Giancarlo Ruffo - Università degli Studi di Torino (Italy)

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

giancarlo.ruffo@unito.it

@giaruffo

di.unito.it

Divided we Stand

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

Boston, October 9th, 2019

netsi

Northeastern University
Network Science Institute

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

Fictional background

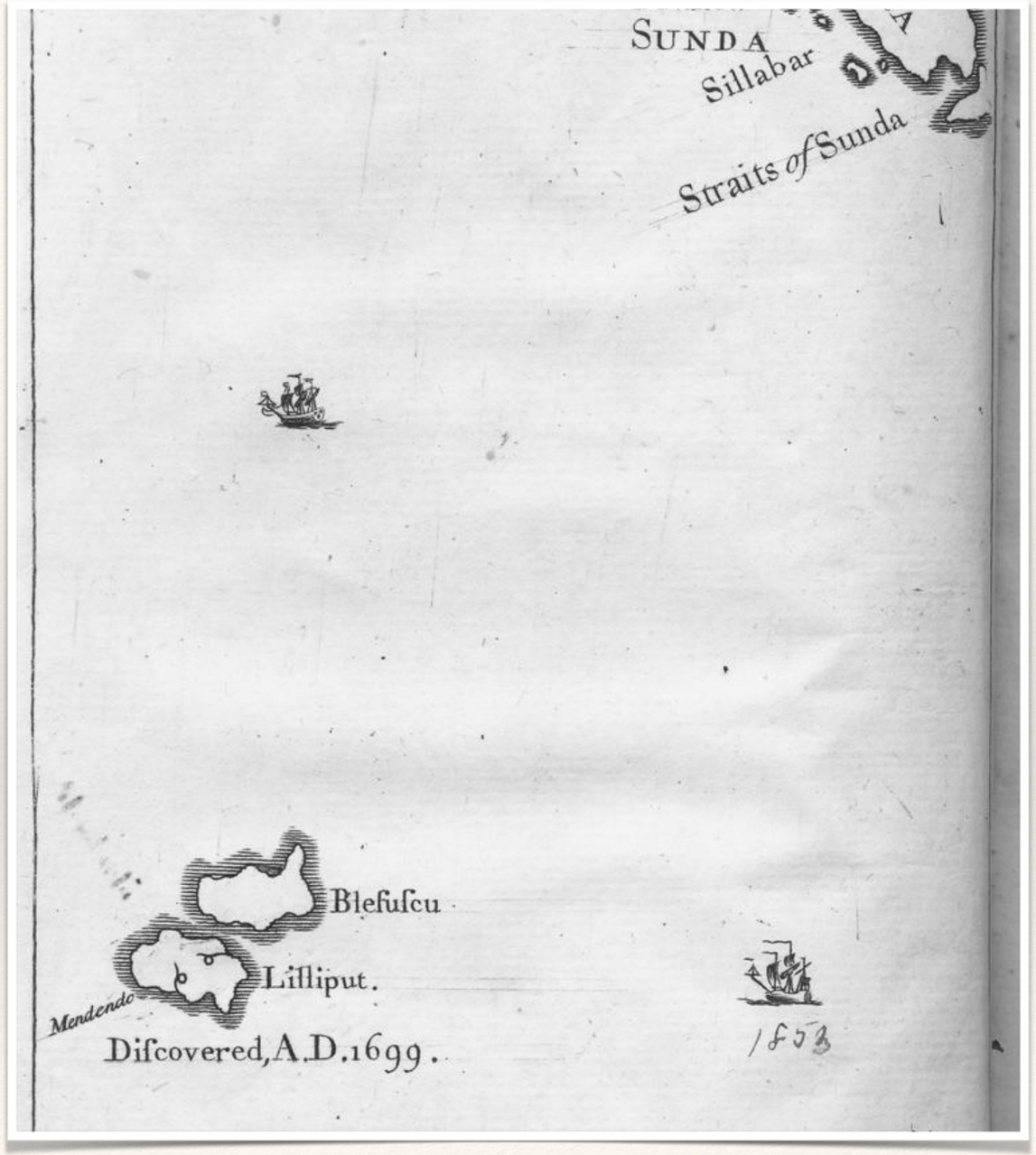
Jonathan Swift

Lilliput and Blefuscu

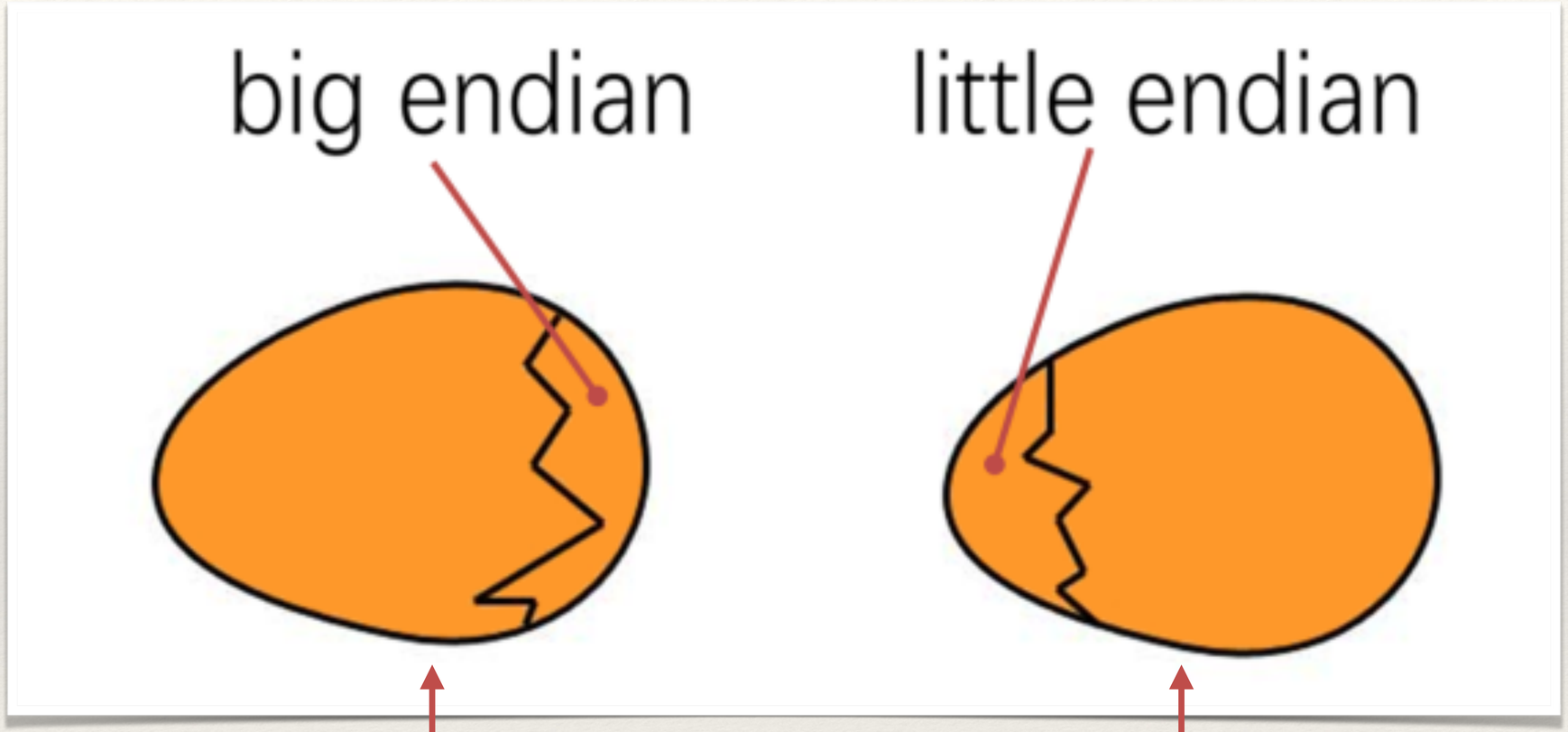
According to "*Gulliver's Travels*", they are two islands in the *South Indian Ocean*

Two *different kingdoms* inhabited by tiny people

Even if similar in nature and in religious belief, they have a long lasting debate called the *"egg war"*



Big-Endians/Little-Endians



Holy Scriptures: *"Always break the egg on the most convenient side"*, that is the larger in **Lilliput**

The way Lilliputians always broke their eggs

The way the emperor ordered them to break their eggs.

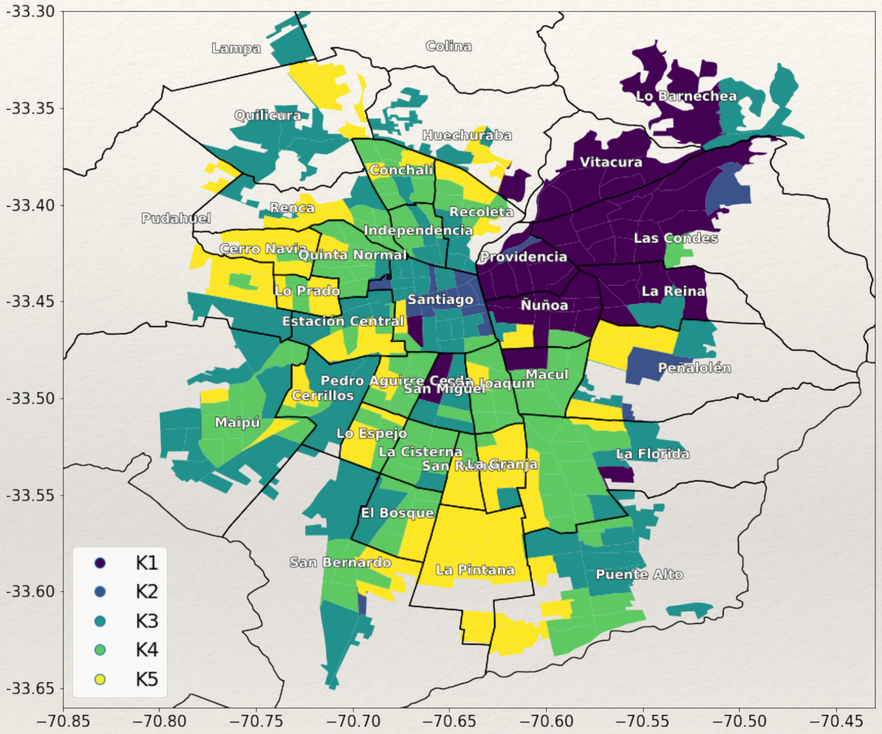
"Little endian" interpretation of holy scriptures was adopted in **Blefuscu**

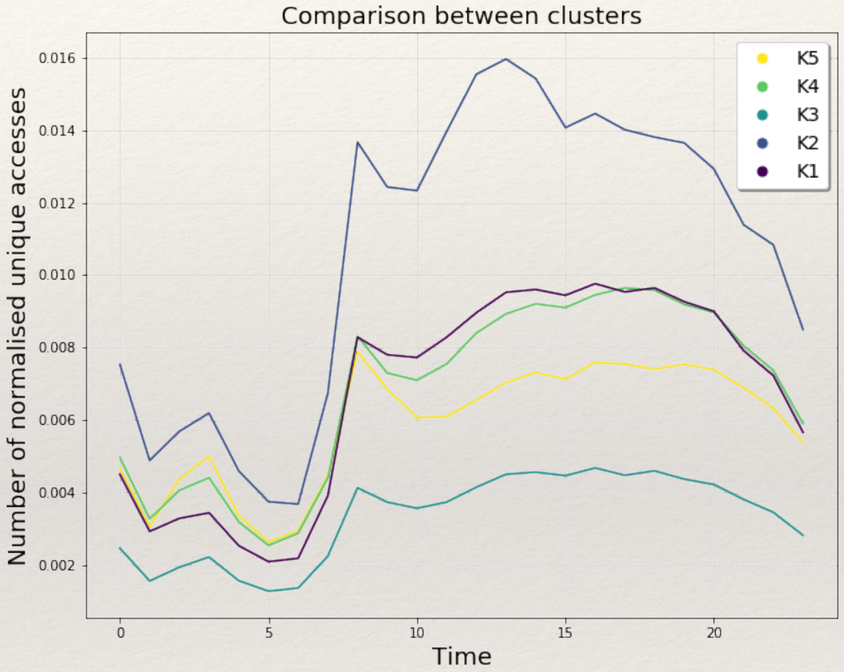
Satirical interpretation

- **Eggs wars**: Catholic England (Big-Endian) and conversion to Protestantism of most of the country (Little-Endian) after Queen Elisabeth I conversion
- **Lilliput and Blefuscu**: Kingdom of Great Britain and Kingdom of France
- **Internal politics in Lilliput:** the Whigs and the Tories
- In perspective: human beings divide themselves because of what may appear a futile reason to an alien
- It contains the intuition of the interplay between (structural) **segregation** and (opinion) **polarization**

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.





