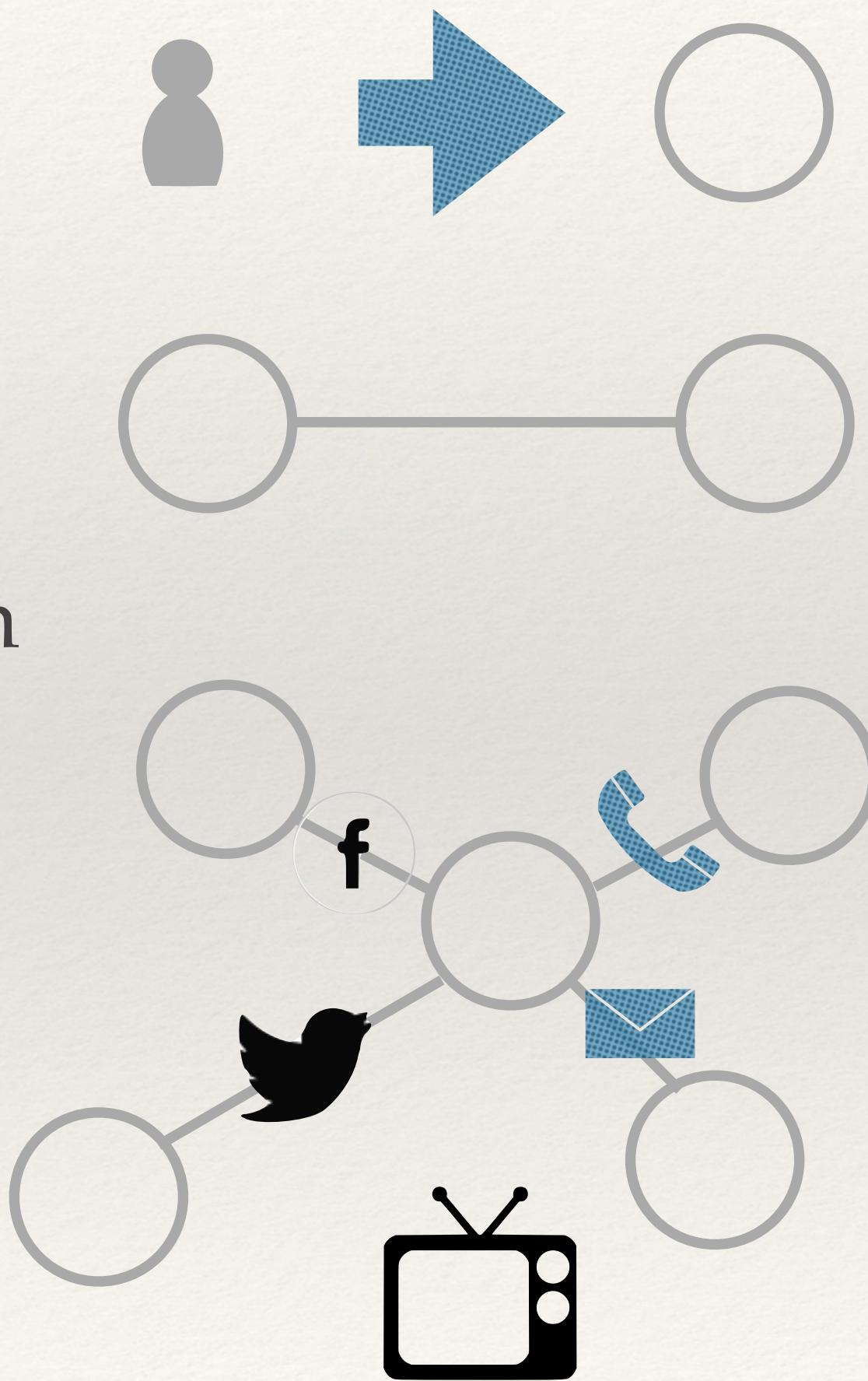


- ❖ Do “echo-chambers” and “islands” play a role as inhibitors or facilitators of fake-news spreading?



# Networks and their context

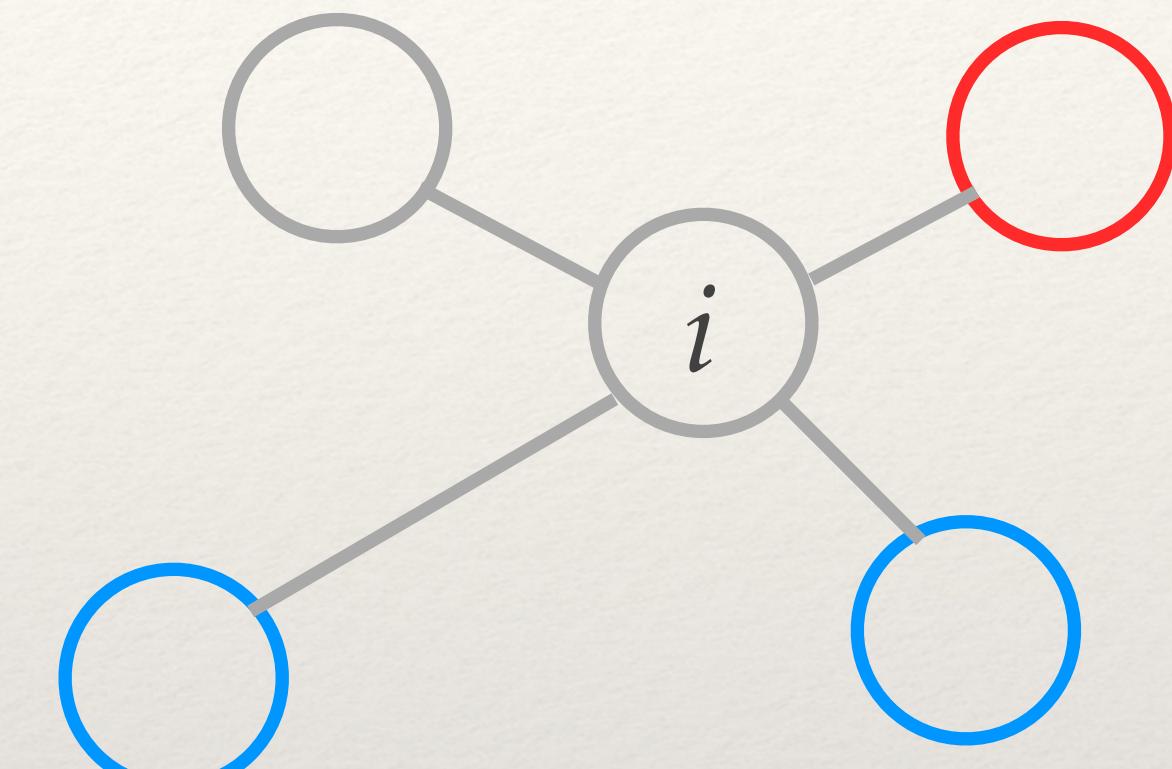
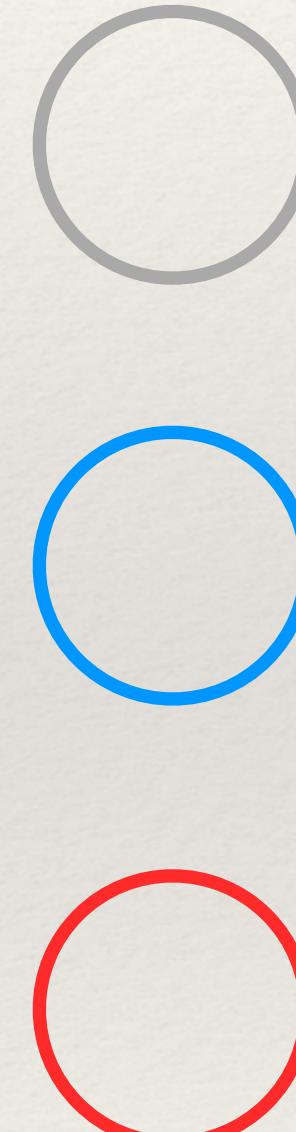
- ❖ nodes are **actors** involved in a **generic** social network (no assumption is given)
- ❖ links are **social relationships**
- ❖ nodes can be exposed to news from both **internal and external sources** and via different communication devices



- ❖ **network topologies** can be created artificially or built from real data
- ❖ The **news is factually false** (can be debunked or someone else has already debunked it)
- ❖ We need a **model** for predictions and what-if analysis; data for validation and tuning only

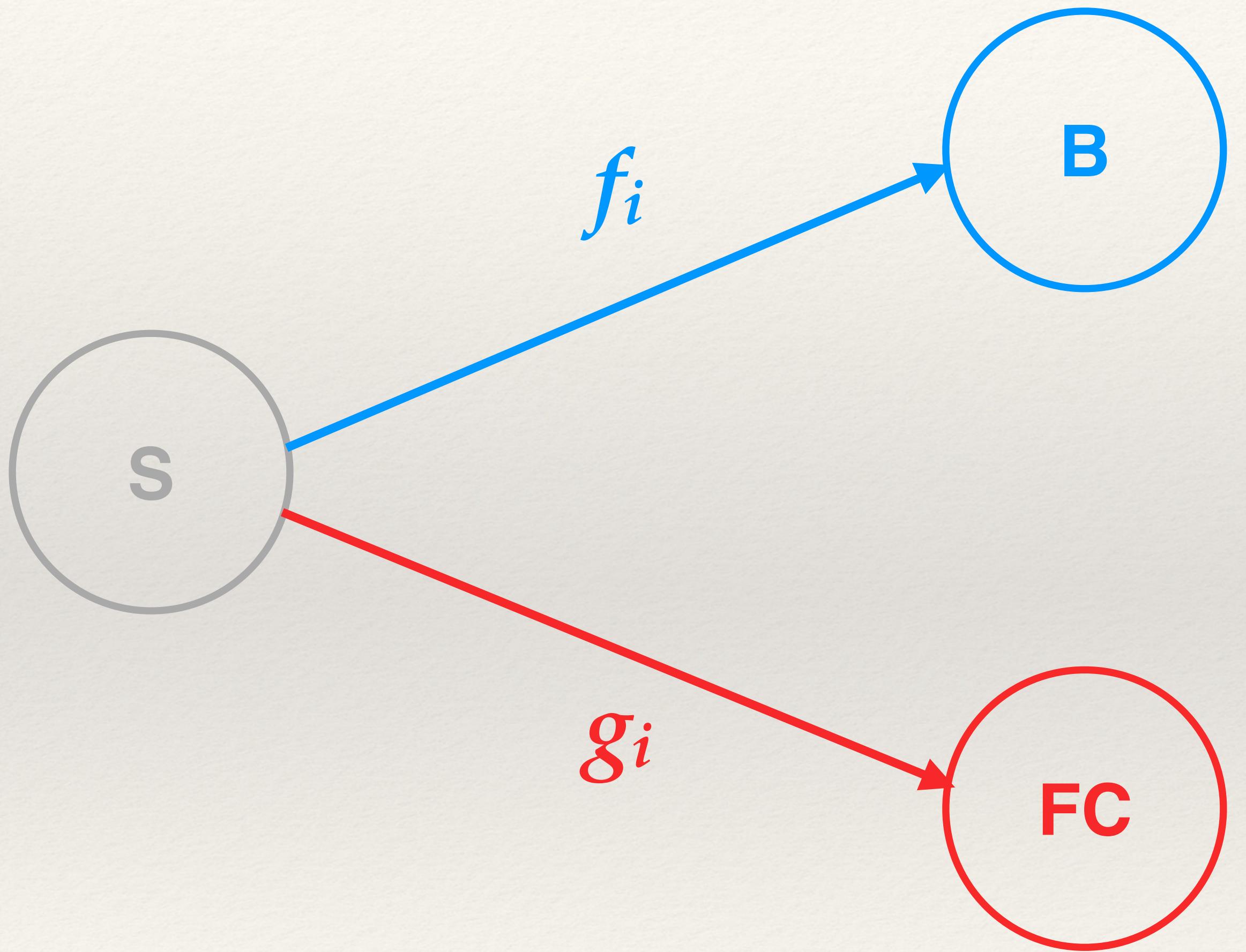
# Node states in the SBFC model

- ❖ Susceptible
- ❖ Believer
- ❖ Fact-Checker

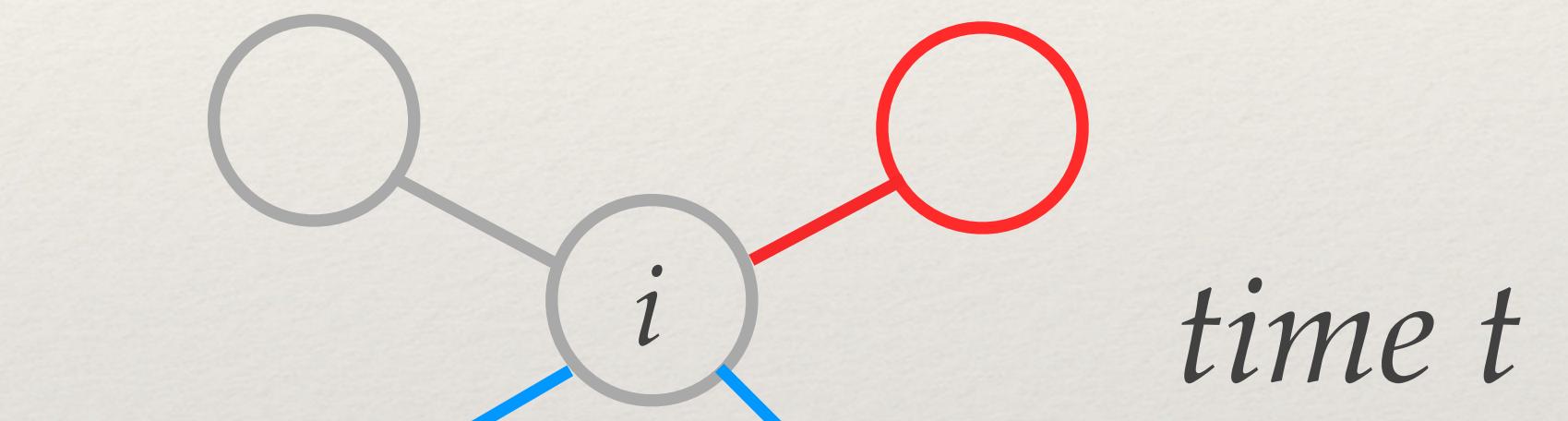


*neighbors of  $i$ :  $n_i$*   
*credibility of the hoax:  $\alpha$*   
*spreading rate:  $\beta$*

# From Susceptible to Believer/Fact-Checker

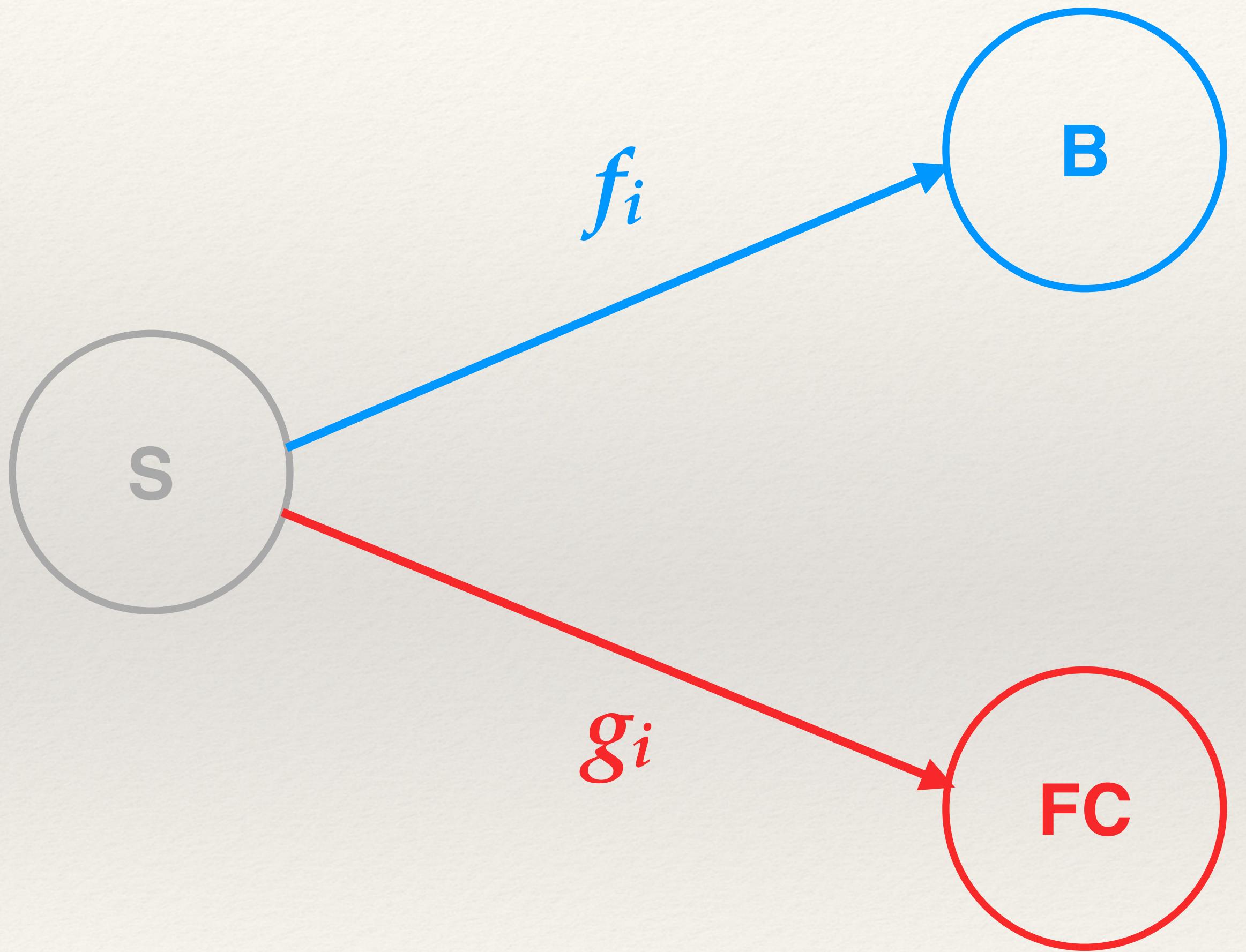


$$f_i(t) = \beta \frac{n_i^B(t)(1 + \alpha)}{n_i^B(t)(1 + \alpha) + n_i^F(t)(1 - \alpha)}$$