S Vilella, D Paolotti, G Ruffo, L Ferres, News and the city: understanding online press consumption patterns through mobile data, https://arxiv.org/abs/1907.02480

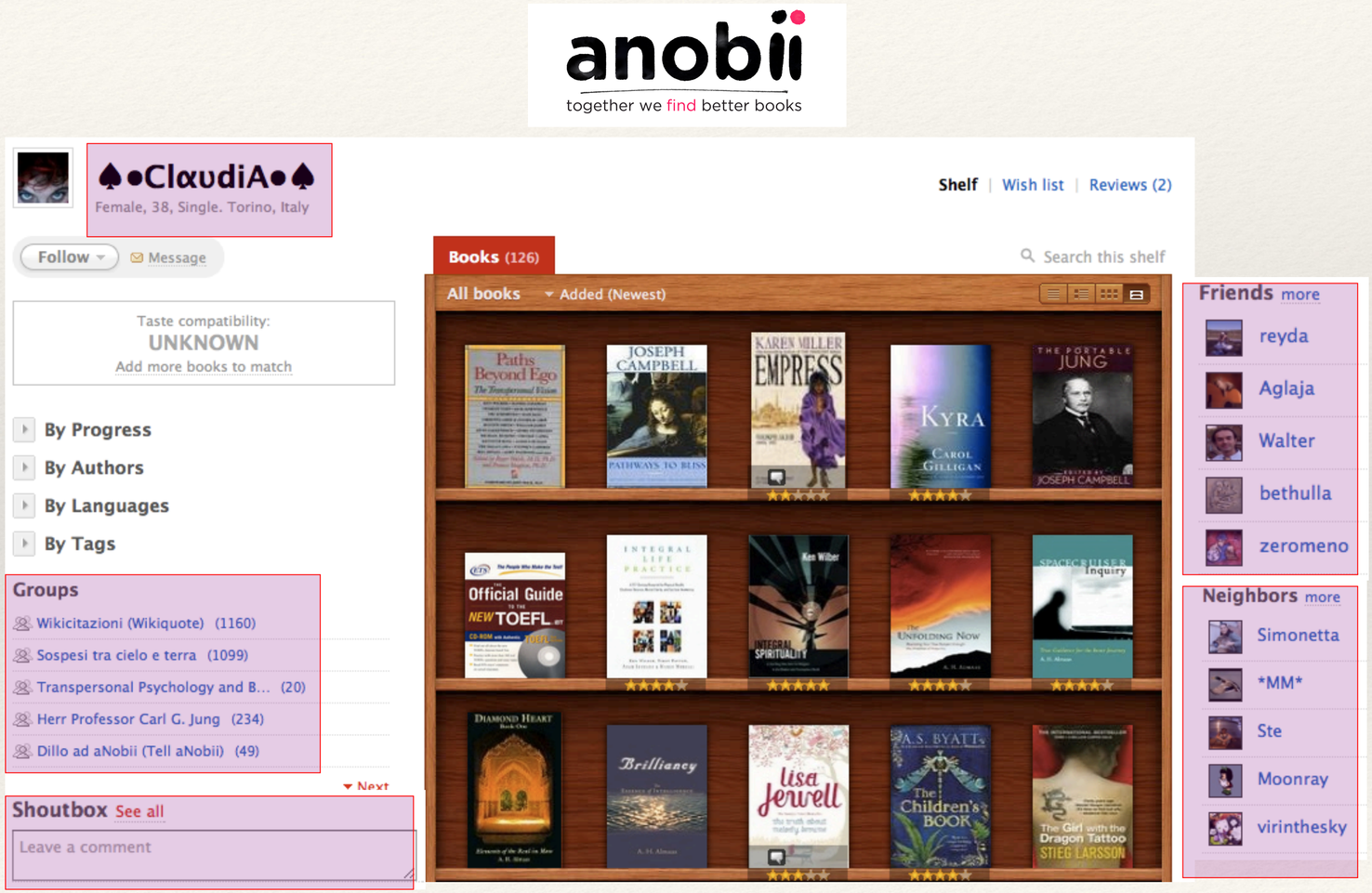
Agenda of the talk

- The strange case of **Lajello**
- Modeling the spread of **misinformation**
- The role of **segregation**
- Evaluating debunking **strategies**
- **Language** and network structure
- Balance in networks: **algorithms** and **visualizations**
- Discussion and **Conclusion**

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

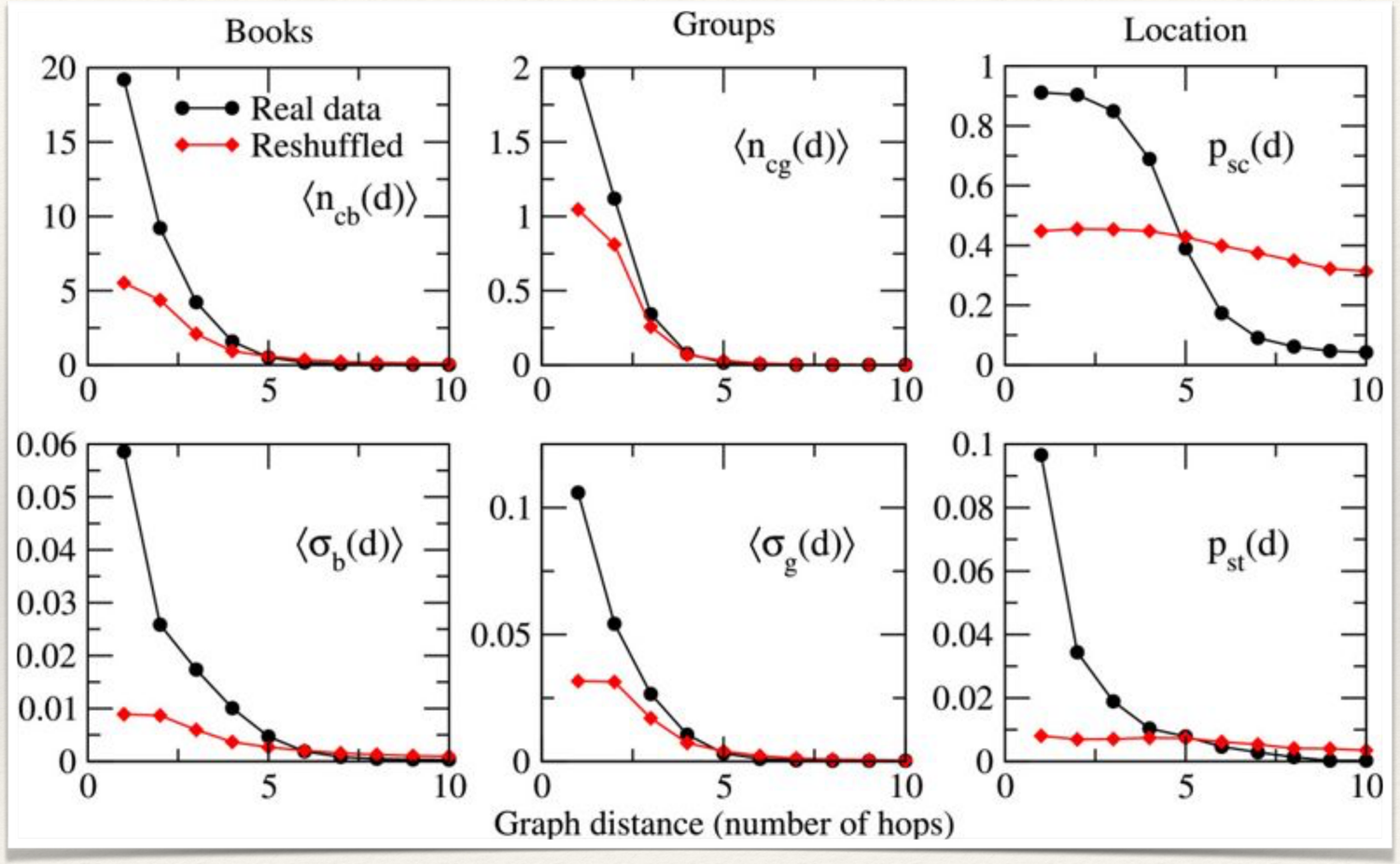


Analyzing social network with a bot

- 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**

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**

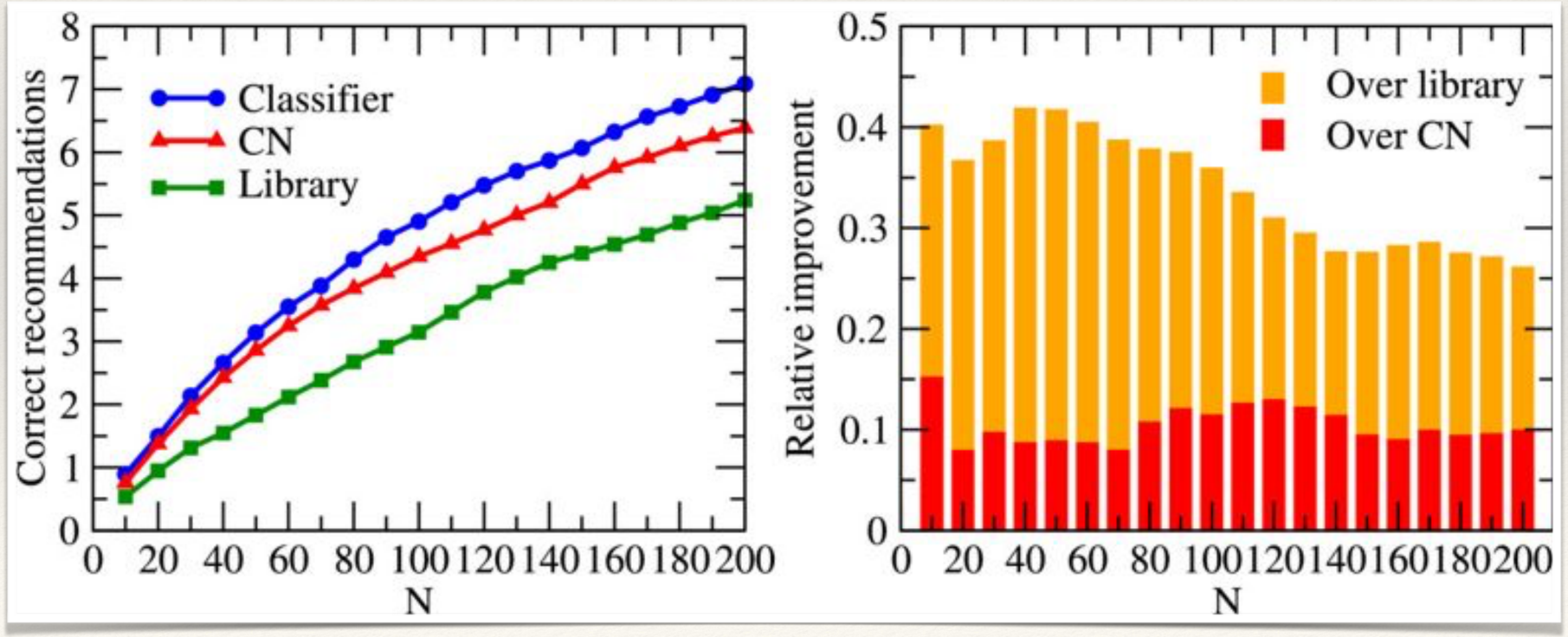


LM Aiello, A Barrat, C Cattuto, G Ruffo, R Schifanella, Link creation and profile alignment in the aNobii social network, 2010 IEEE 2nd Int.. Conf. on Social Computing, 249-256

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

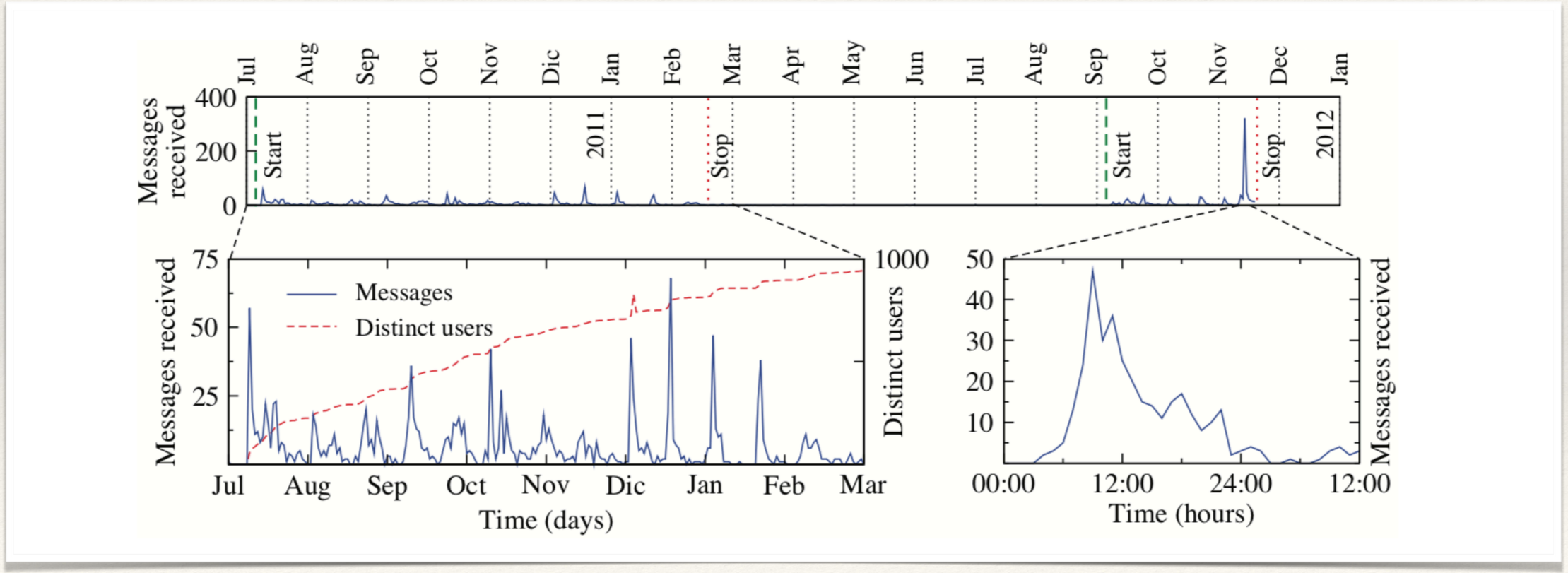
Application: a link recommendation algorithm

- A link recommendation algorithm based on prediction of profile similarities was proposed and tested
- Results showed an improvement w.r.t. the baselines



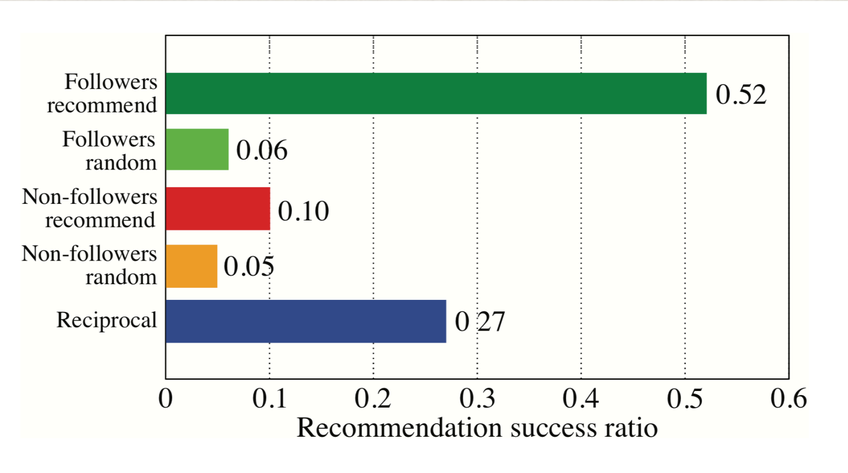
What happened to Lajello?

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



LM Aiello, M. Deplano, R Schifanella, G Ruffo, People are Strange when you're a Stranger: Impact and Influence of Bots on Social Networks, in Proc. of the 6th Intern. AAAI Conf. on Weblogs and Social Media (ICWSM'12), Dublin, Ireland, 2012

Influence of bots

COMMUNICATIONS OF THE ACM

HOME | CURRENT ISSUE | NEWS | BLOGS | OPINION | RESEARCH | PRACTIC

Home / Magazine Archive / July 2016 (Vol. 59, No. 7) / The Rise of Social Bots / Full Text

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

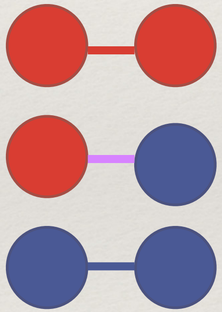
Incidentally, we created an “egg war”

- 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?

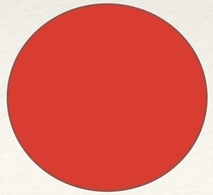
Social polarization and emotional reaction

red dots are lajello **supporters**

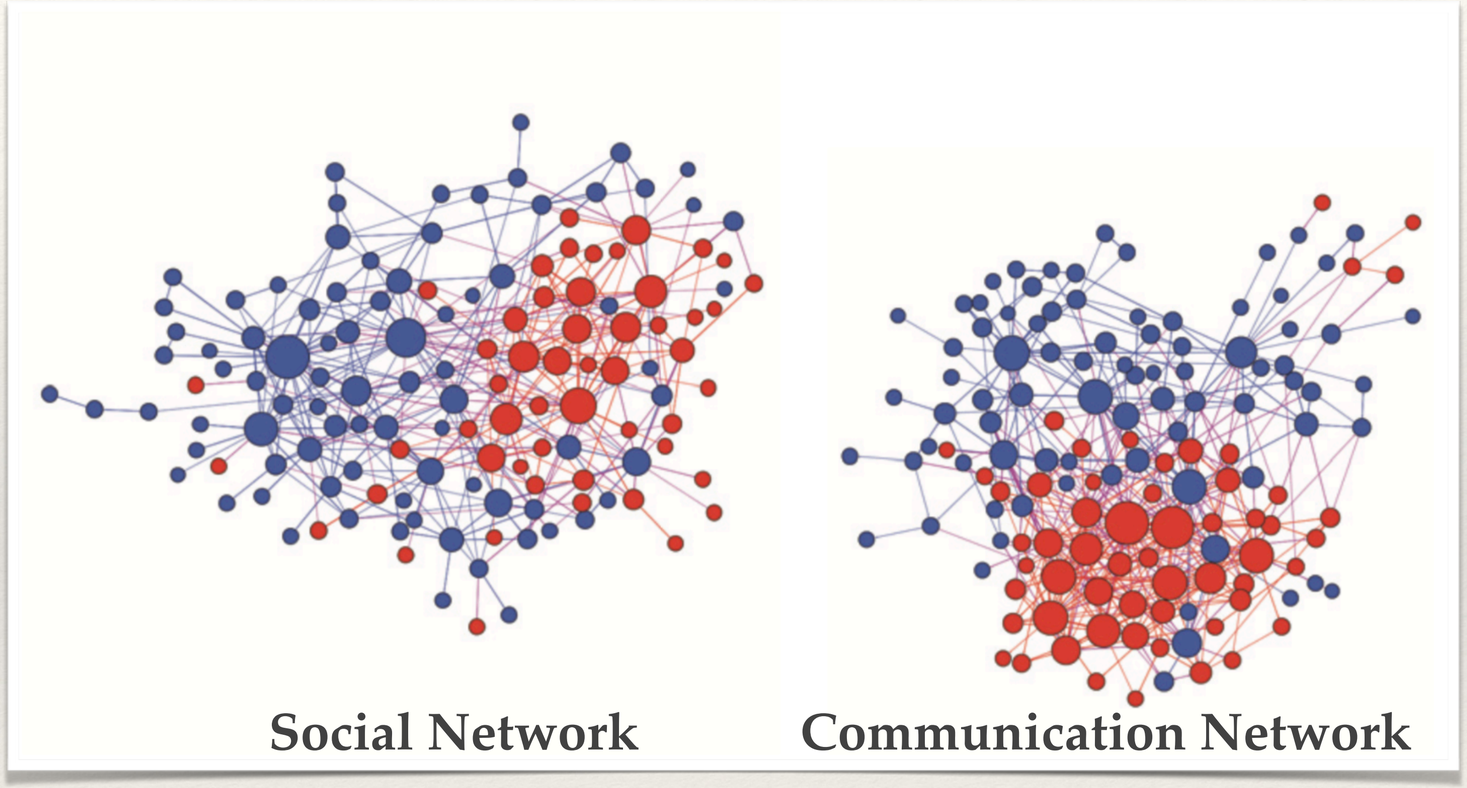
blu dots are lajello **haters**



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

ahahahhahahaha 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

chapeau!!

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

Due set

ahahahaahah tu sei un genio!!

Le tue visite cominciano ad essere inquietanti....

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** (Lilliput and Blefuscu were two different islands…)
- **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?