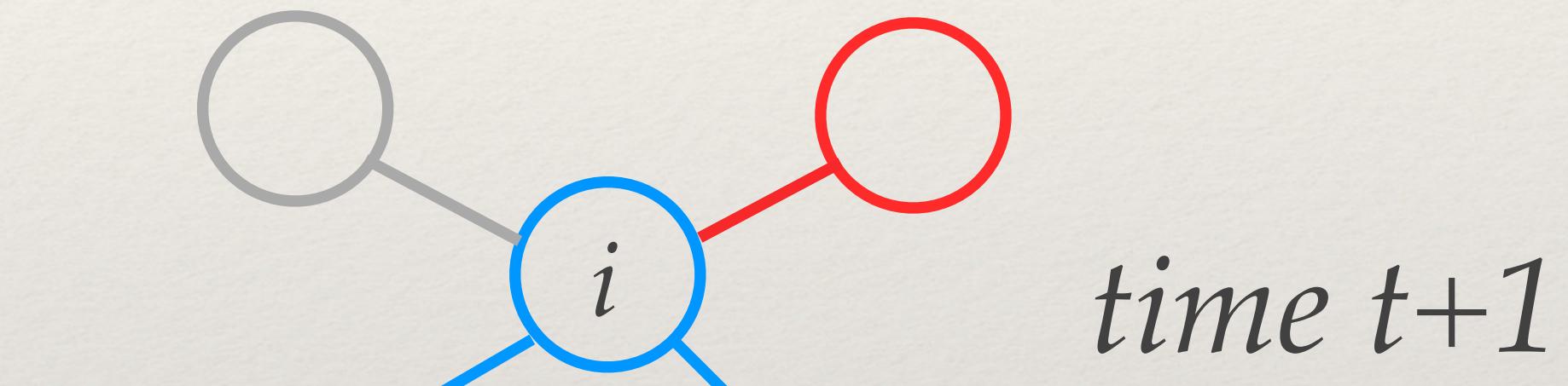


$$g_i(t) = \beta \frac{n_i^F(t)(1 - \alpha)}{n_i^B(t)(1 + \alpha) + n_i^F(t)(1 - \alpha)}$$

# From Susceptible to Believer/Fact-Checker

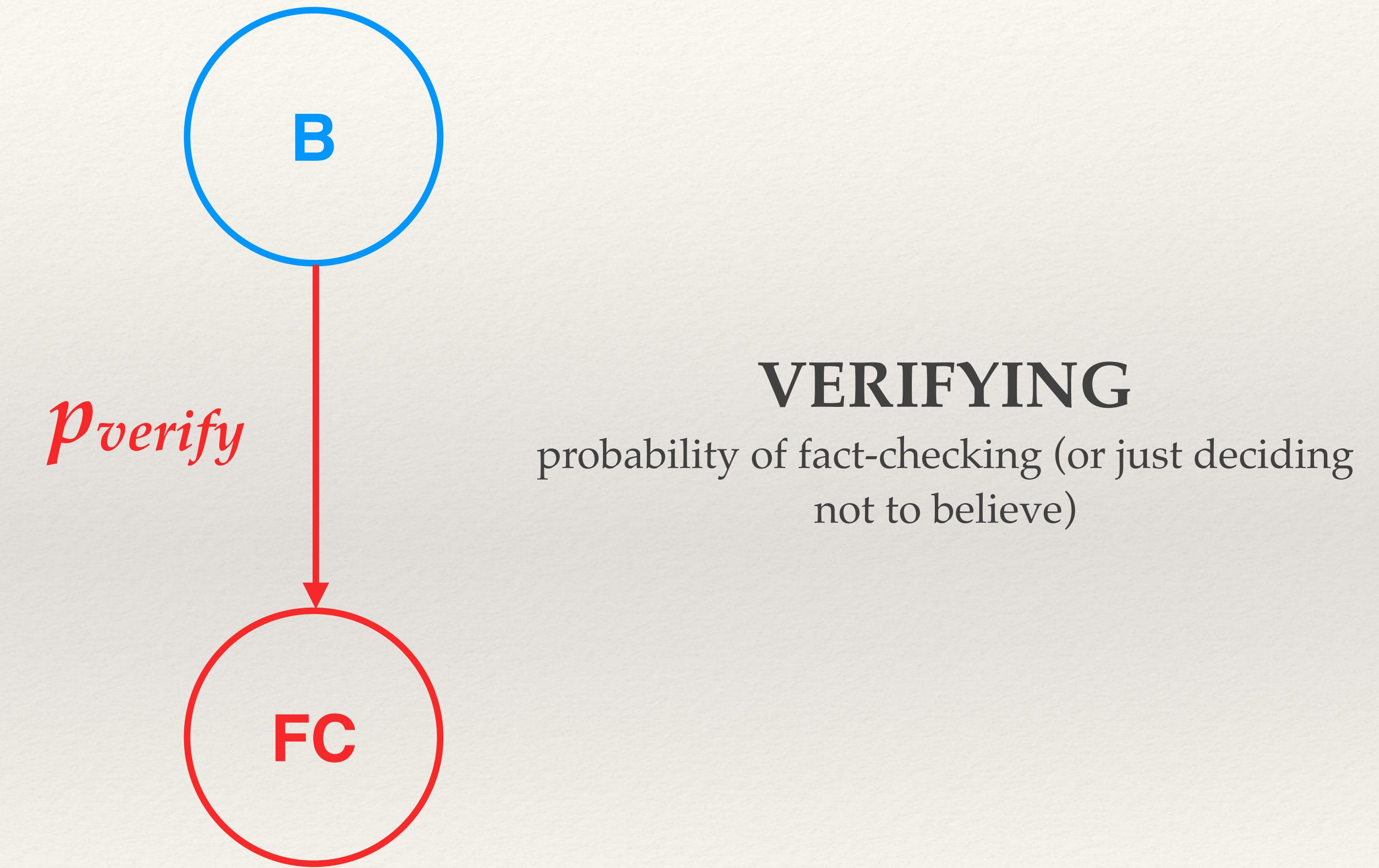


$$f_i(t) = \beta \frac{n_i^B(t)(1 + \alpha)}{n_i^B(t)(1 + \alpha) + n_i^F(t)(1 - \alpha)}$$

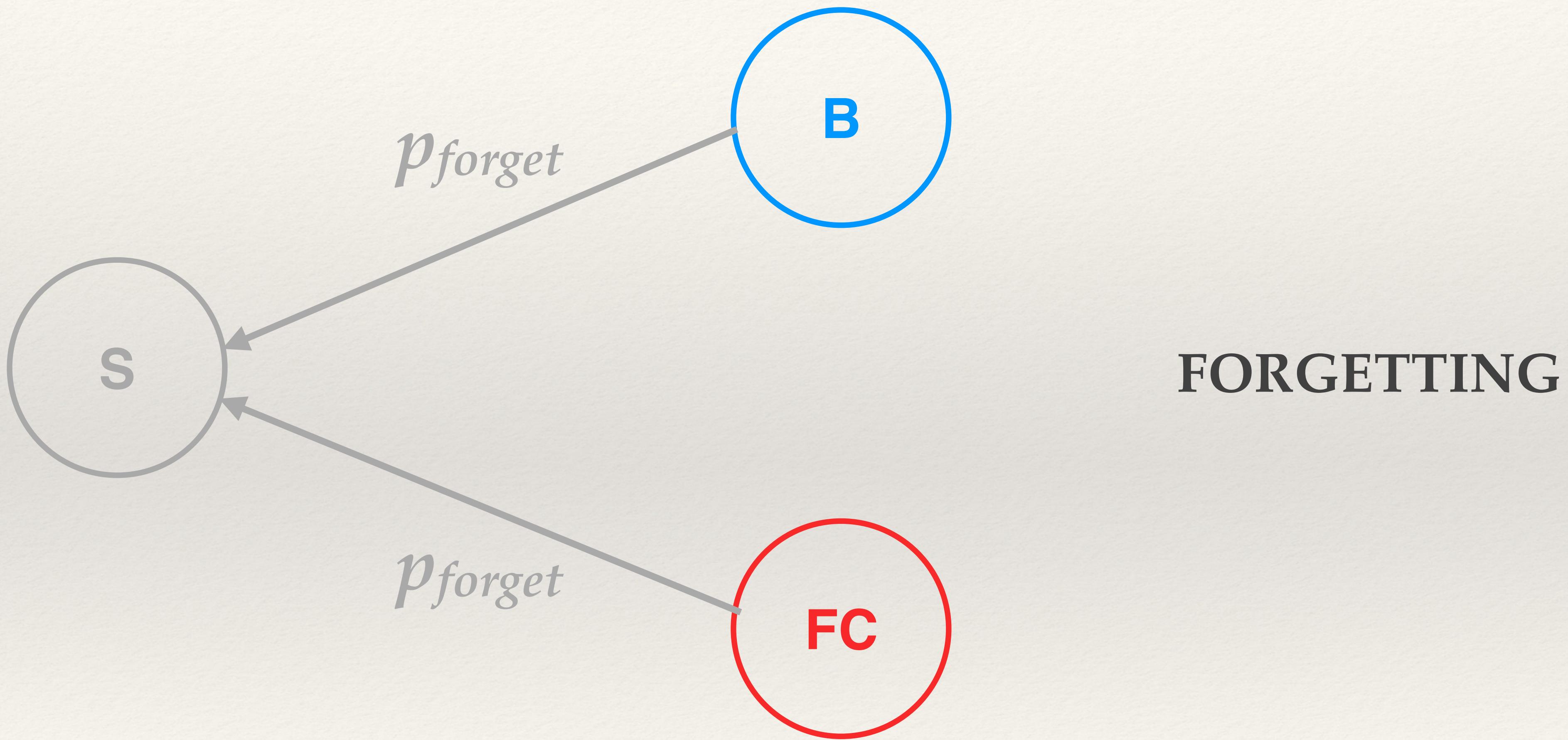


$$g_i(t) = \beta \frac{n_i^F(t)(1 - \alpha)}{n_i^B(t)(1 + \alpha) + n_i^F(t)(1 - \alpha)}$$

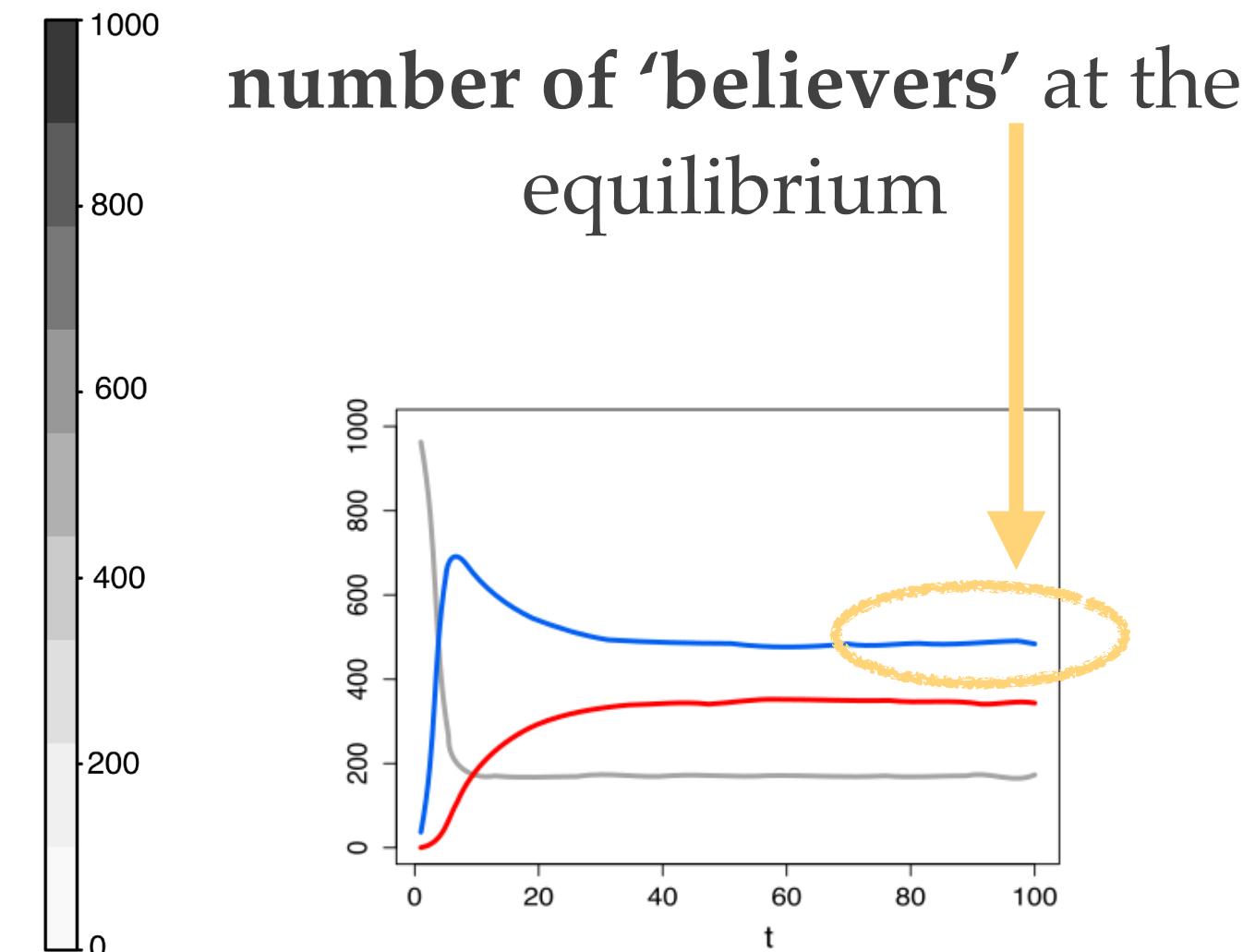
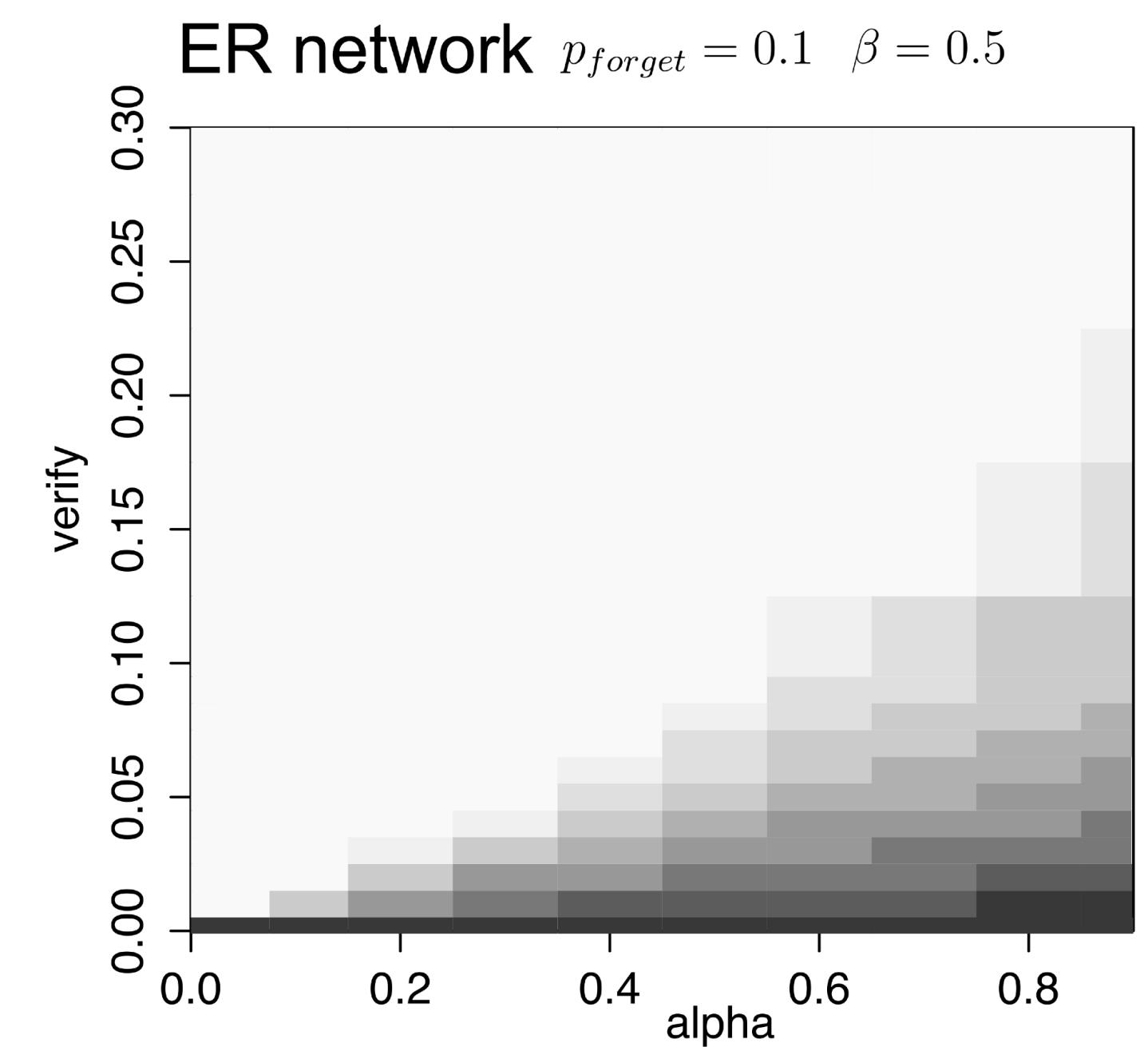
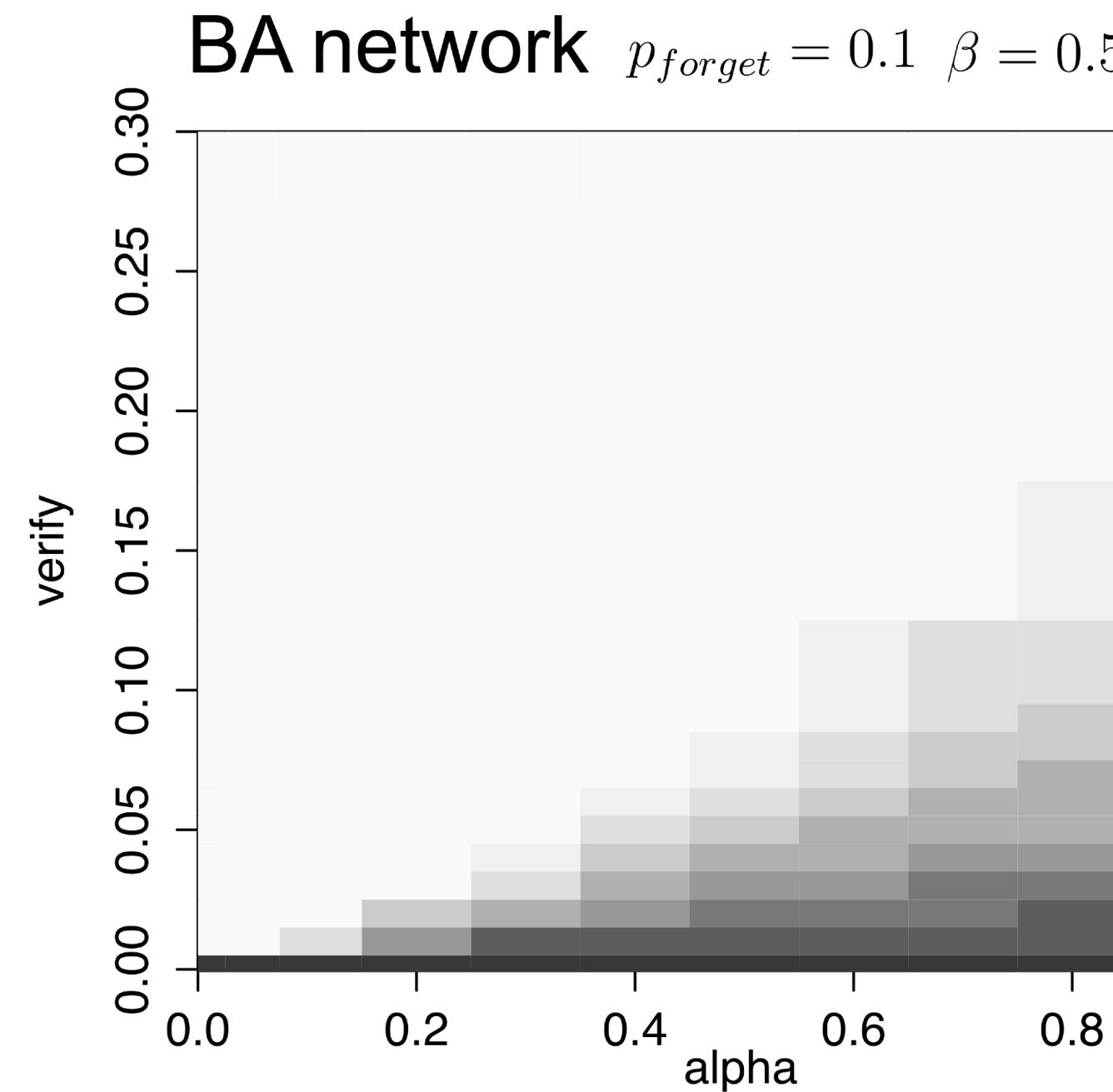
# From Believer to Fact-Checker



# From Believer/Fact-Checker to Susceptible



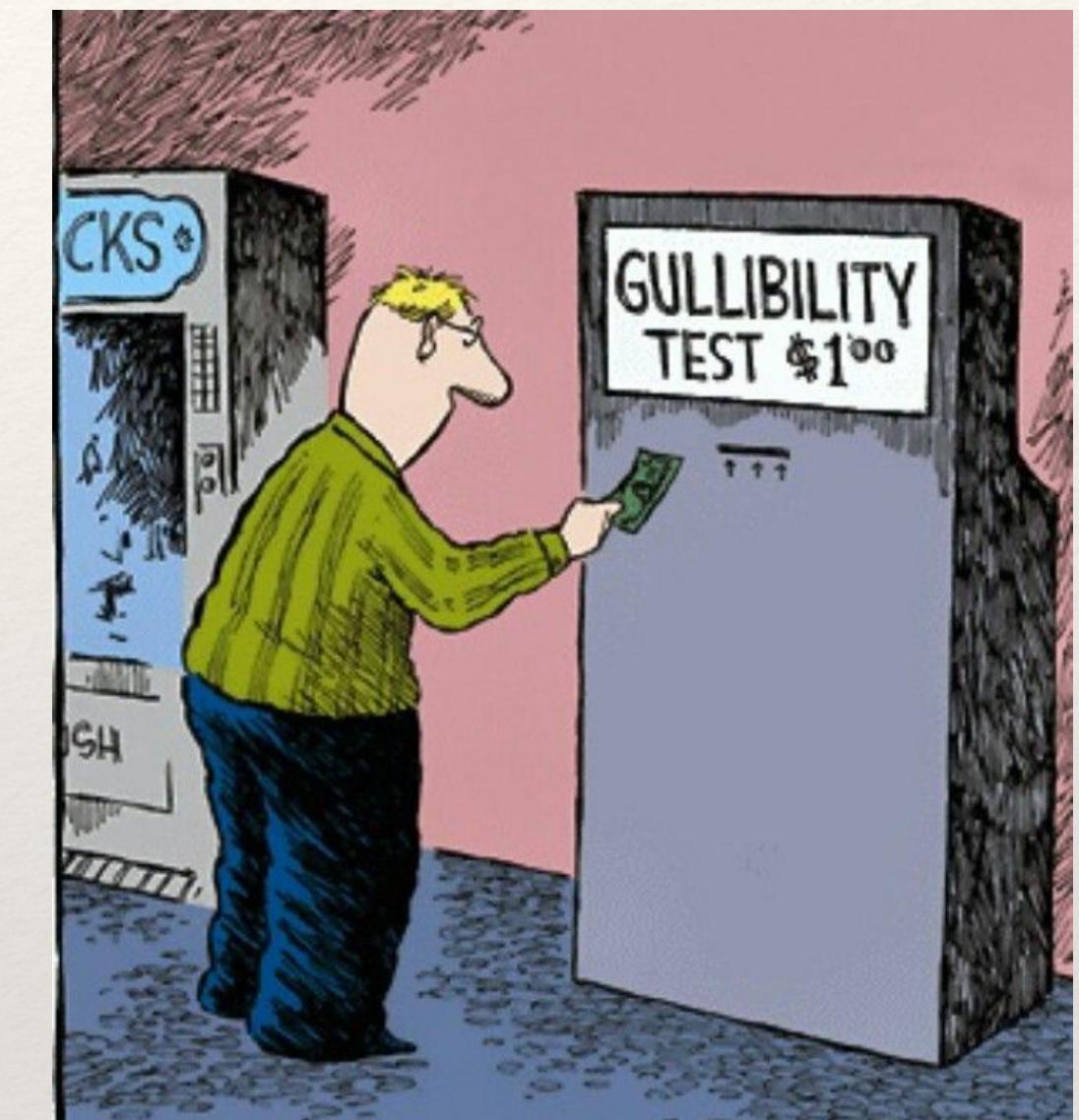
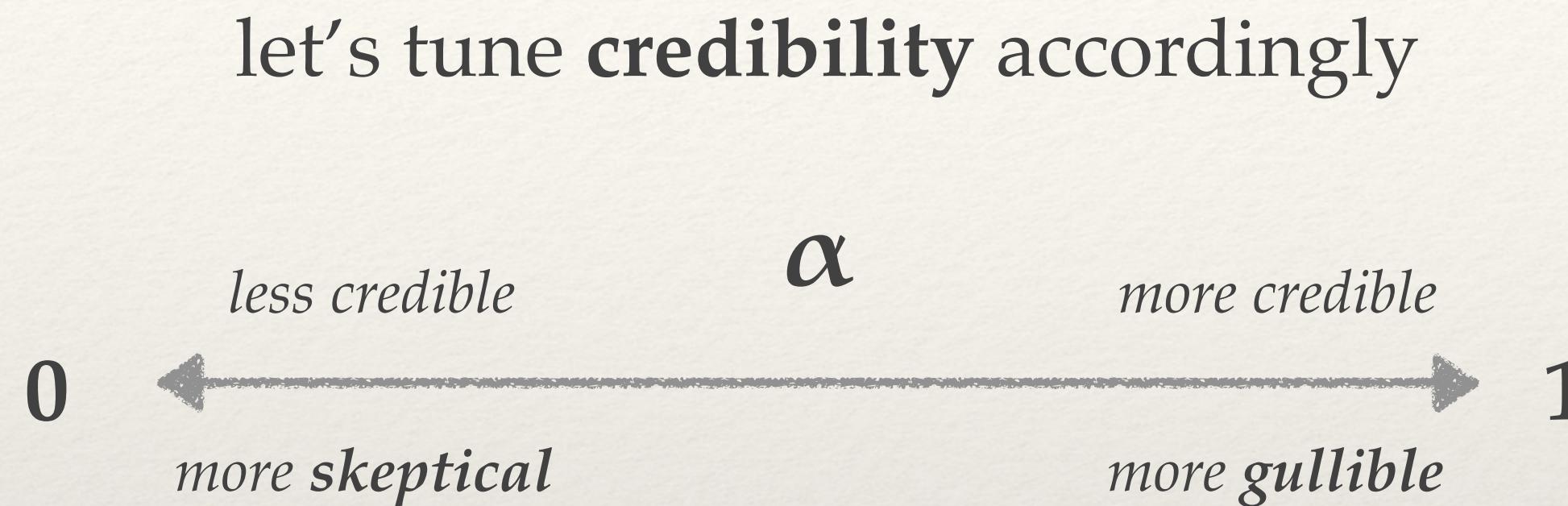
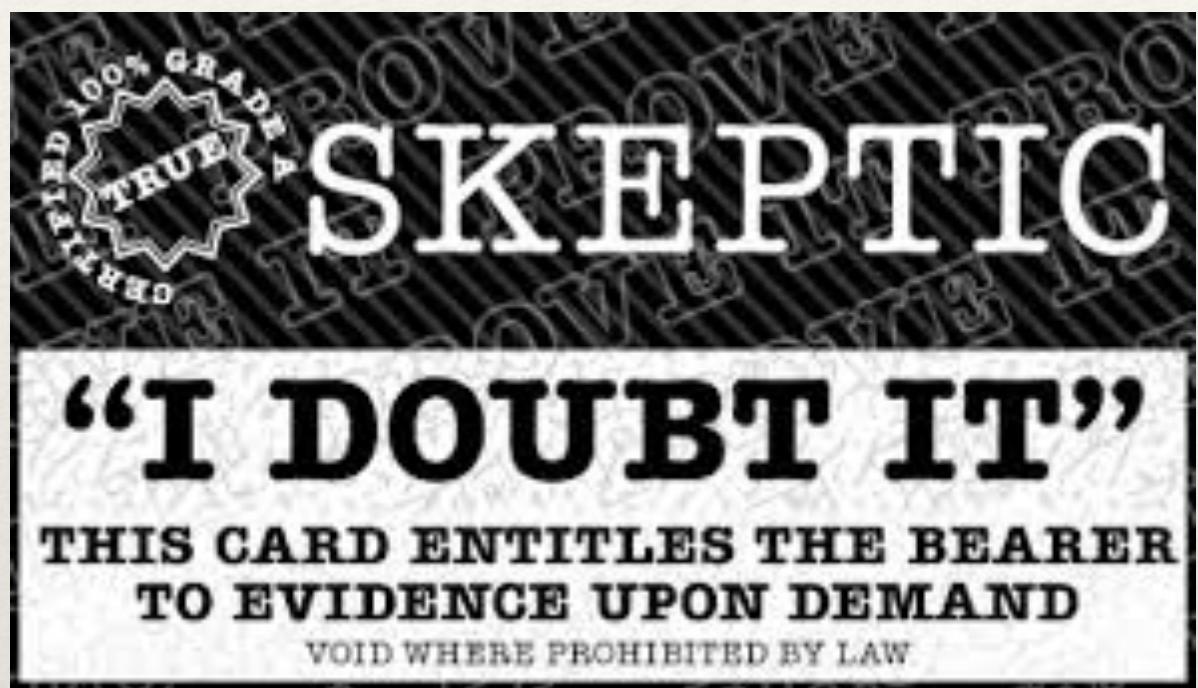
# Dynamics (agent-based simulations)



*threshold on verifying probability:* this provides an idea of how many believers we need to convince to guarantee the removal of the hoax

# The role of segregation

# Skeptical and gullible agents



the propensity to believe is also a property of the node (gullibility)

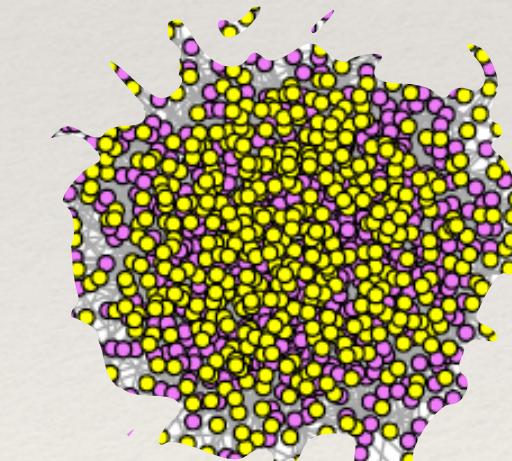
What does it happen when skeptics and gullible agents are segregated?

# Modeling two segregated communities

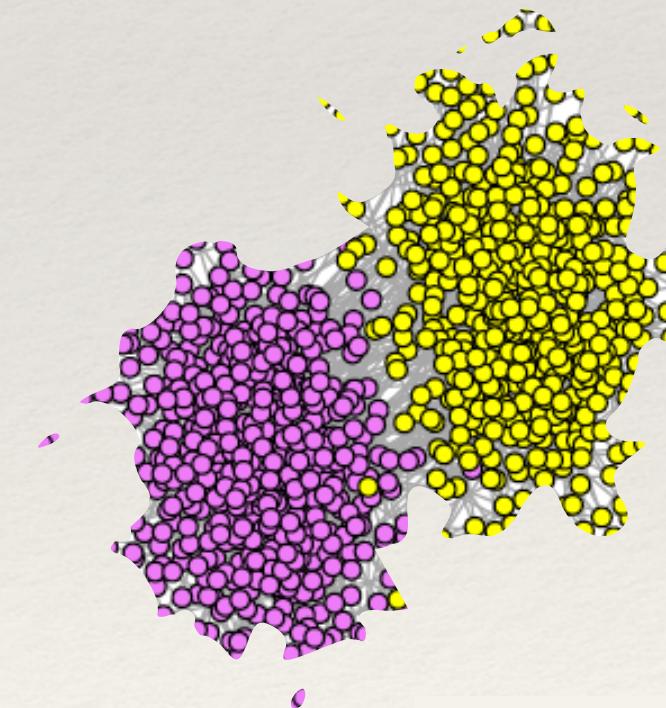
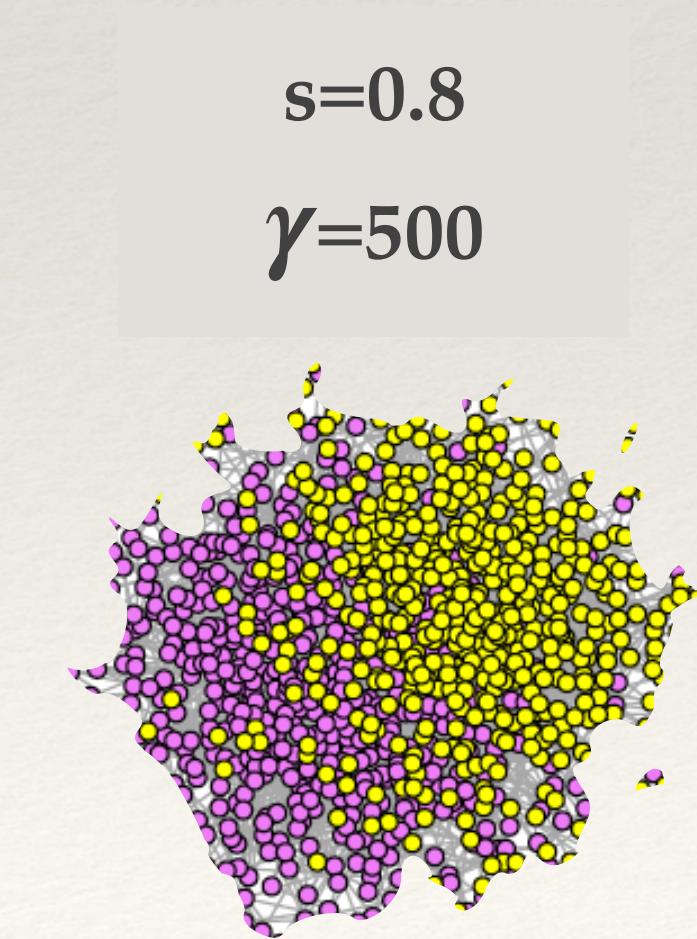


size ( $0 < \gamma < N$ )  
# nodes in the gullible community

segregation ( $0.5 < s < 1$ )  
fraction of edges within same community  
[Gu-Gu, Sk-Sk]