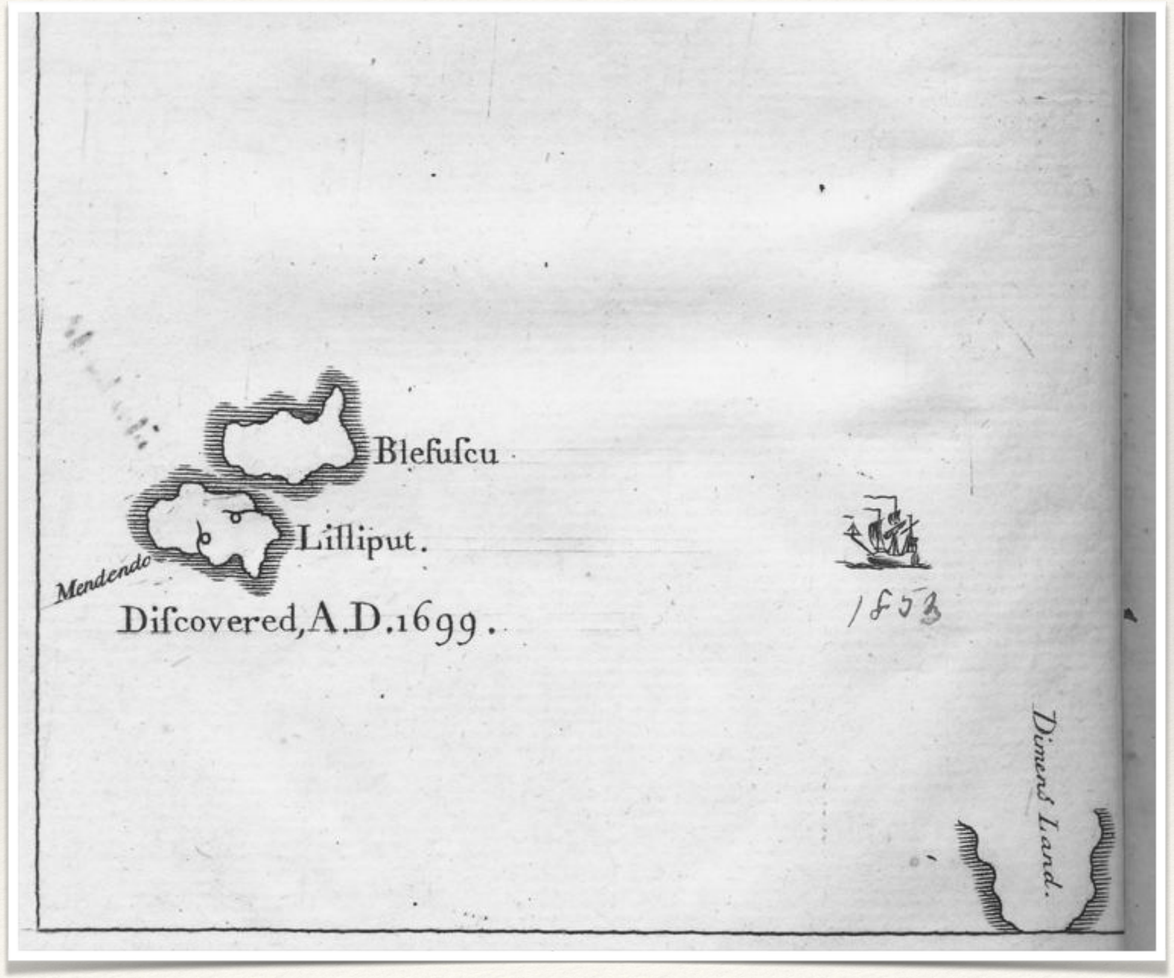
POLITIFACT

FACTCHECK.ORG

Snopes.com
Rumor Has It

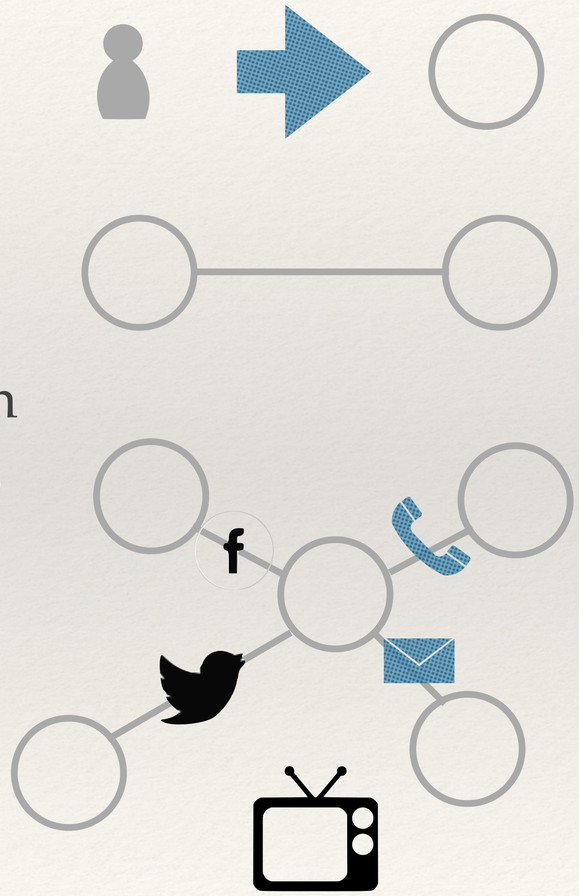
Emergent
A real-time rumor tracker.

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



Networks and their context

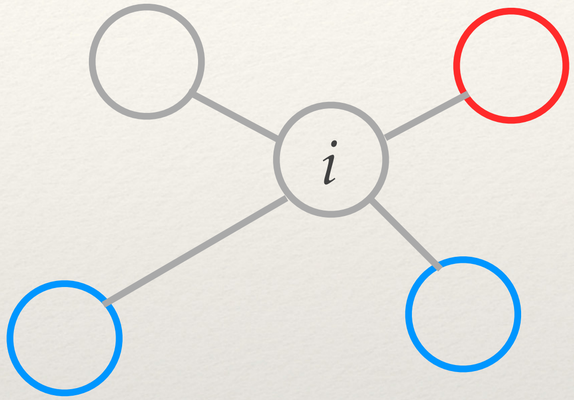
- nodes are **actors** involved in a **generic** social network (no assumption is given)
- links are **social relationships**
- nodes can be exposed to news from both **internal and external sources** and via different communication devices



- **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

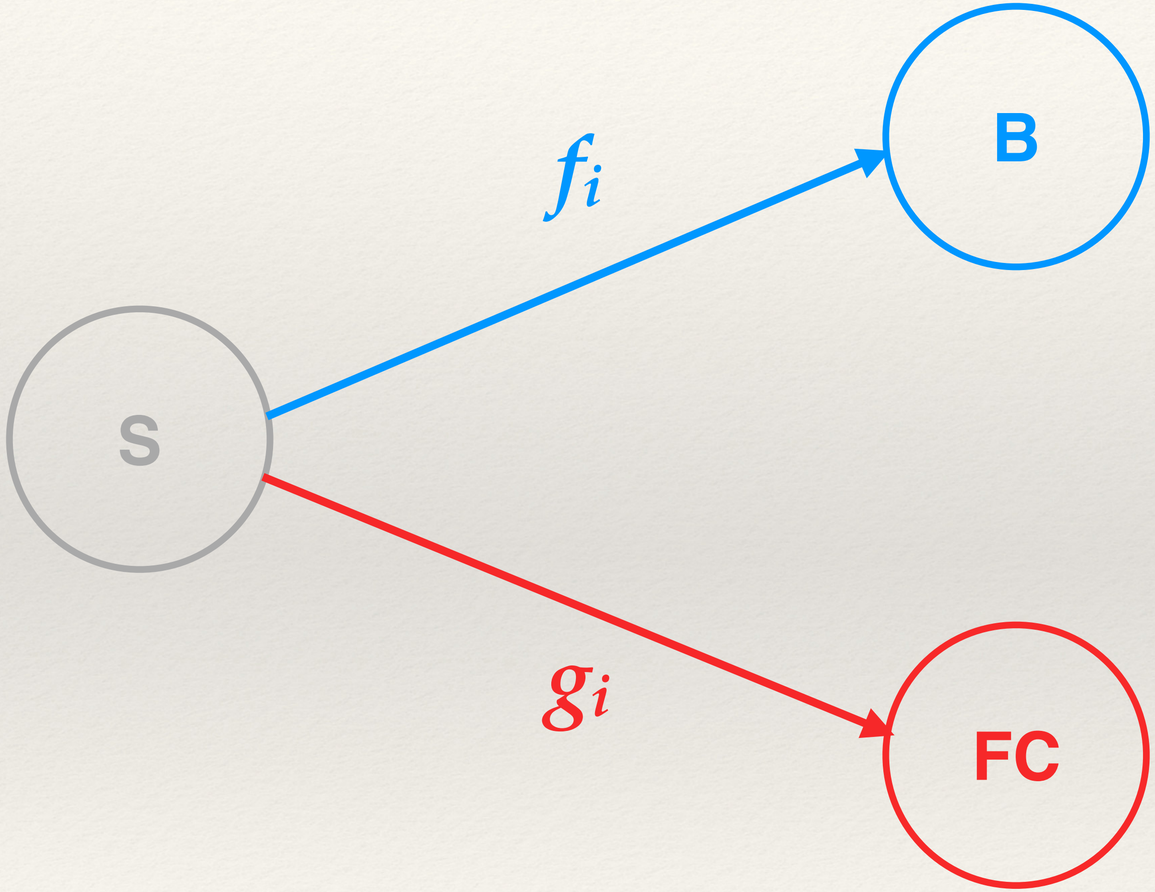


neighbors of i: n_i

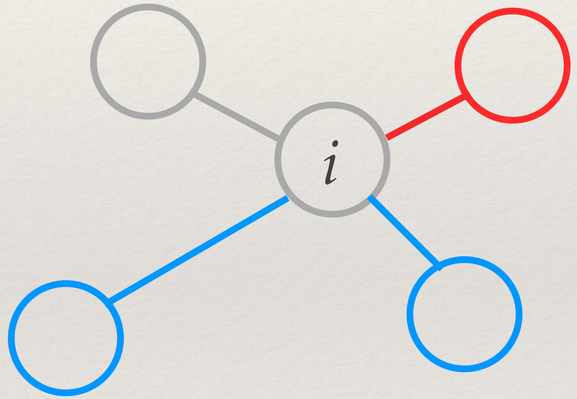
credibility of the hoax: α

spreading rate: β

From Susceptible to Believer/Fact-Checker



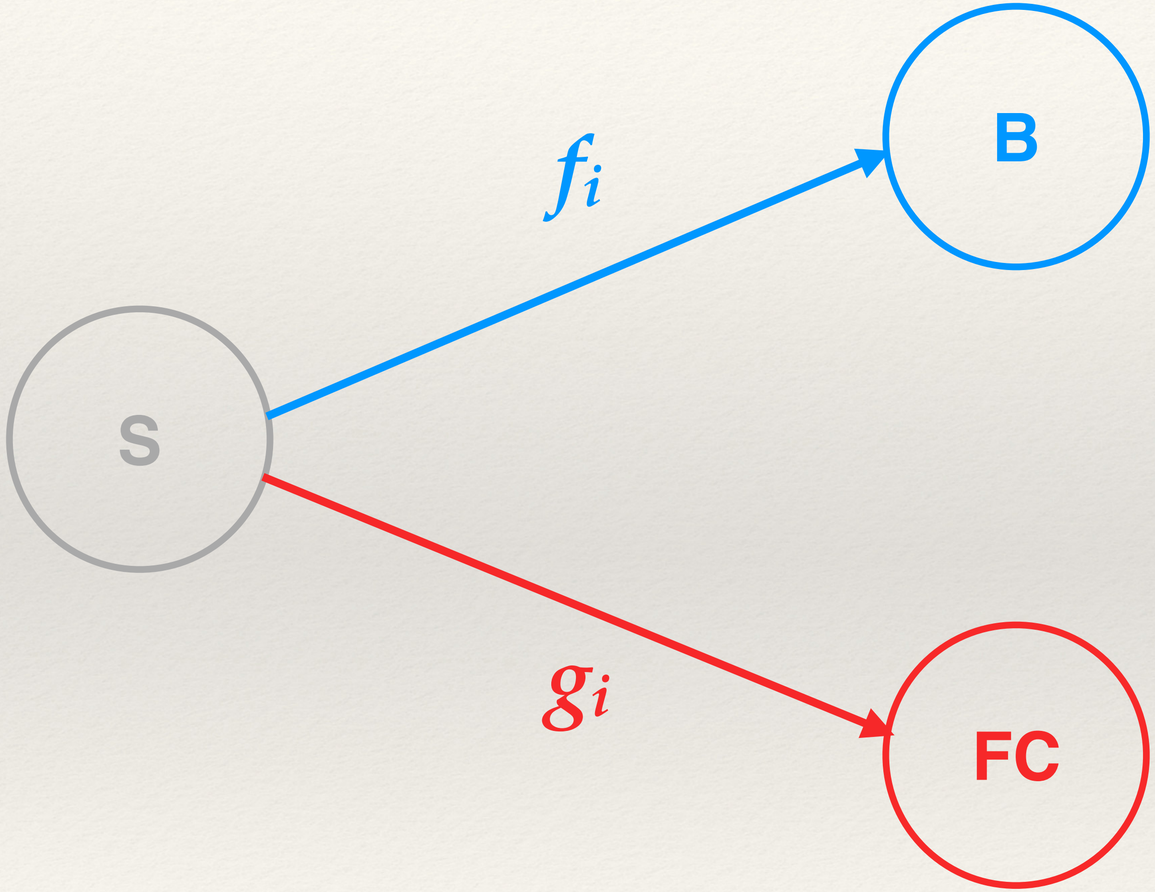
$$f_i(t) = \beta \frac{n_i^B(t)(1+\alpha)}{n_i^B(t)(1+\alpha) + n_i^F(t)(1-\alpha)}$$