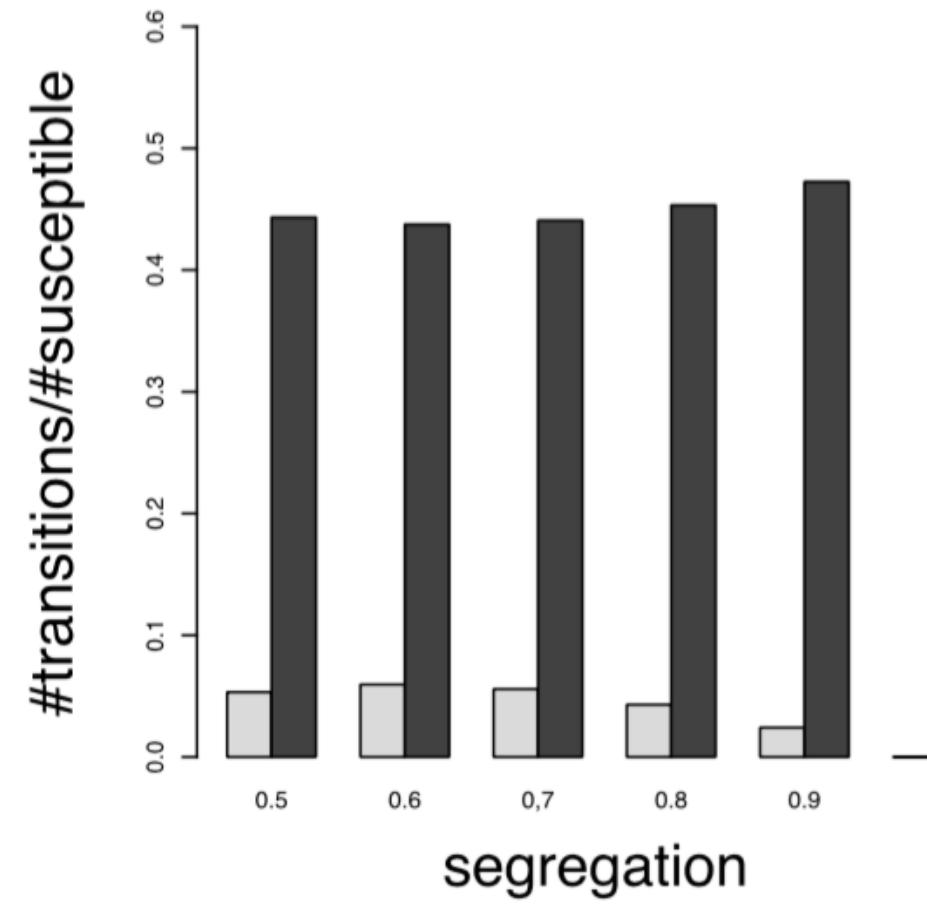
$s=0.55$   
 $\gamma=500$



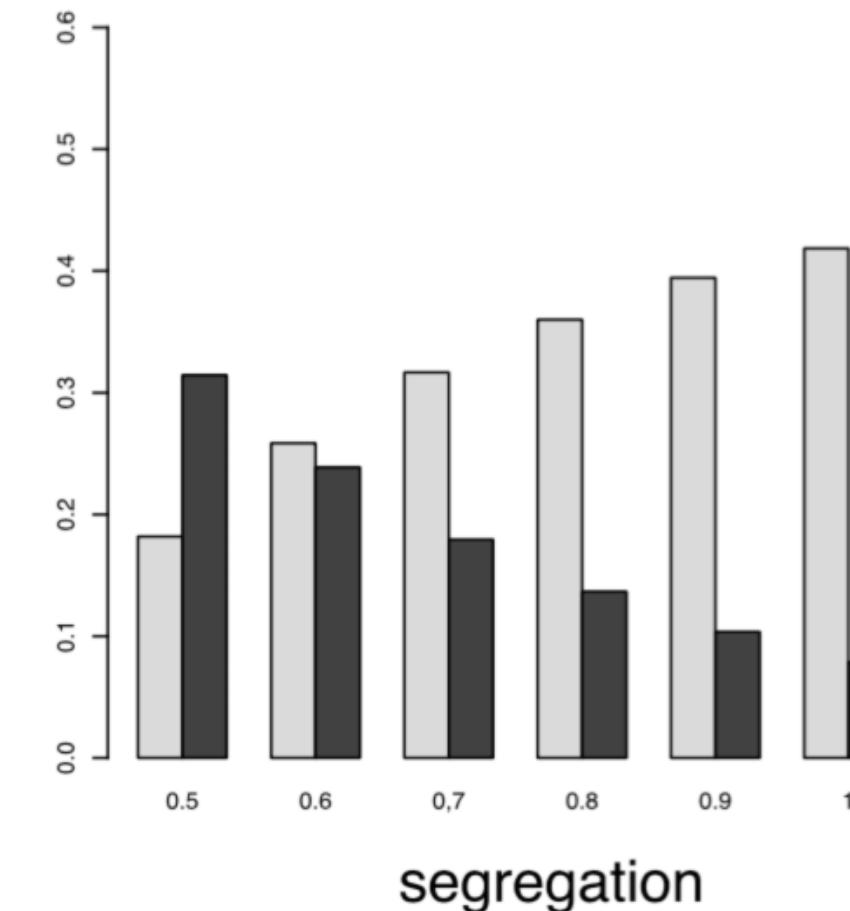
$s=0.95$   
 $\gamma=500$

# Transitions

**SKEPTIC GROUP**

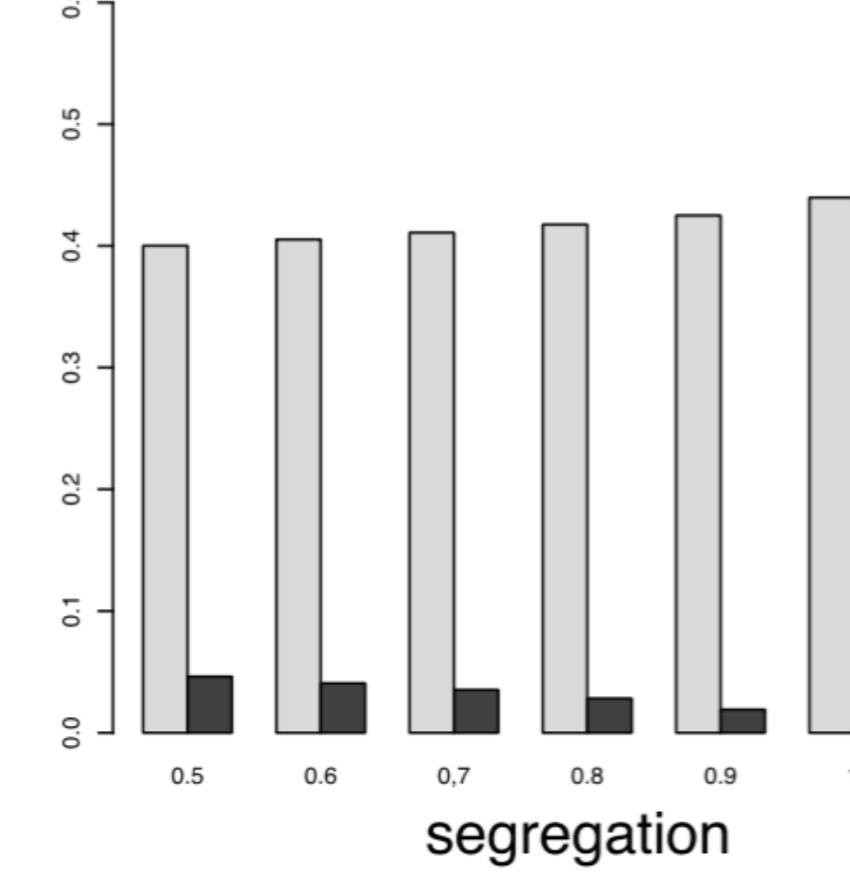
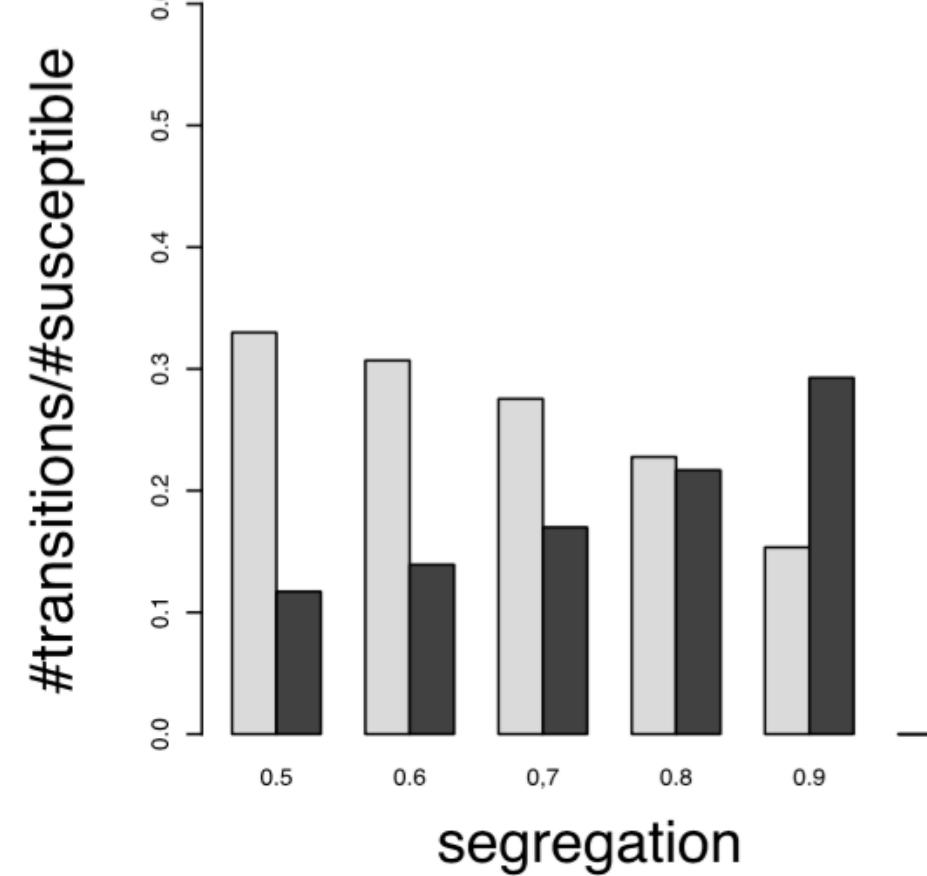


**GULLIBLE GROUP**



■ SUSCEPTIBLE>>FACT-CHECKER  
□ SUSCEPTIBLE>>BELIEVER

**LOW FORGETTING PROBABILITY**

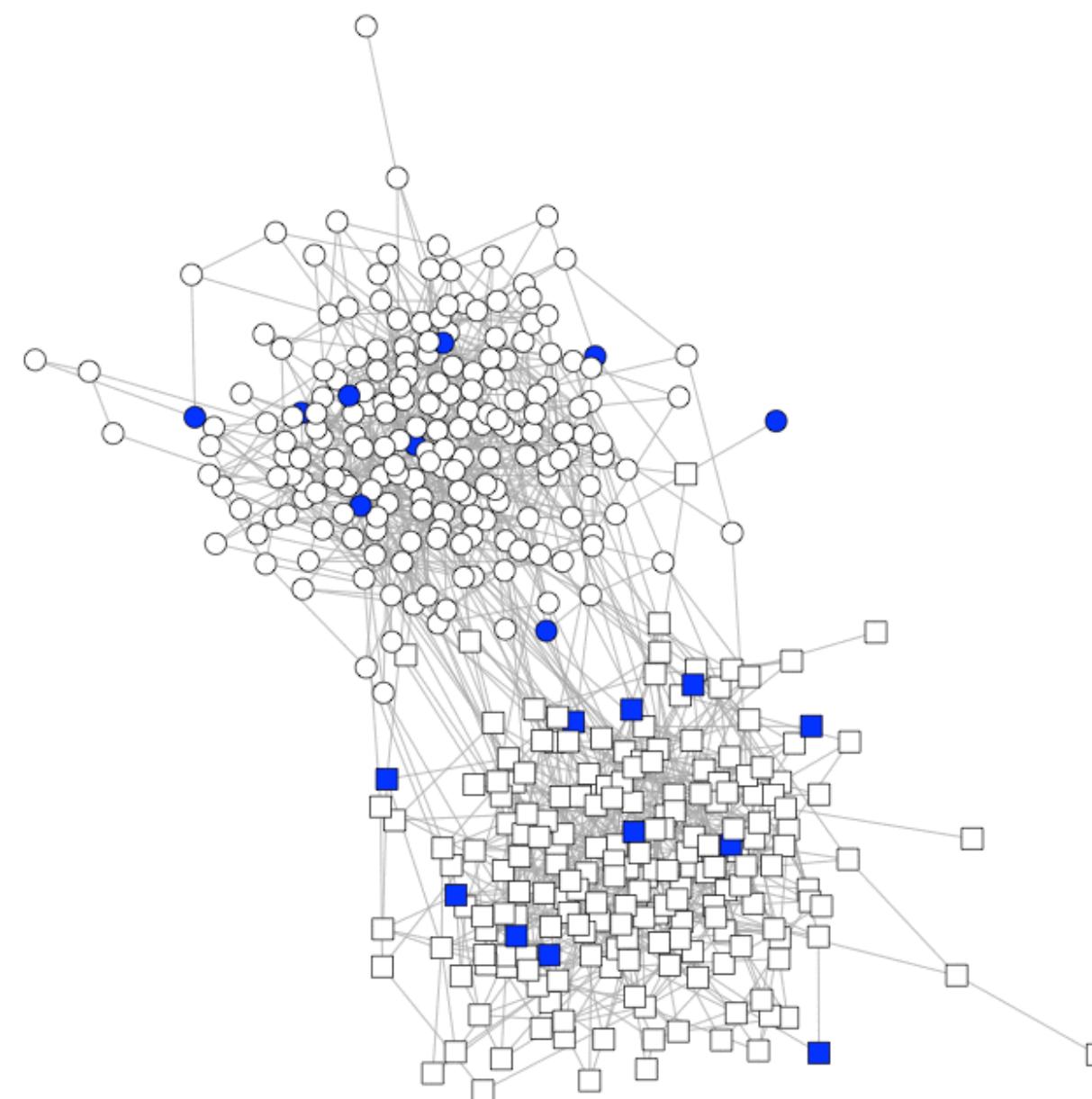


**HIGH FORGETTING PROBABILITY**

# Role of forgetting

LOW Forgetting Rate

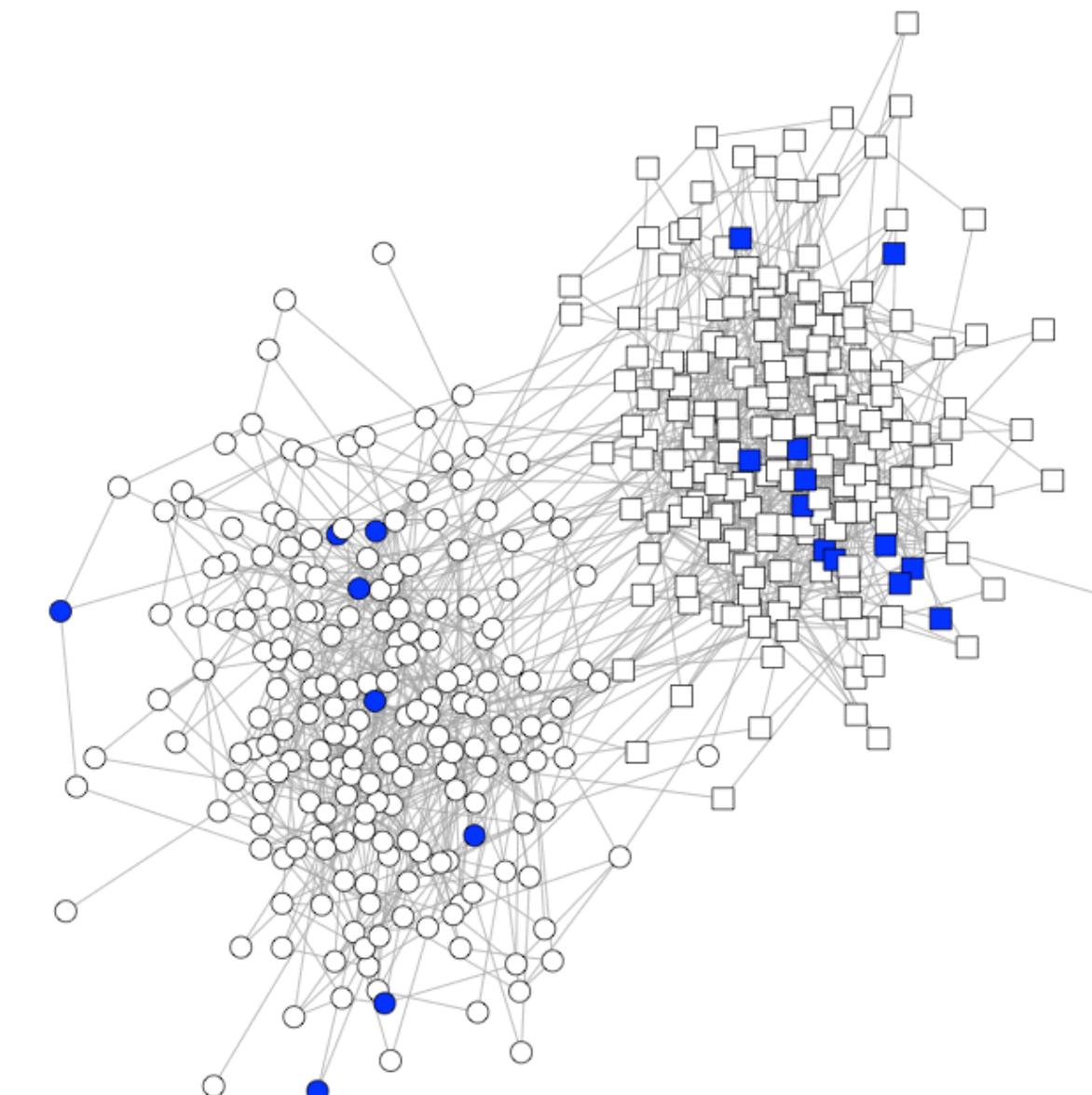
$$p_f = 0.1$$



Time = 1

HIGH Forgetting Rate

$$p_f = 0.8$$



Time = 1

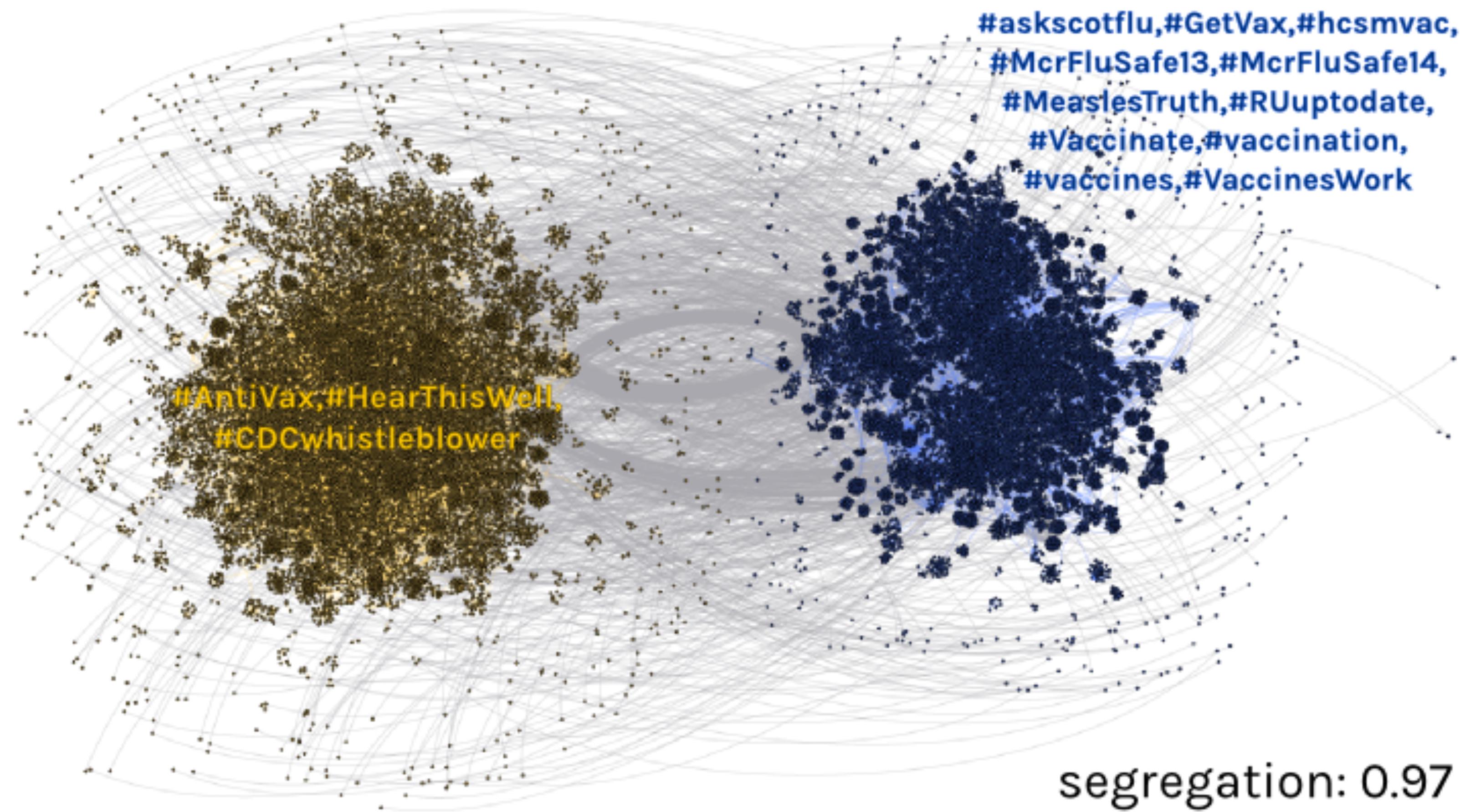
# Lessons learned and observations

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- ❖ We can use our model to study the fake-news diffusion process in **segregated community**
- ❖ **Complex contagion** is observed: interplay and not trivial outcomes
- ❖ **Forgetting probability** becomes relevant as well as the **level of segregation**:
  - ❖ **high forgetting probability** (e.g., just `normal' unfounded gossip) vanishes soon in **segregated communities**
  - ❖ **low forgetting probability** (e.g., conspiracy theories or partisanship beliefs) requires **low segregation**

M Tambuscio, D F M Oliveira, G L Ciampaglia, G Ruffo, [Network segregation in a model of misinformation and fact-checking](#), Journal of Computational Social Science (2018) 1: 261.

# real data: vaccines

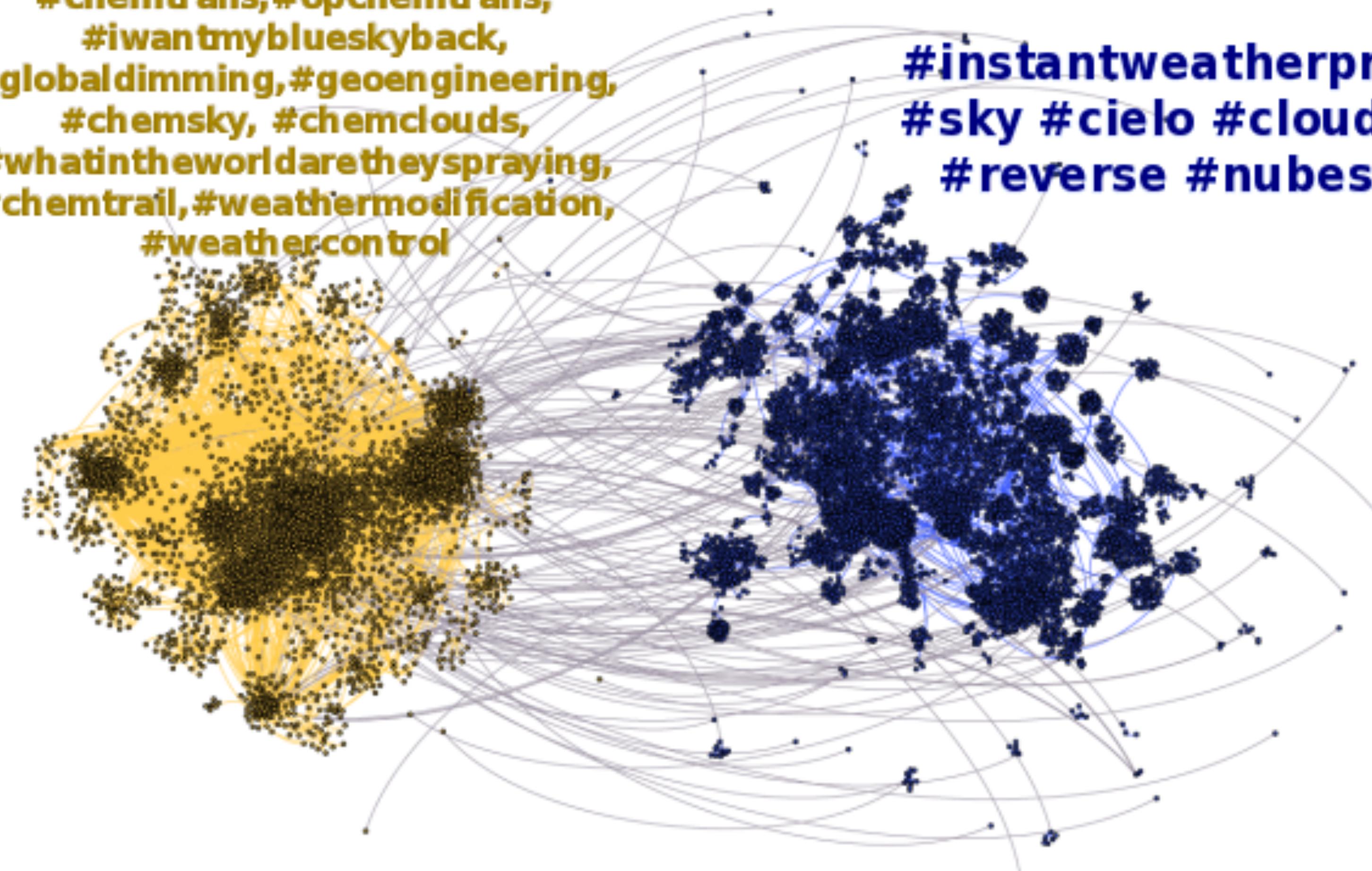


twitter data from IU <https://osome.iuni.iu.edu>

# real data: chemtrails

#chemtrails, #opchemtrails,  
#iwantmyblueskyback,  
#globaldimming, #geoengineering,  
#chemsky, #chemclouds,  
#whatintheworldaretheyspraying,  
#chemtrail, #weathermodification,  
#weathercontrol

#instantweatherpro  
#sky #cielo #clouds  
#reverse #nubes



twitter data from IU <https://osome.iuni.iu.edu>

segregation: 0.99

# Evaluating debunking strategies

---

# What-if analysis

---

- ❖ We live in a **segregated** society: let's accept it!
- ❖ **Polarization** can last for a long time: **low forgetting probability**
- ❖ **Computational epidemiology**: immunization works better if some node in the network (e.g., hubs, bridges) is vaccinated first
- ❖ **Where** to place fact-checkers?
- ❖ Stronger hypothesis: a believer do not verify ( $p_{\text{verify}} = 0$ )
  - ❖ they can still forget
  - ❖ we can accept to leave half of the population breaking the egg on the wrong side, but we want at least to protect the skeptics!

# Basic settings with no verification

## Setting

segregation: 0.92 (high)

forgetting: 0.1 (low)

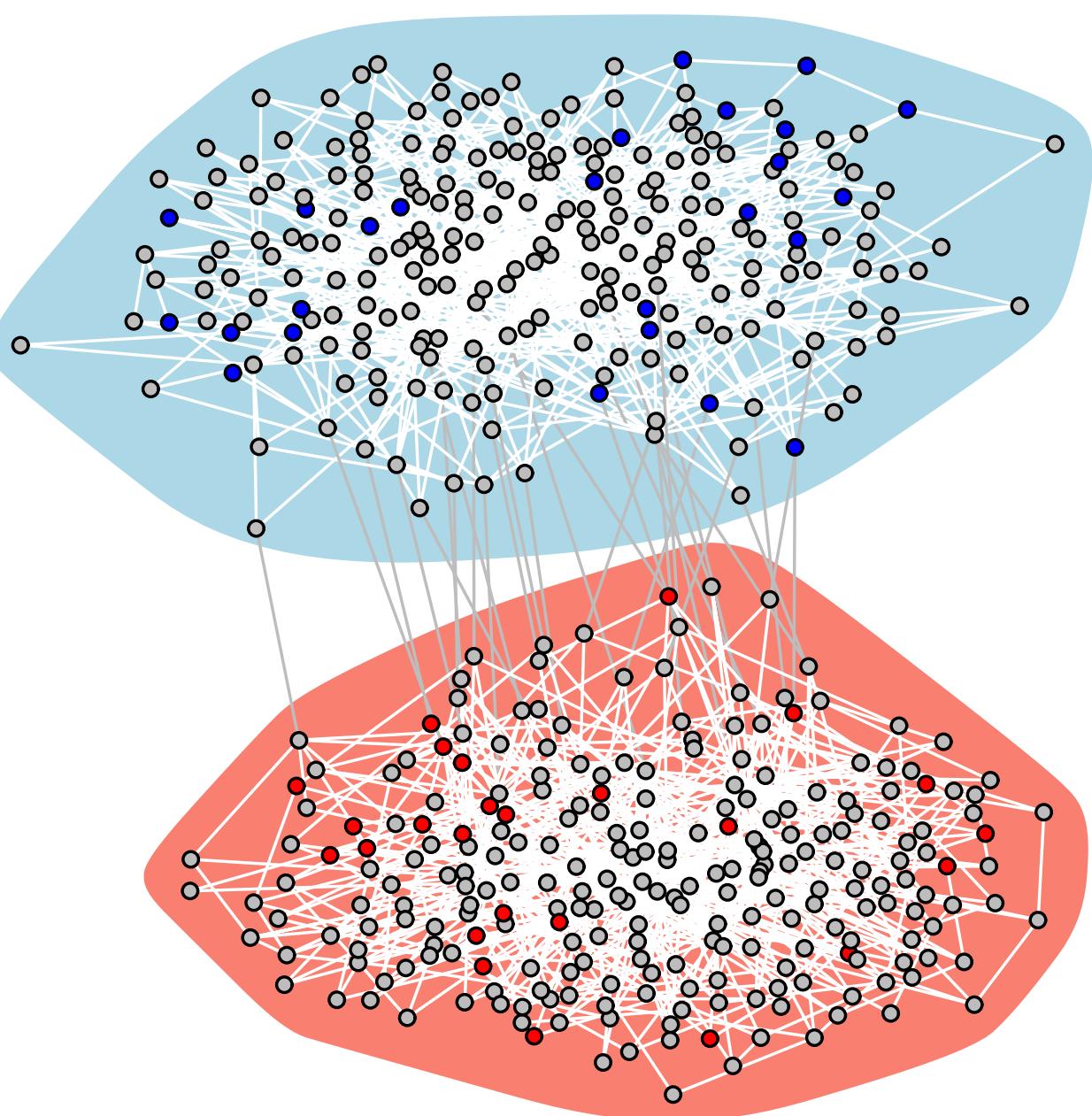
gullible group:

- $\alpha$ : 0.8
- seeders B: 10%

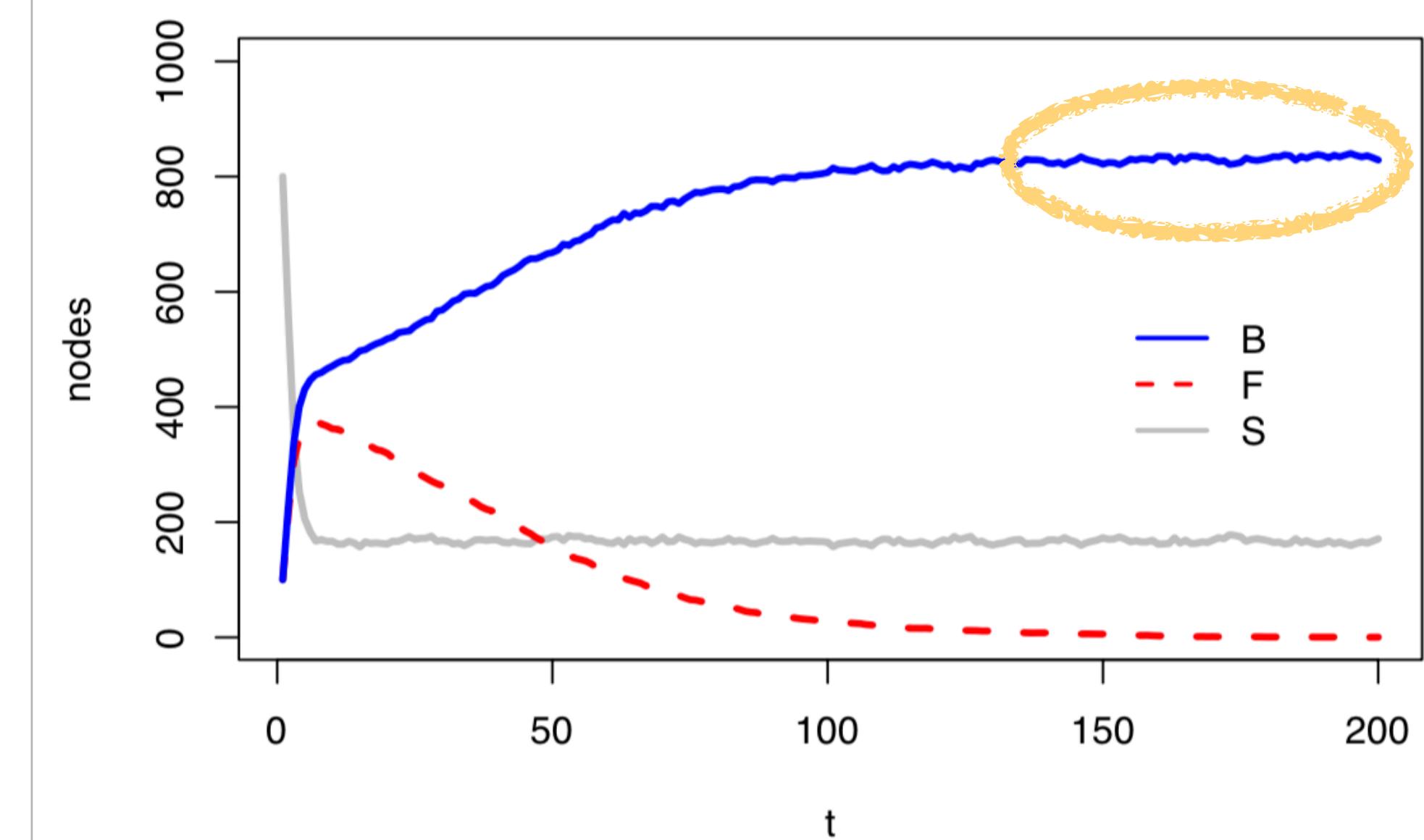
skeptical group:

- $\alpha$ : 0.3
- seeders FC: 10%

## Simulation start



## Simulation results



As expected: very **bad!**

# Eternal fact-checkers placed at random

## Setting

segregation: 0.92 (high)

forgetting: 0.1 (low)

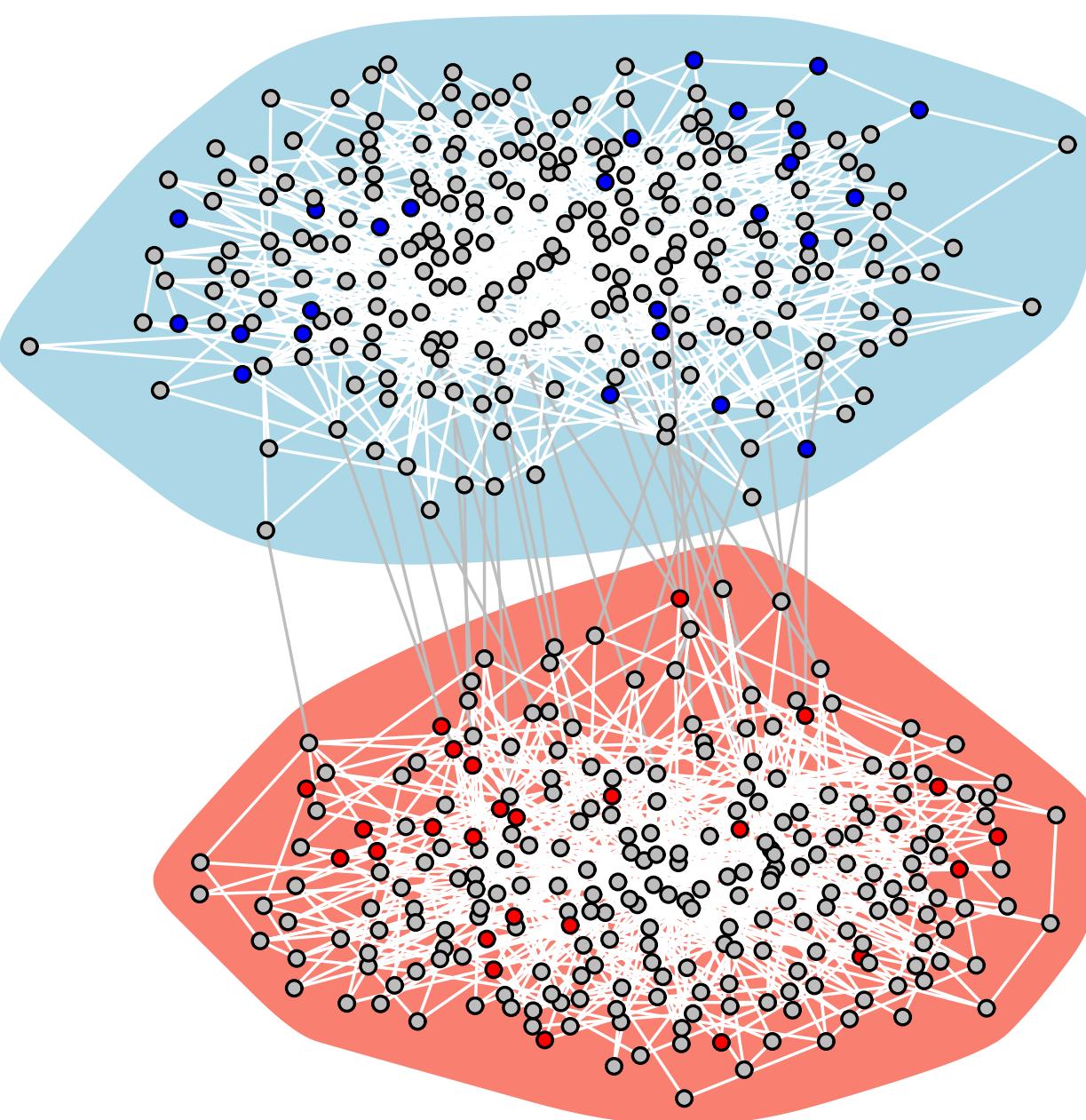
gullible group:

- $\alpha$ : 0.8
- seeders B: 10%

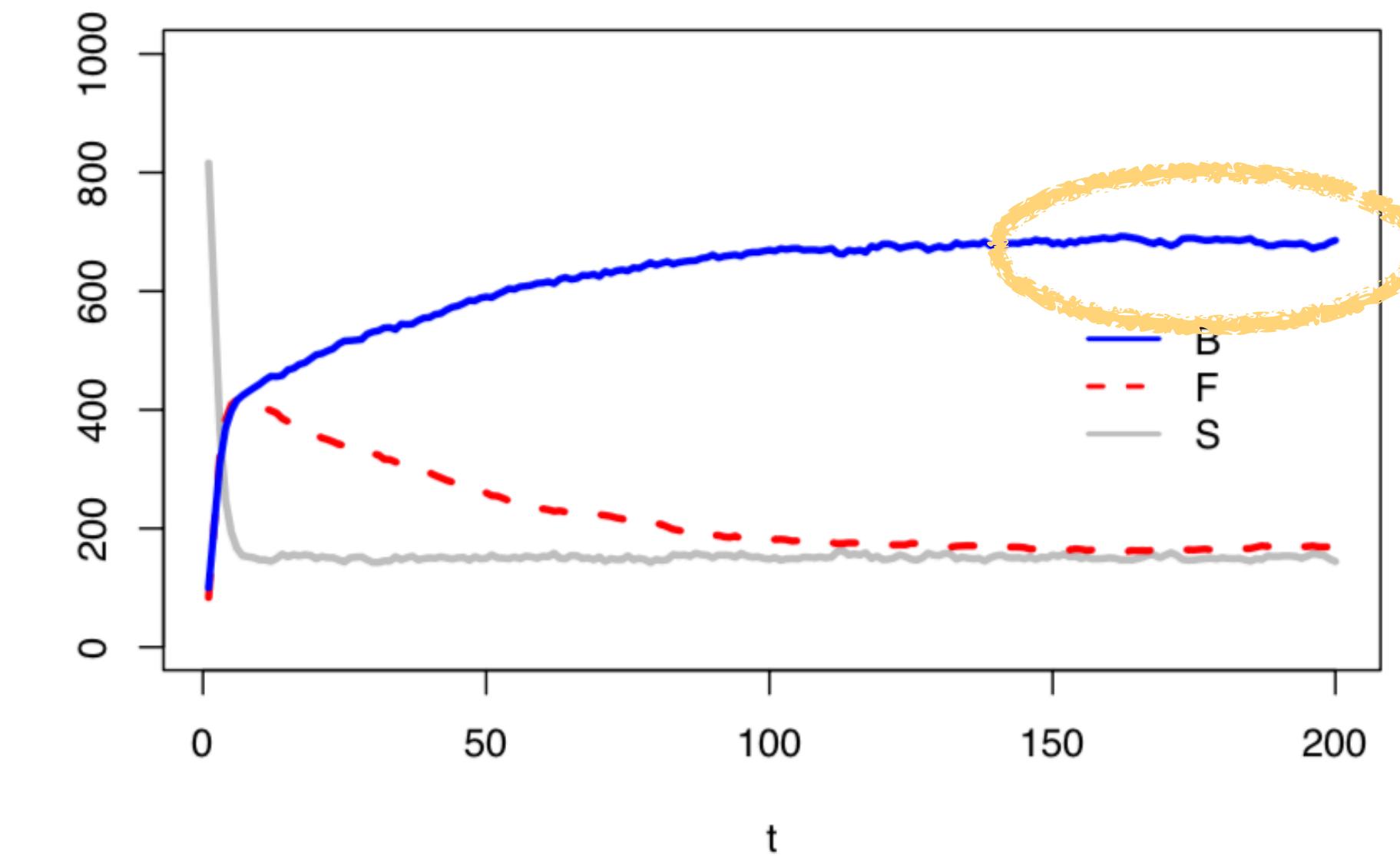
skeptical group:

- $\alpha$ : 0.3
- seeders F: 10%
- seeders are eFC

## Simulation start



## Simulation results



better, but still...

# Hubs as eternal fact-checkers

## Setting

segregation: 0.92 (high)

forgetting: 0.1 (low)

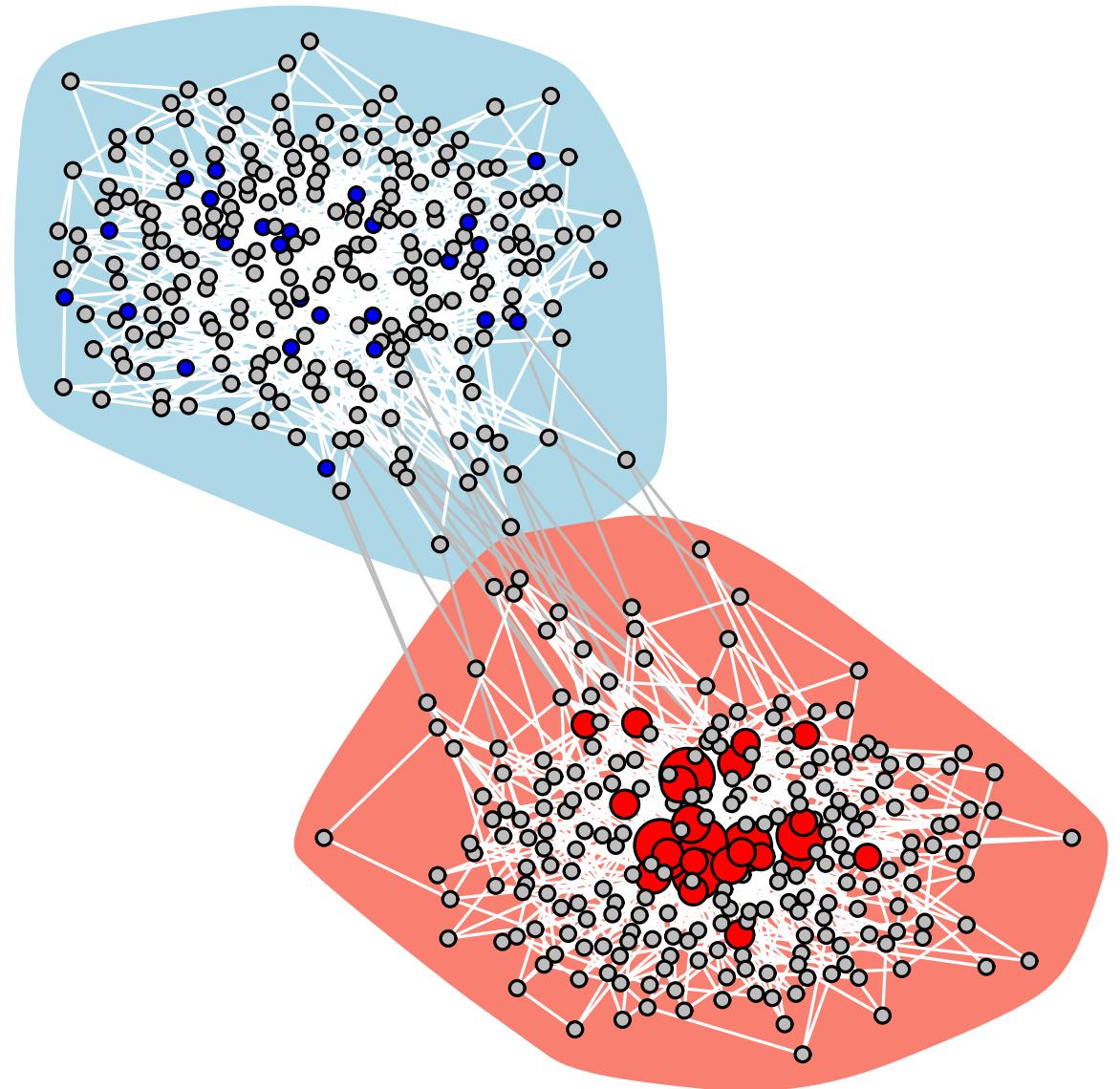
gullible group:

- $\alpha$ : 0.8
- seeders B: 10%

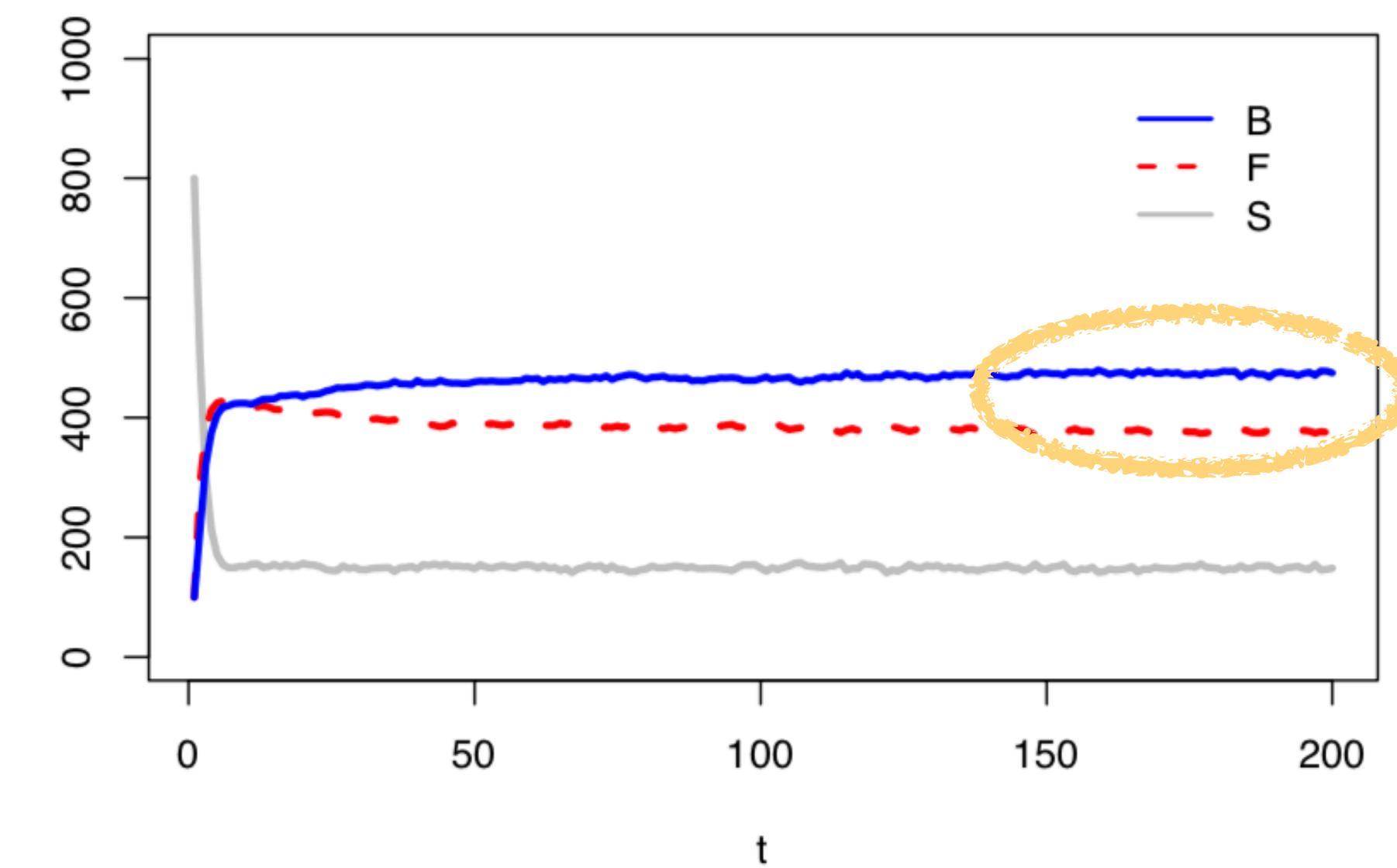
skeptical group:

- $\alpha$ : 0.3
- seeders F: 10%
- HUBS are eFC!

## Simulation start



## Simulation results



better

# Bridges as eternal fact-checker

## Setting

segregation: 0.92 (high)

forgetting: 0.1 (low)

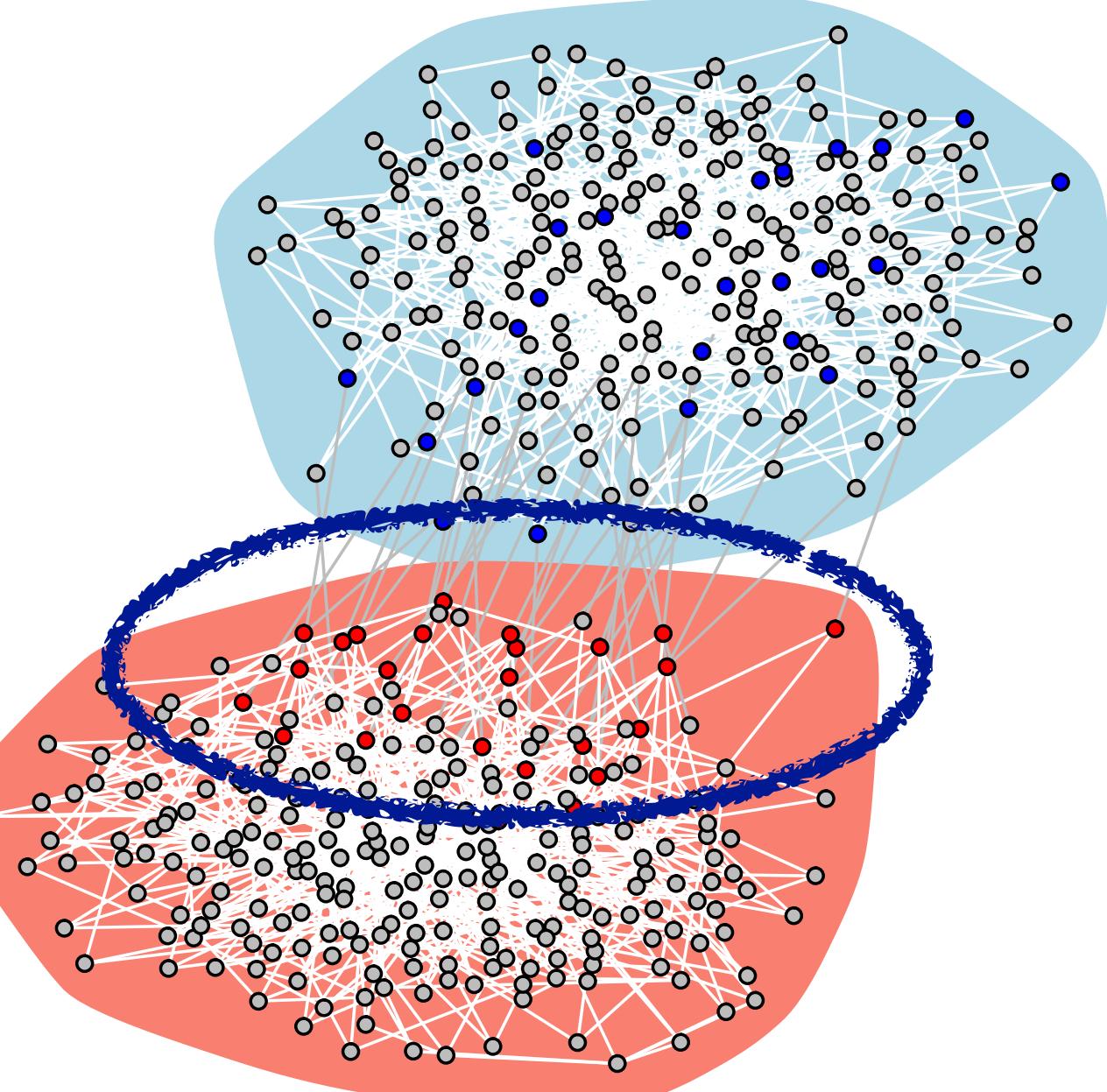
gullible group:

- $\alpha$ : 0.8
- seeders B: 10%

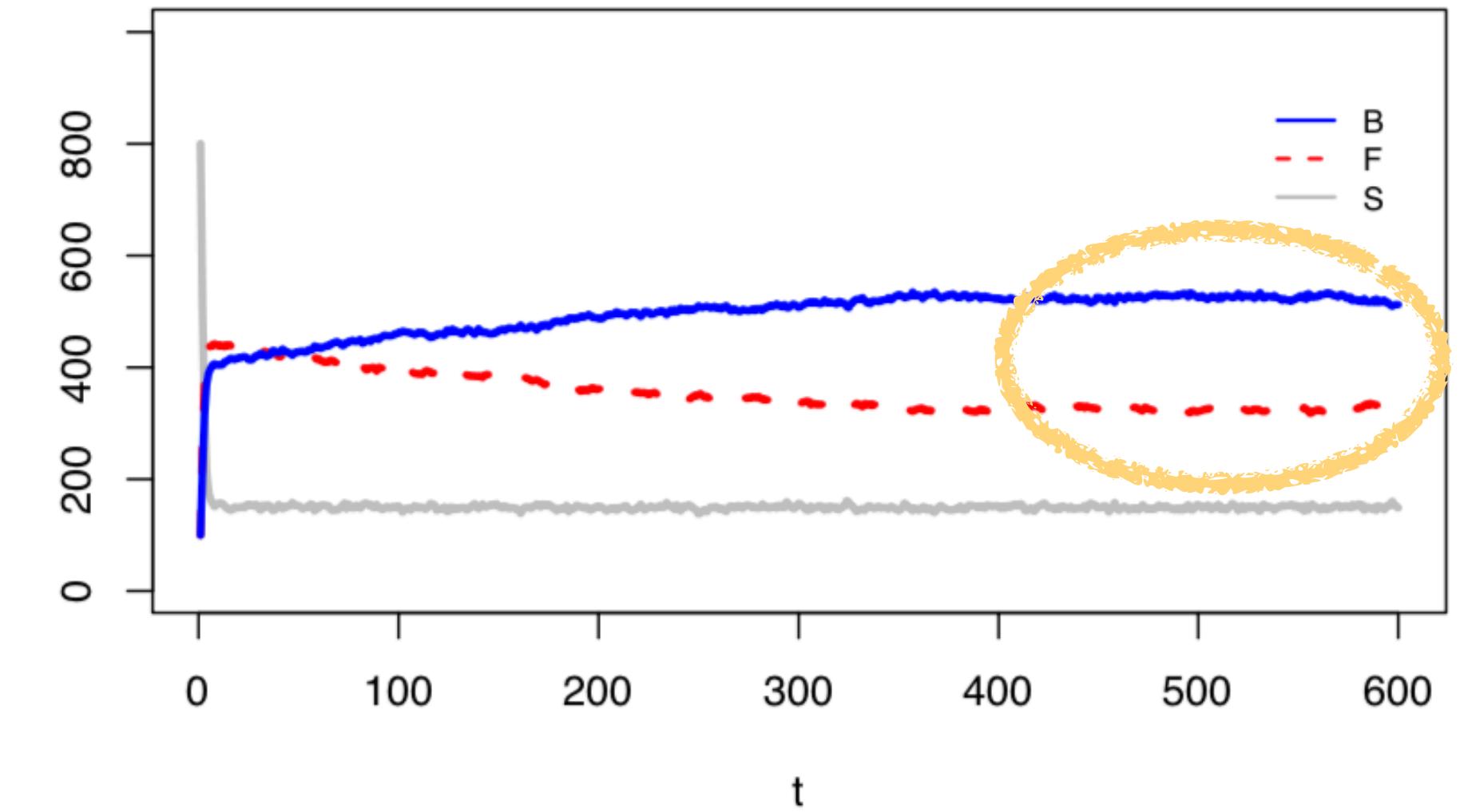
skeptical group:

- $\alpha$ : 0.3
- seeders FC: 10%
- BRIDGES are eFC!