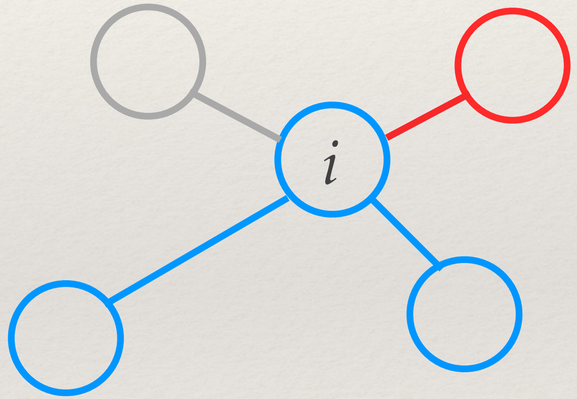
time t

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

From Susceptible to Believer/Fact-Checker



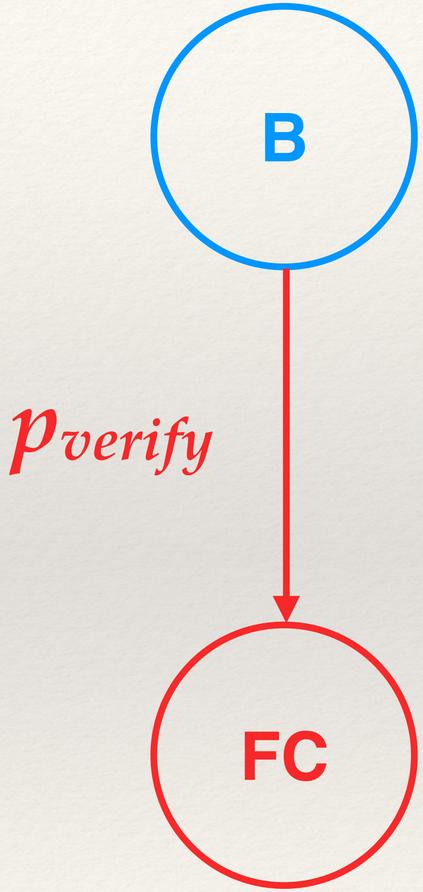
$$f_i(t) = \beta \frac{n_i^B(t)(1+\alpha)}{n_i^B(t)(1+\alpha) + n_i^F(t)(1-\alpha)}$$



time t+1

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

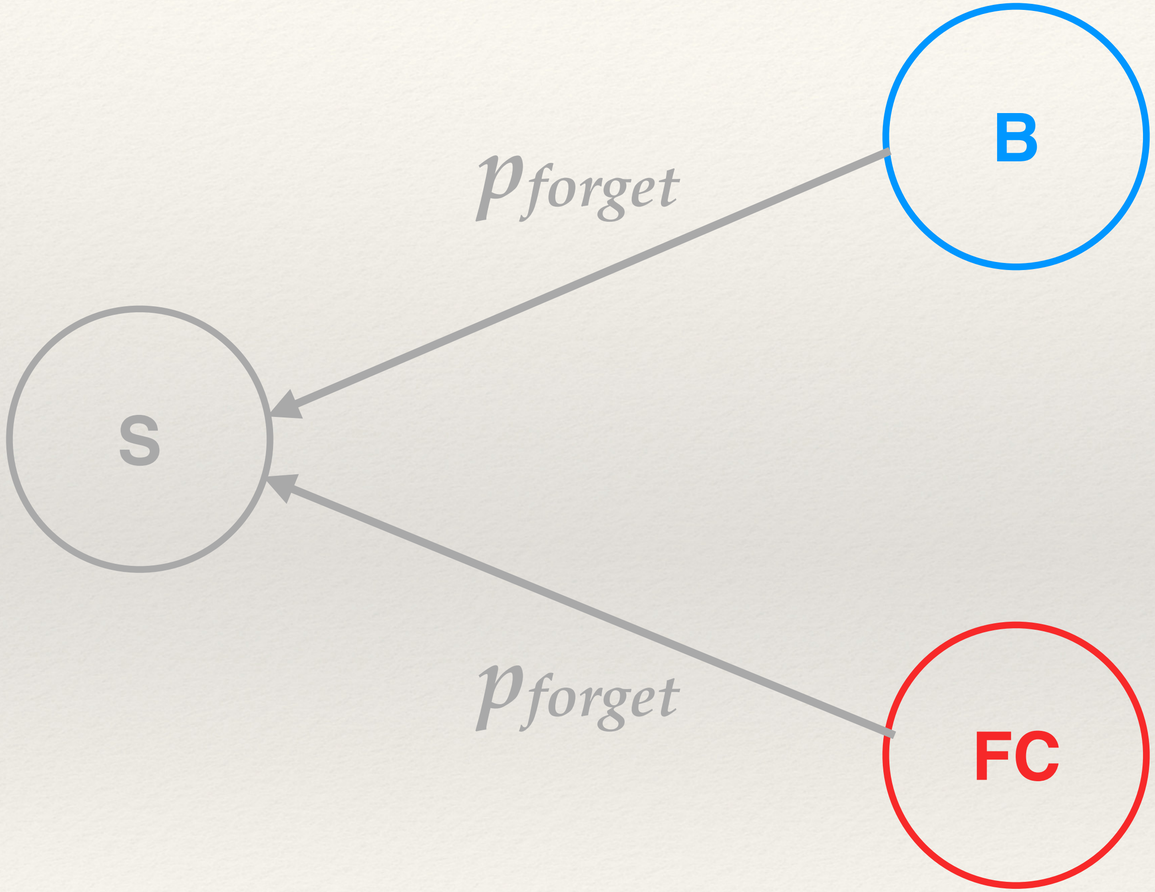
From Believer to Fact-Checker



VERIFYING

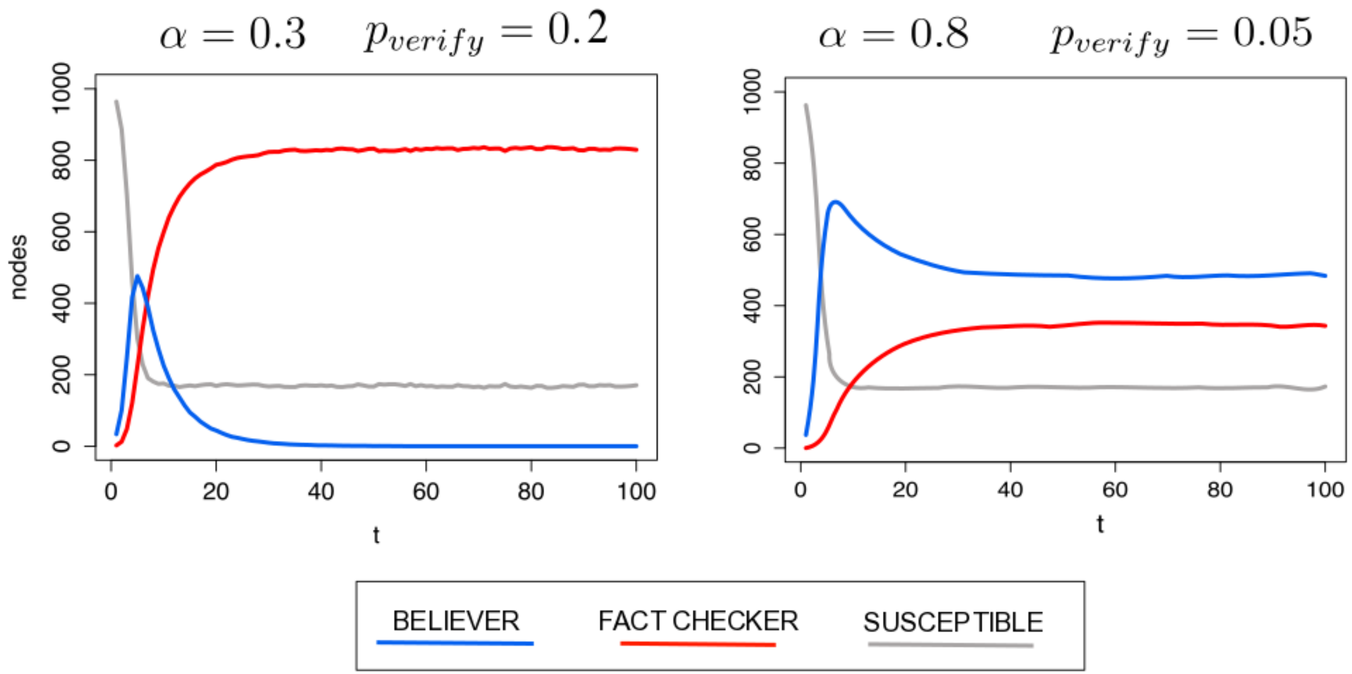
probability of fact-checking (or just deciding not to believe)