## Simulation start



## Simulation results



comparable, more realistic

# Lessons learned and observations

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- ❖ **Debunking activism** is often considered useless or **counterproductive**
- ❖ However, a world without fact-checking is harmless against fake-news circulation: **skeptics exposed to misinformation** will turn into **believers** because of **social influence**
- ❖ **Skeptics with links to gullible subjects** should be the first to be exposed to the fact-checking: misinformation will survive in the network, but their communities can be ‘protected’ by such **gatekeepers**
- ❖ Note: no socio-psychological assumption so far. Real world is much more complicated

*protect the vulnerable, encourage skepticism*

# Who is the gatekeeper?

Finland is winning the war against fake news in the classrooms: **education first**

Teachers and the education system have a great responsibility

CNN

[Twitter](#) [Facebook](#)

SPECIAL REPORT

## Finland is winning the war on fake news. What it's learned may be crucial to Western democracy

By Eliza Mackintosh, CNN  
Video by Edward Kiernan, CNN



**Helsinki, Finland (CNN)** – On a recent afternoon in Helsinki, a group of students gathered to hear a lecture on a subject that is far from a staple in most community college curriculums.

Standing in front of the classroom at Espoo Adult Education Centre, Jussi Toivanen worked his way through his PowerPoint presentation. A slide titled “Have you been hit by the Russian troll army?” included a checklist of methods used to deceive readers on social media: image and video manipulations, half-truths, intimidation and false profiles.

# Language and network structure

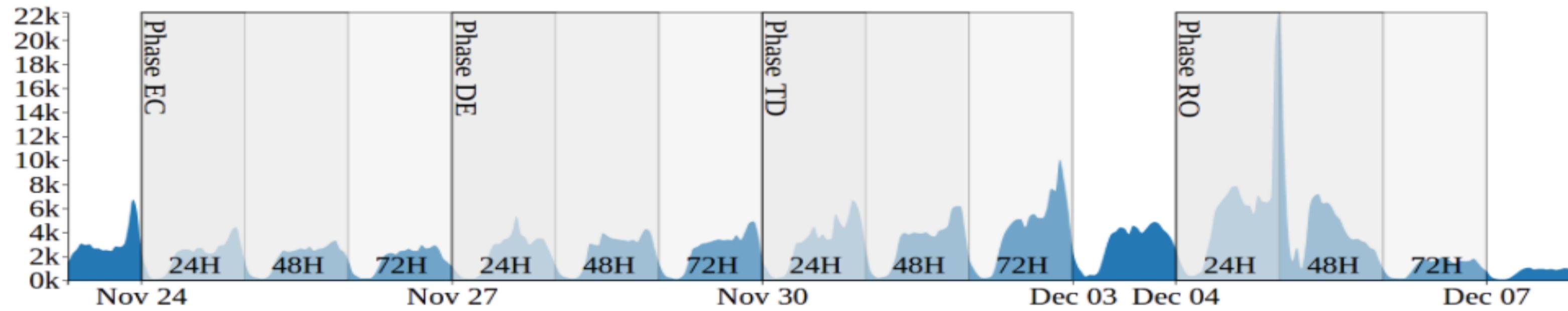
# Links to NLP

- ❖ Individual's opinions are often hidden
- ❖ Social Media provide much data for stance detection, emotion analysis, and so on
- ❖ Communication styles can be another trigger or just a reaction to news exposition and partisanships
- ❖ Relationships between structural segregation and opinion formation and polarization should be explored further by a joint effort between our scientific communities



# Italian 2016 Constitutional Referendum

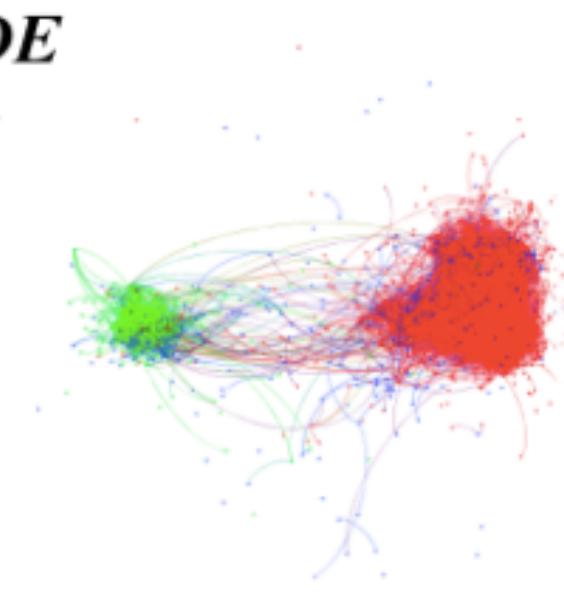
## Collected Tweets



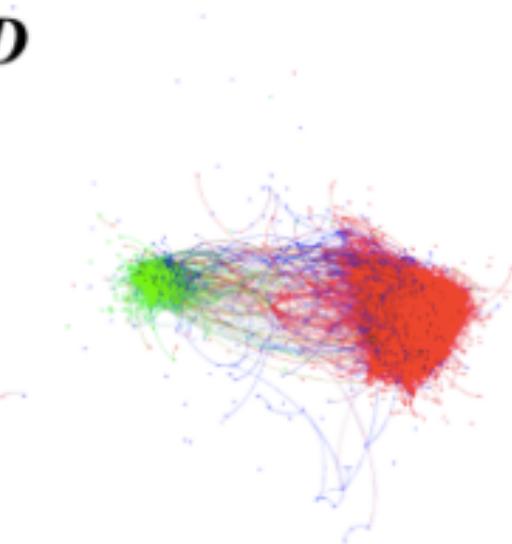
*EC*



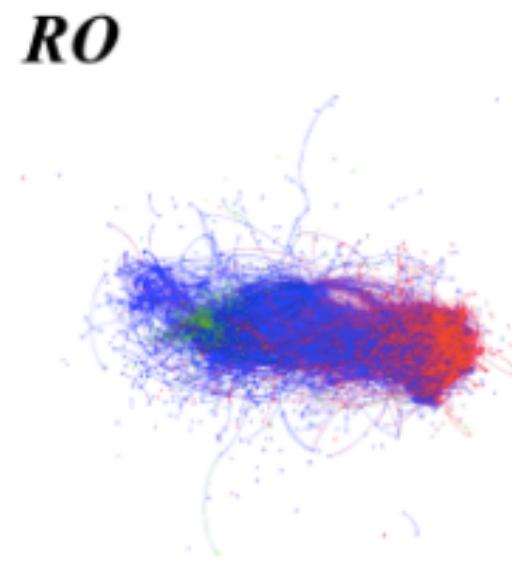
*DE*



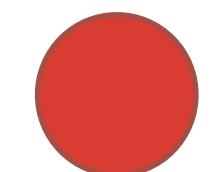
*TD*



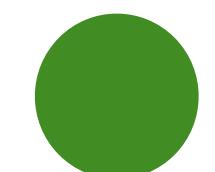
*RO*



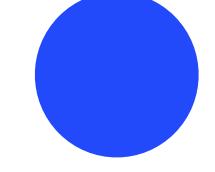
## Retweet Network



stance detected as **AGAINST**



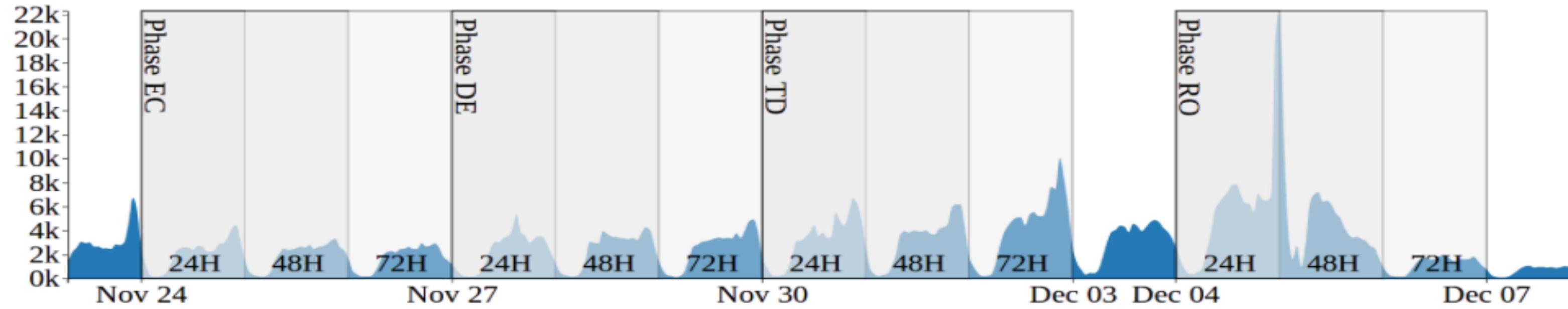
stance detected as **IN FAVOR**



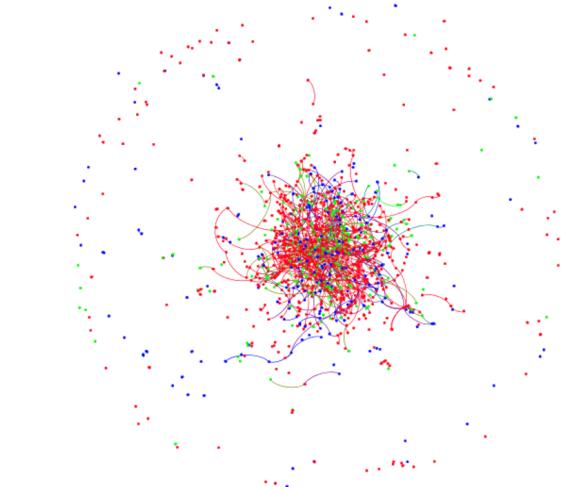
stance detected as **NONE**

# Italian 2016 Constitutional Referendum

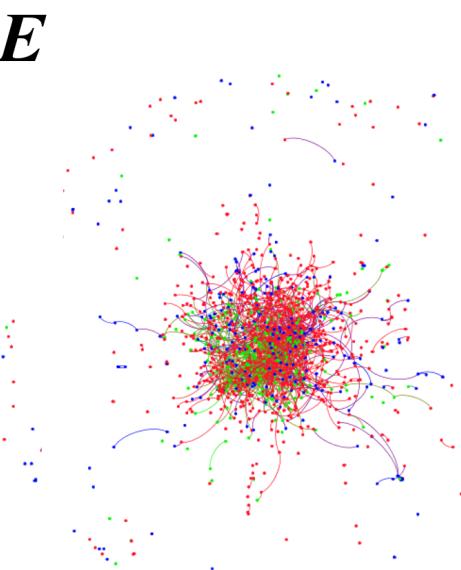
## Collected Tweets



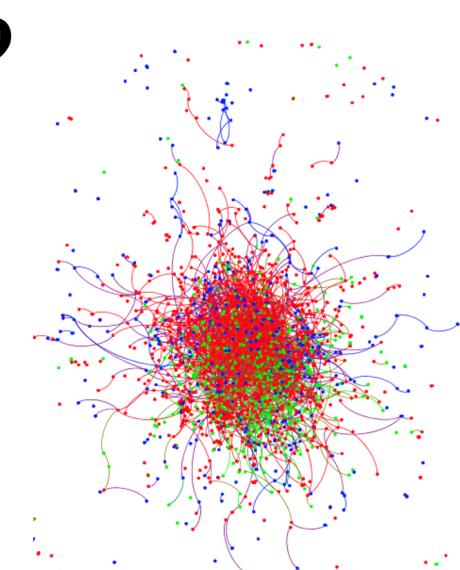
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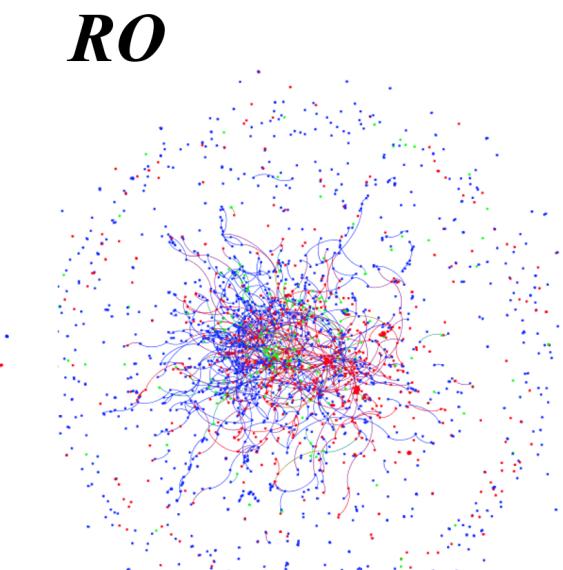
*DE*



*TD*

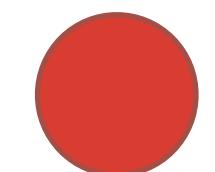


*RO*

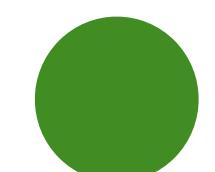


## Reply-to Network

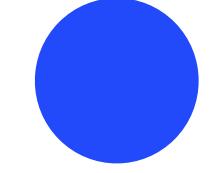
signal of inverse  
homophily



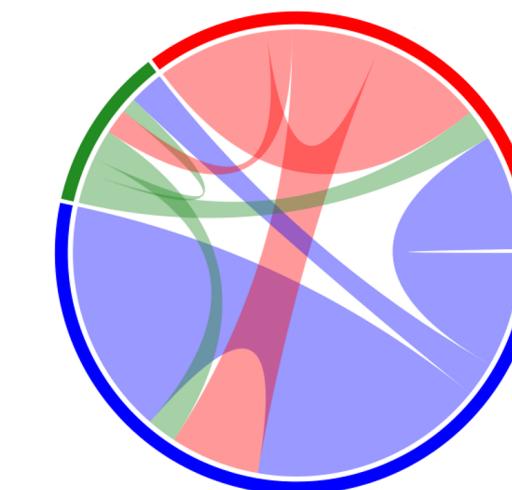
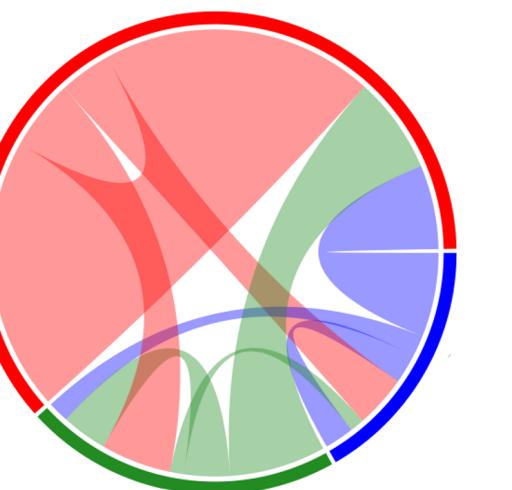
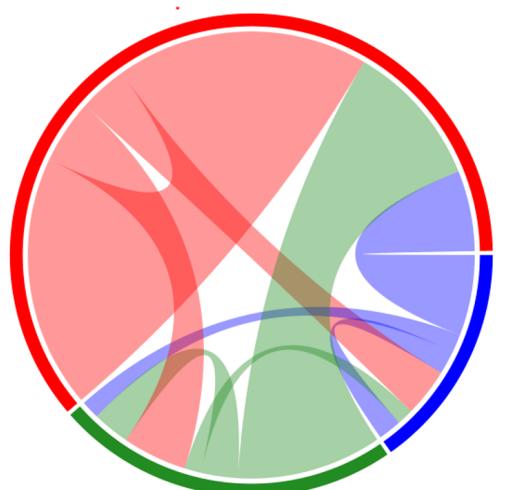
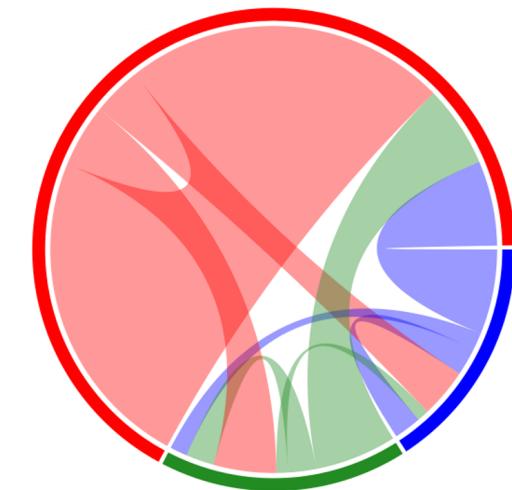
stance detected as **AGAINST**



stance detected as **IN FAVOR**



stance detected as **NONE**

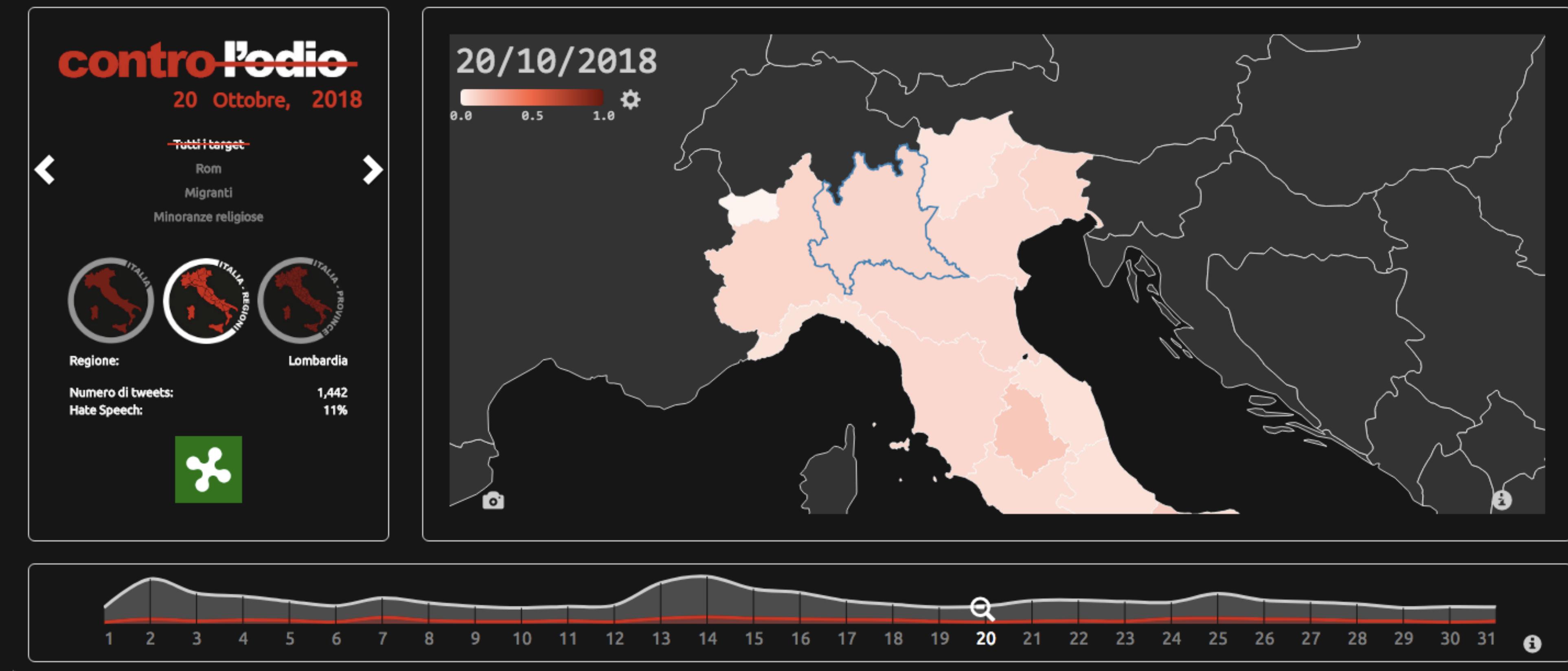


# Stance detection and Network Homophily

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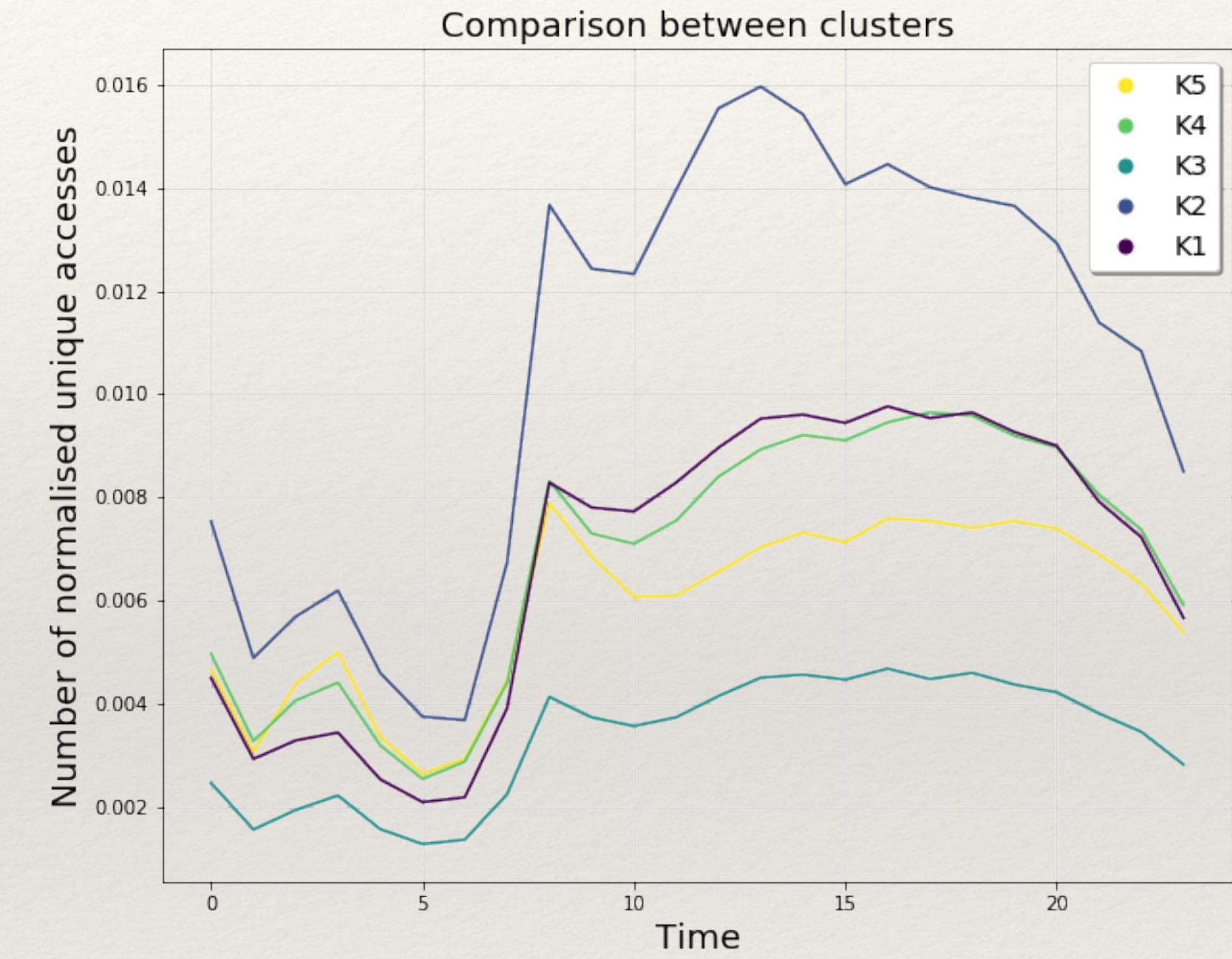
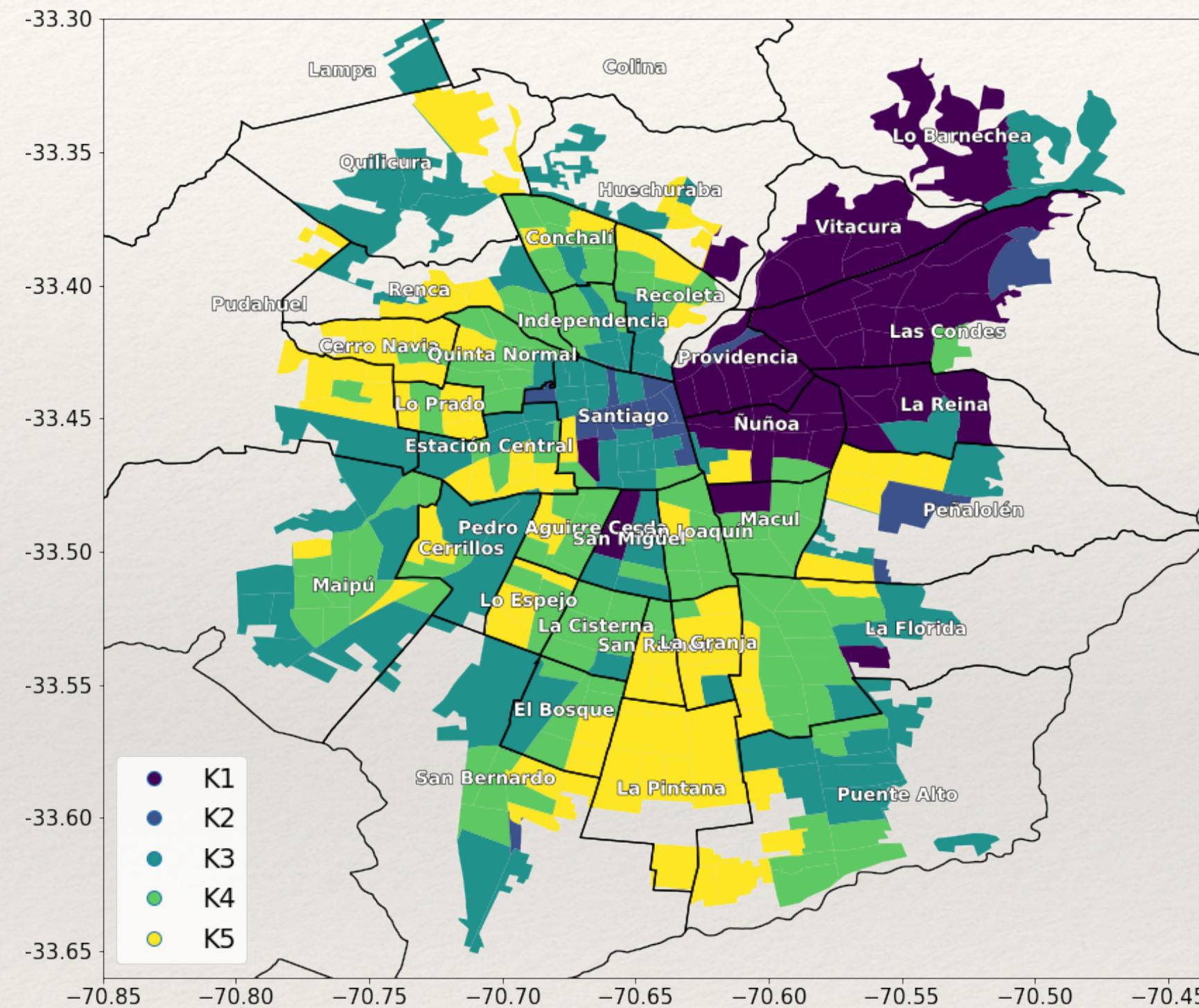
- ❖ ML-based **stance detection** is a NLP tool extremely useful for computational social science analyses
- ❖ We need **approximation** of users' opinions
- ❖ Building networks that **evolve** when the polarizing debate takes place is an opportunity to study the **interplay between structure and opinions**
- ❖ Apparently in Twitter retweets and reply-to are used to respectively show agreement or disagreement. If you look for disputes, **dig the reply-to messages**

# Hate speech monitoring (Contro l'Odio)



# Segregation vs information consumption

Study of geo-located accesses to websites of **news media** revealed strong differences between different “classes” of the population of SCL.



# Recap and conclusions

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- ❖ **Structural segregation** (as in Lilliput and Blefuscu islands) may be one of the main triggers of opinion polarization
- ❖ **Fake-news spreading**, especially when partisanship and antagonistic behavior reinforce the debate, is facilitated in segregated networks
- ❖ Fact-checking is needed and skeptics with links to more gullible (vulnerable) contacts can be recruited as **gatekeepers**
- ❖ **Network Analysis** and **NLP** are great tools for modeling and analyzing data in this domain
- ❖ On going work on **balance theory** provides a so far neglected framework to study the interplay between opinion polarization and structural segregation: new **algorithms** and **visualizations tools** can be added to the analytical loop
- ❖ Beware of the **interplay**: segregation causes polarization and vice-versa



di.unito.it



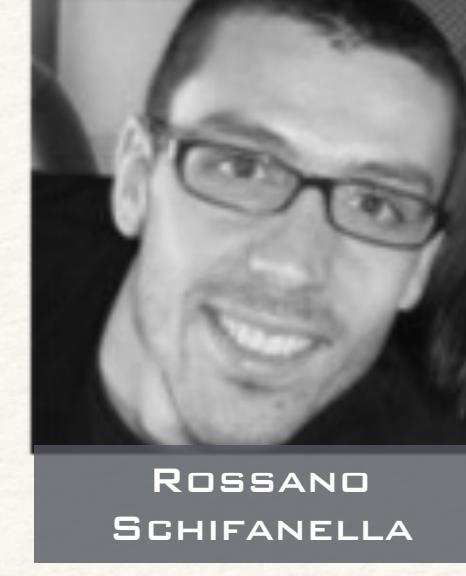
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RUFFO



MARCELLA  
TAMBUSCIO



MIRKO  
LAI



ROSSANO  
SCHIFANELLA



ANDRÉ  
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LUCA  
AIELLO



VIVIANA  
PATTI



ARTHUR  
CAPOZZI



EDOARDO  
GALIMBERTI



ALFONSO  
SEMERARO



ALESSANDRA  
URBINATI



SALVATORE  
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EMILIO  
SULIS



MARTINA  
DEPLANO

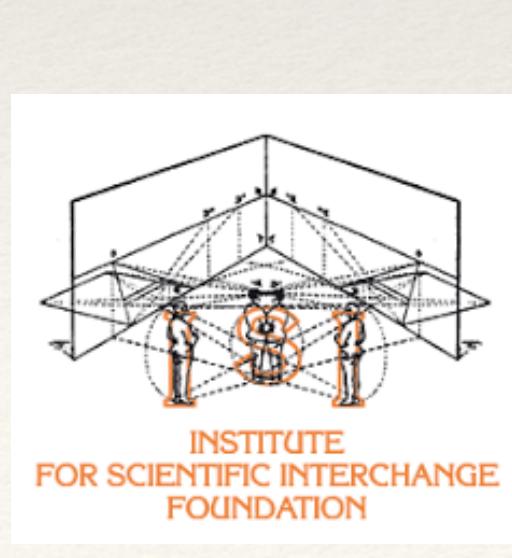


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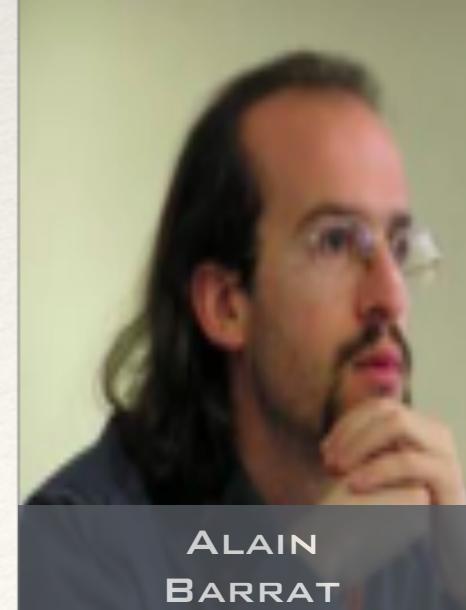
## ARC<sup>2</sup>S: Applied Research on Computational Complex Systems

# Thanks!

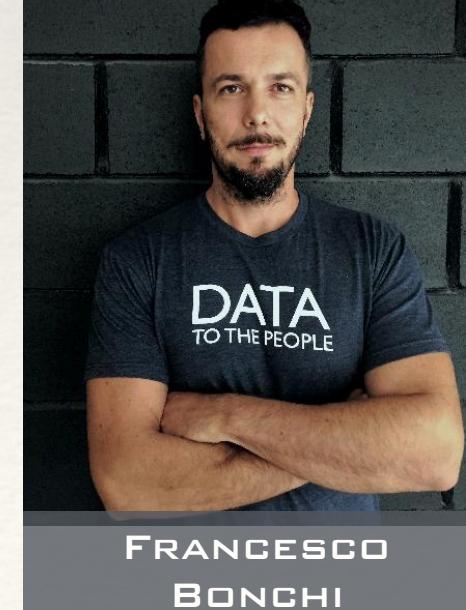
[http://www.di.unito.it/~ruffo/talks/2019\\_Oct\\_NEU.pdf](http://www.di.unito.it/~ruffo/talks/2019_Oct_NEU.pdf)



CIRO  
CATTUTO



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BARRAT



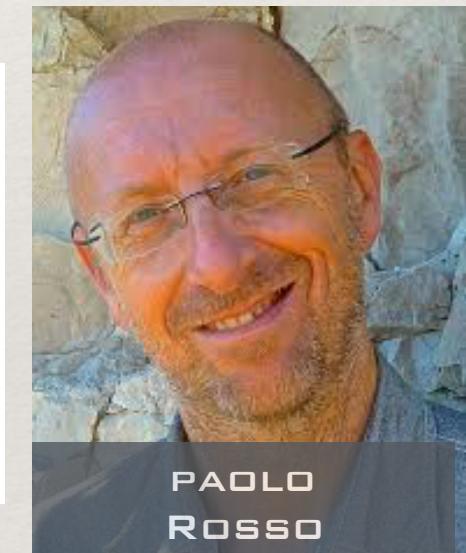
FRANCESCO  
BONCHI



DANIELA  
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UNIVERSITAT  
POLITÈCNICA  
DE VALÈNCIA



PAOLO  
ROSSO



UD

Universidad del Desarrollo



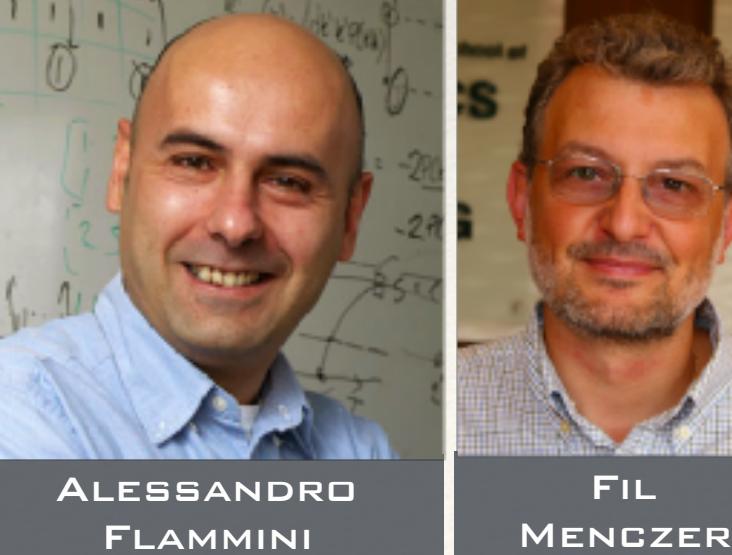
LEO  
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CHENGCHENG  
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GIOVANNI LUIGI  
CIAMPAGLIA



ALESSANDRO  
FLAMMINI      FIL  
MENCZER