From Believer/Fact-Checker to Susceptible



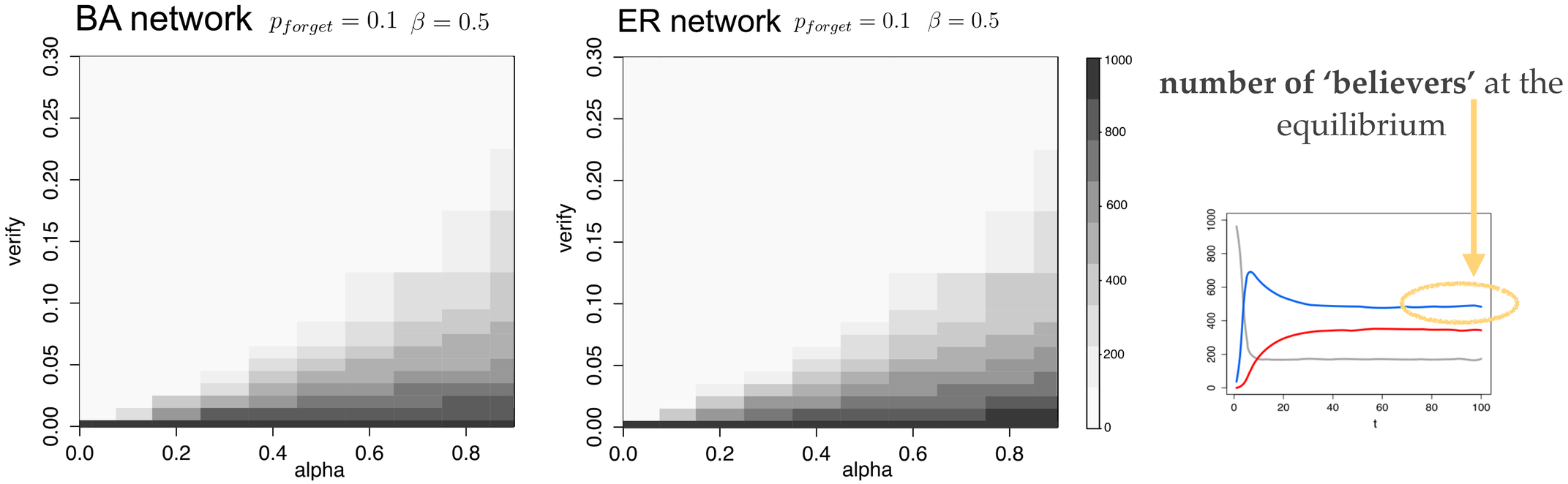
FORGETTING

Dynamics (agent-based simulations)



hoax **credibility** and **fact-checking probability** rule hoax persistence in the network

Dynamics (agent-based simulations)

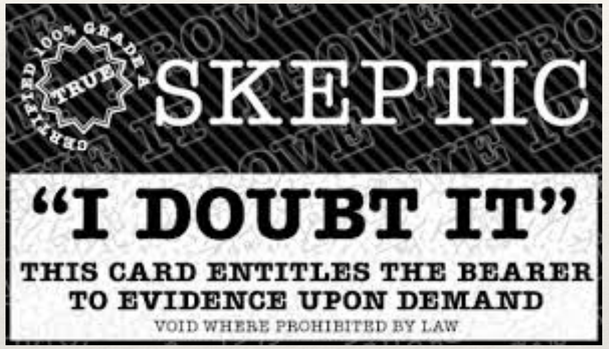


threshold on verifying probability: this provides an idea of how many believers we need to convince to guarantee the removal of the hoax

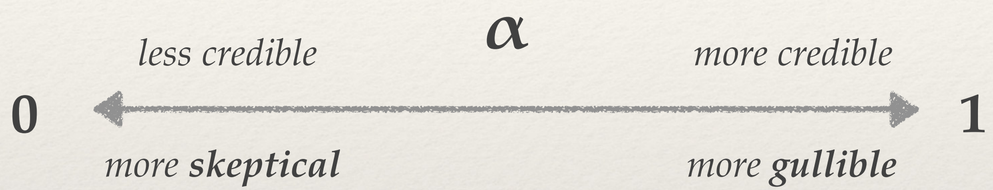
M Tambuscio, G Ruffo, A Flammini, and F Menczer. 2015. Fact-checking Effect on Viral Hoaxes: A Model of Misinformation Spread in Social Networks. In Proc. of the 24th Int. Conf. on World Wide Web (WWW '15 Companion)

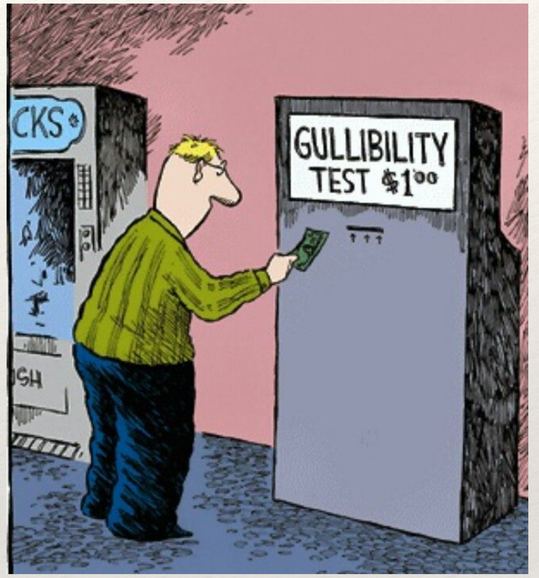
The role of segregation

Skeptical and gullible agents



let's tune **credibility** accordingly





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

Skeptic

α small

size $(0 < \gamma < N)$

nodes in the gullible community

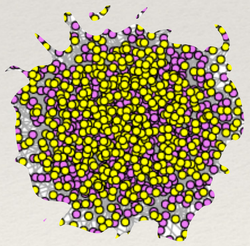
segregation $(0.5 < s < 1)$

fraction of edges within same community

[Gu-Gu, Sk-Sk]

Gullible

α large

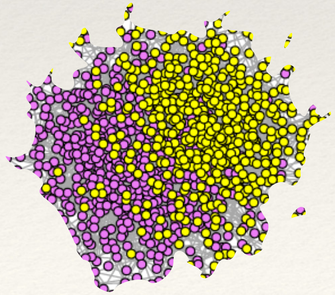


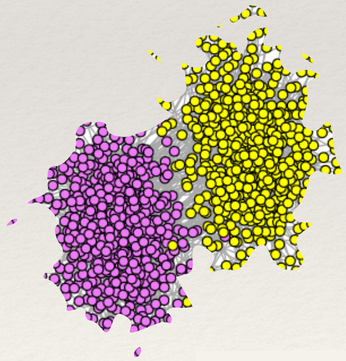
s=0.55

γ=500

s=0.8

γ=500



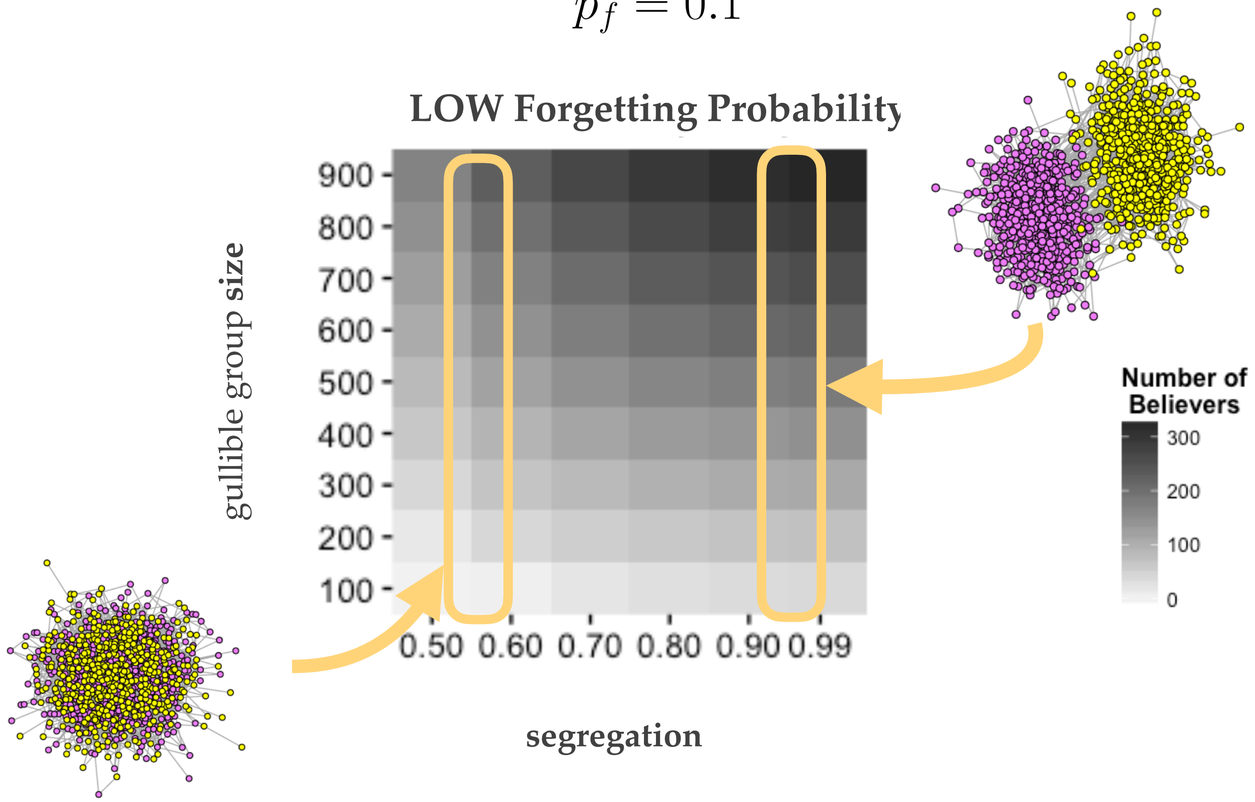


s=0.95

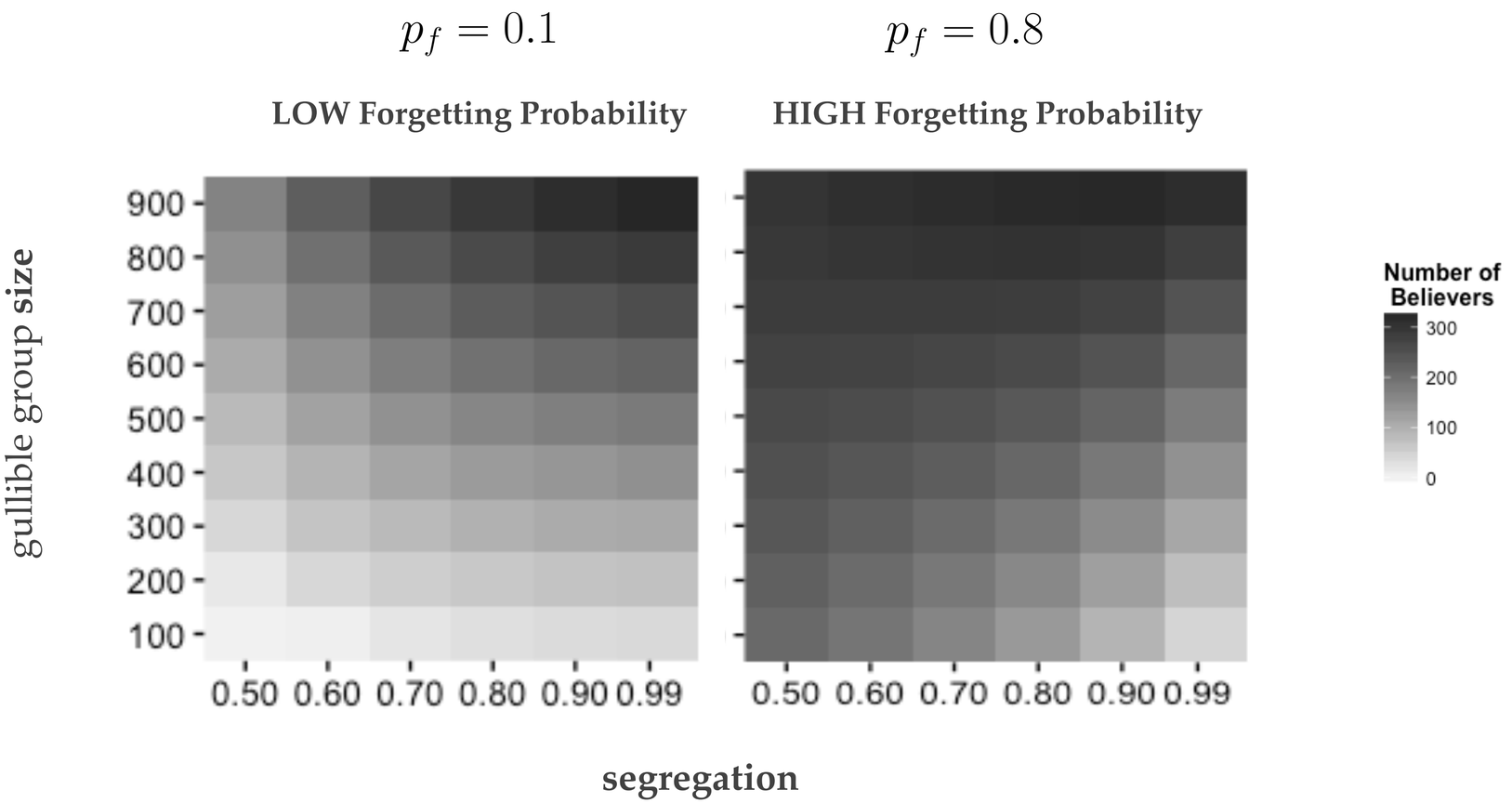
γ=500

Size vs segregation

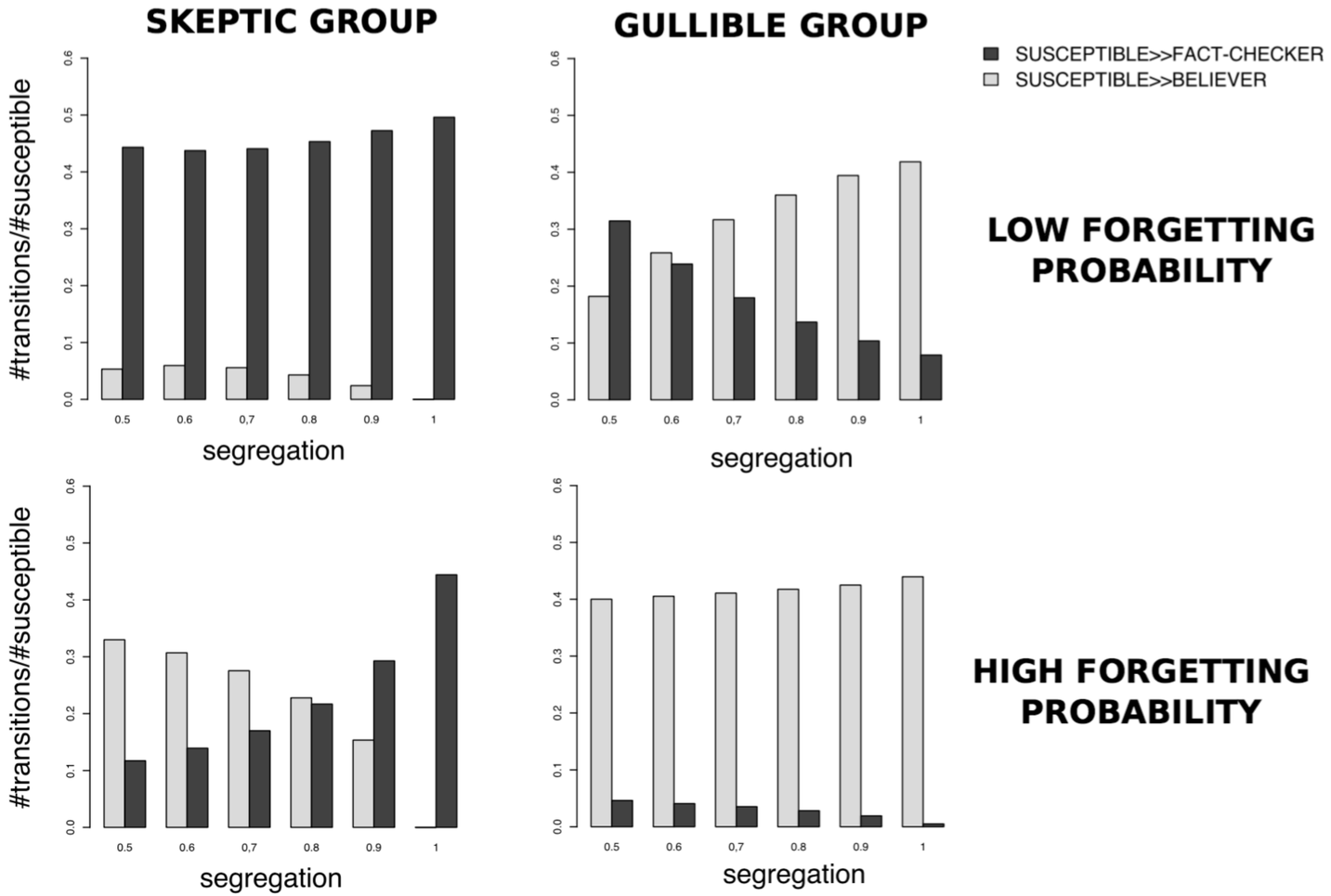
$p_f = 0.1$



Size vs segregation



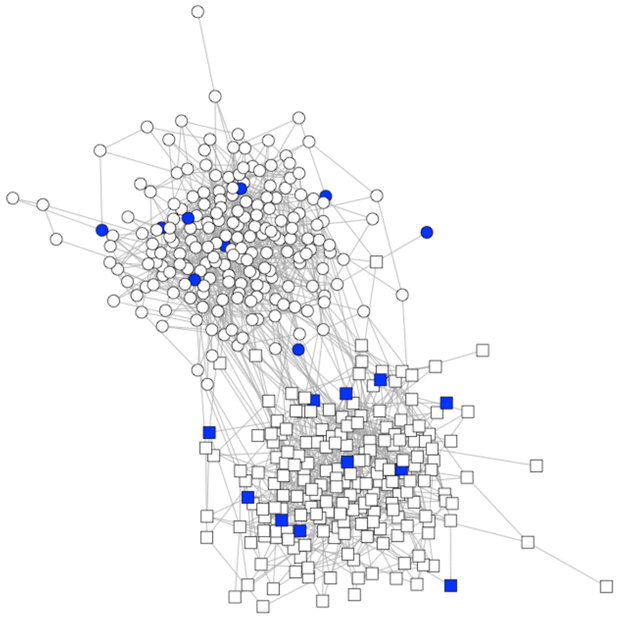
Transitions



Role of forgetting

LOW Forgetting Rate

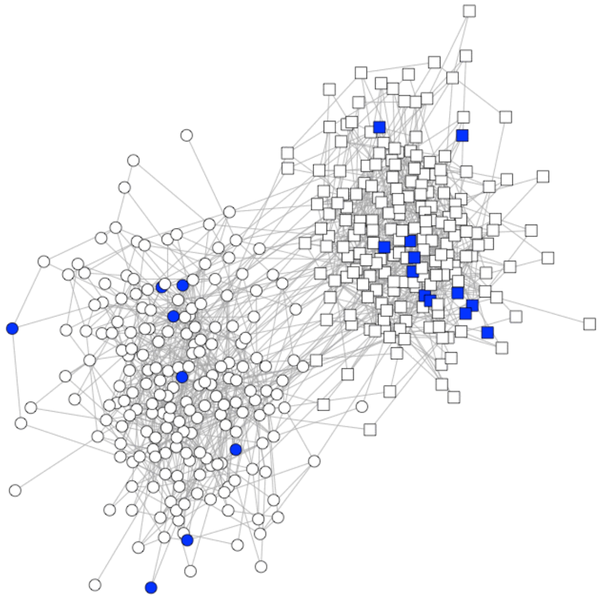
$p_f = 0.1$



Time = 1

HIGH Forgetting Rate

$p_f = 0.8$



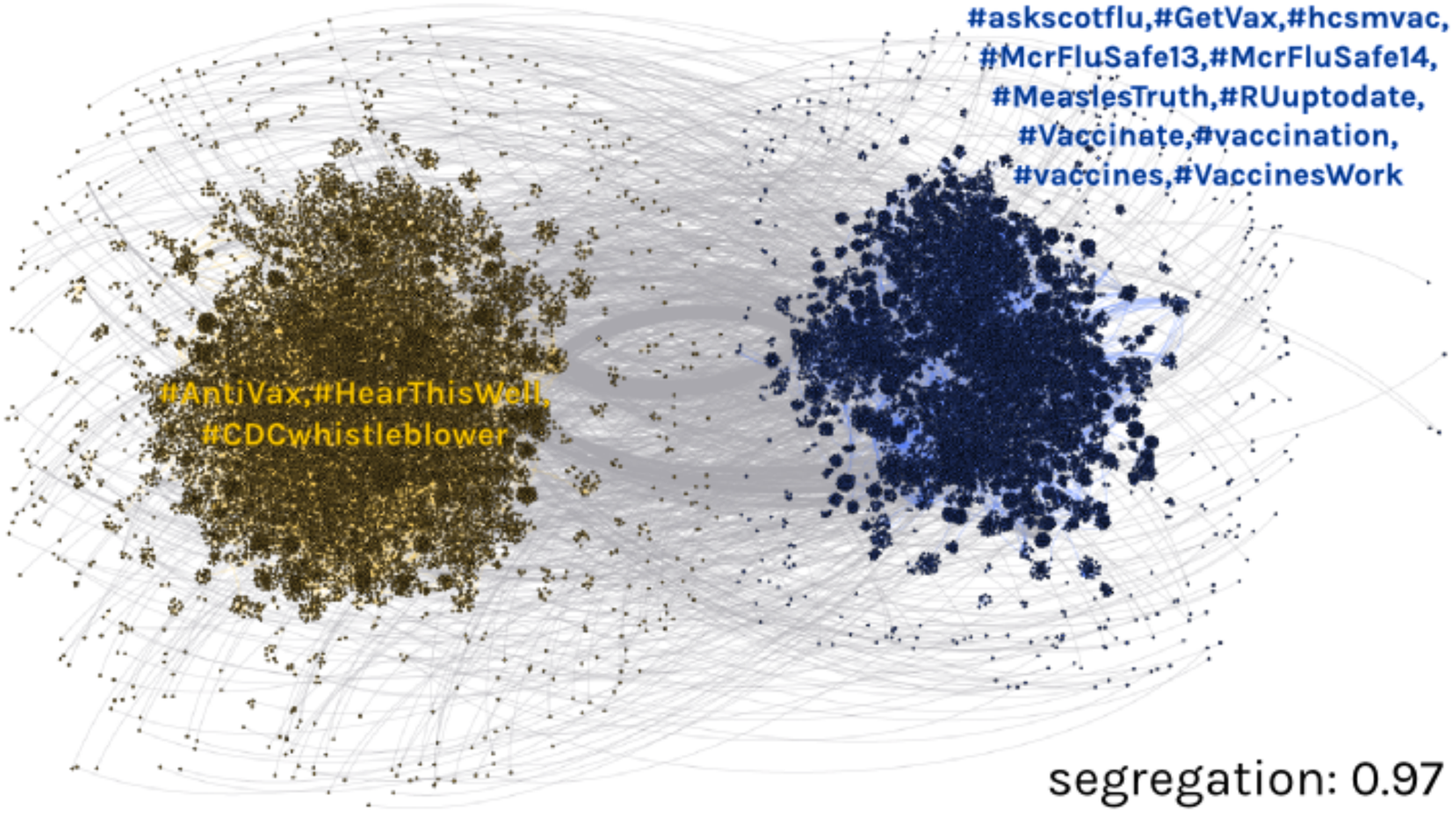
Time = 1

Lessons learned and observations

- 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**

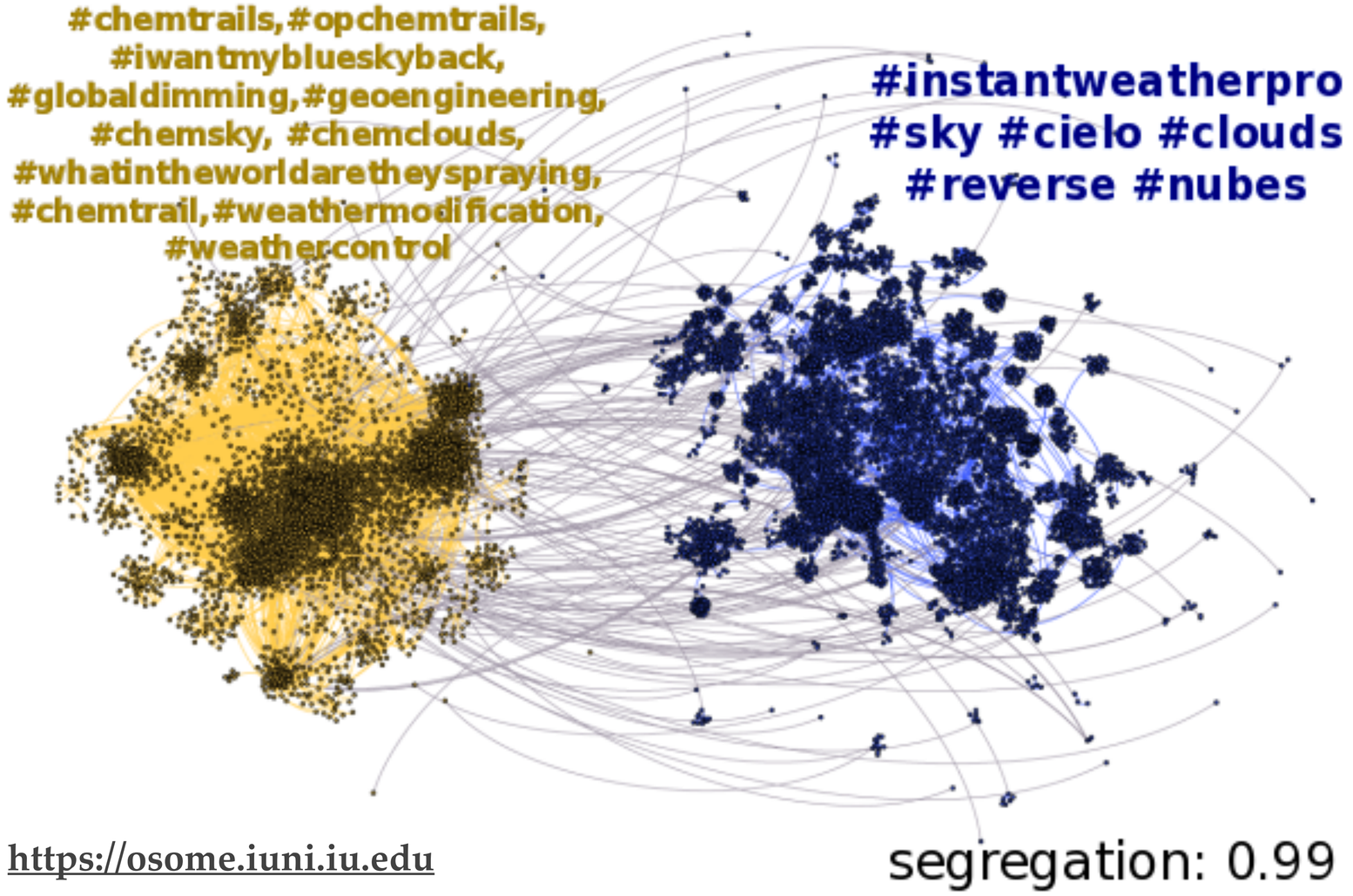
M Tambuscio, D F M Oliveira, G L Ciampaglia, G Ruffo, Network segregation in a model of misinformation and fact-checking, Journal of Computational Social Science (2018) 1: 261.

real data: vaccines



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

real data: chemtrails



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

Evaluating debunking strategies

What-if analysis

- We live in a **segregated** society: let's accept it!
- "Egg wars" 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 ($\mathbf{p_{verify} = 0}$)
  - 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)

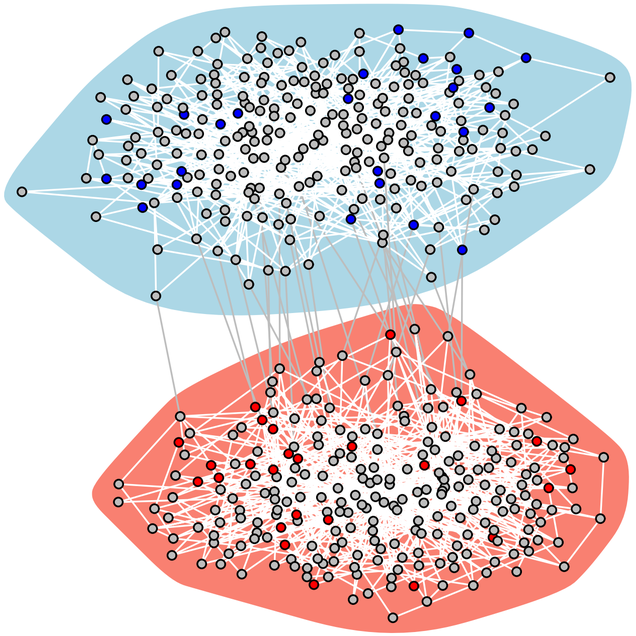
gullible group:

- α: 0.8
- seeders B: 10%

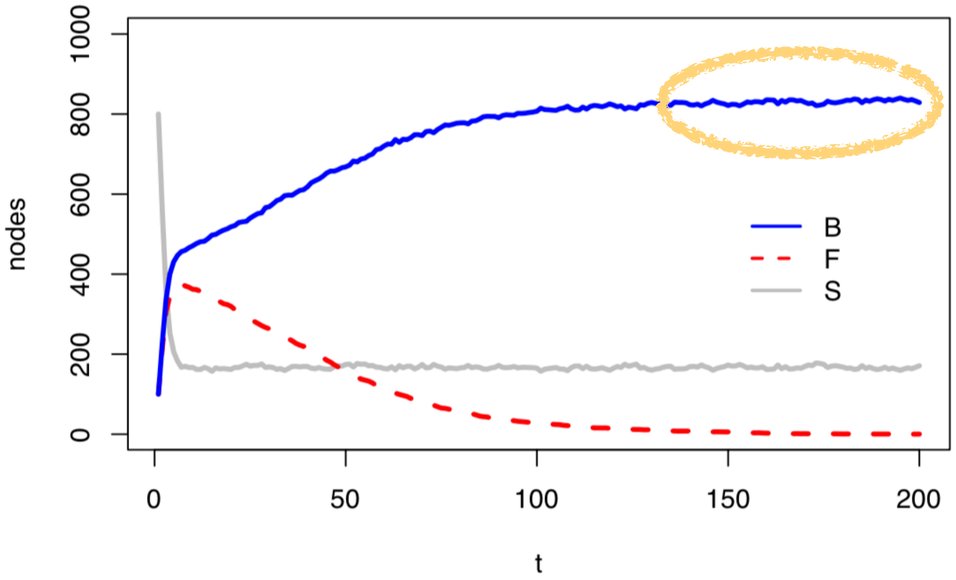
skeptical group:

- α: 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)

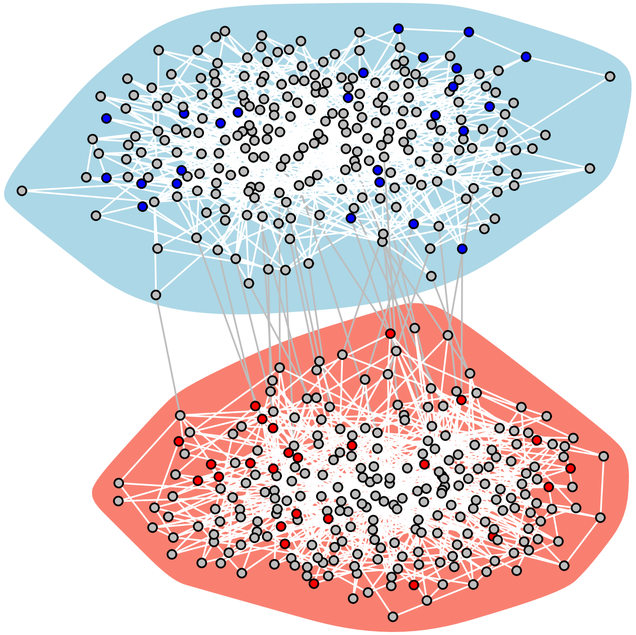
gullible group:

- α: 0.8
- seeders B: 10%

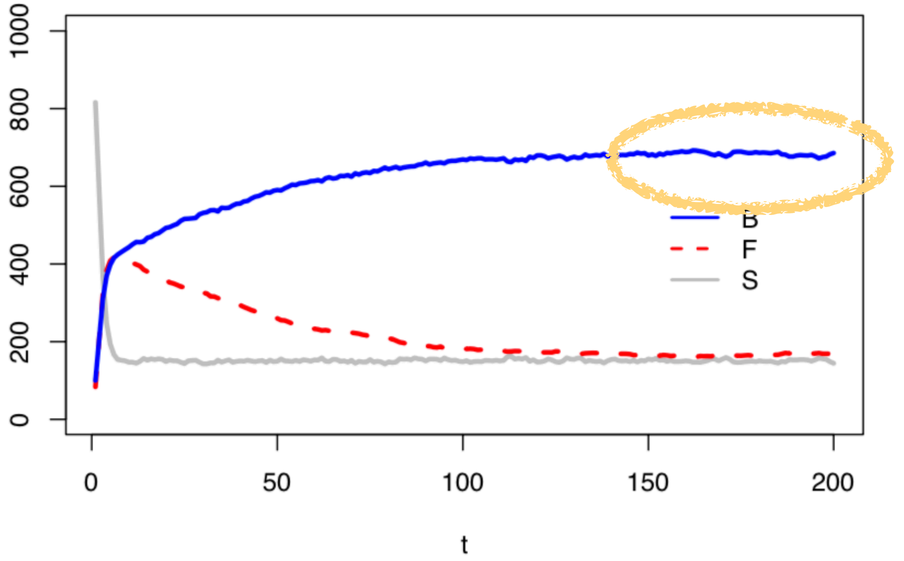
skeptical group:

- α: 0.3
- ~~seeders FC: 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)

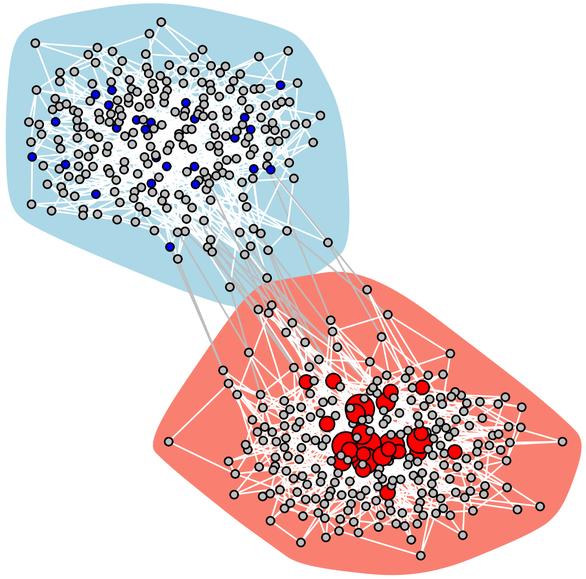
gullible group:

- α: 0.8
- seeders B: 10%

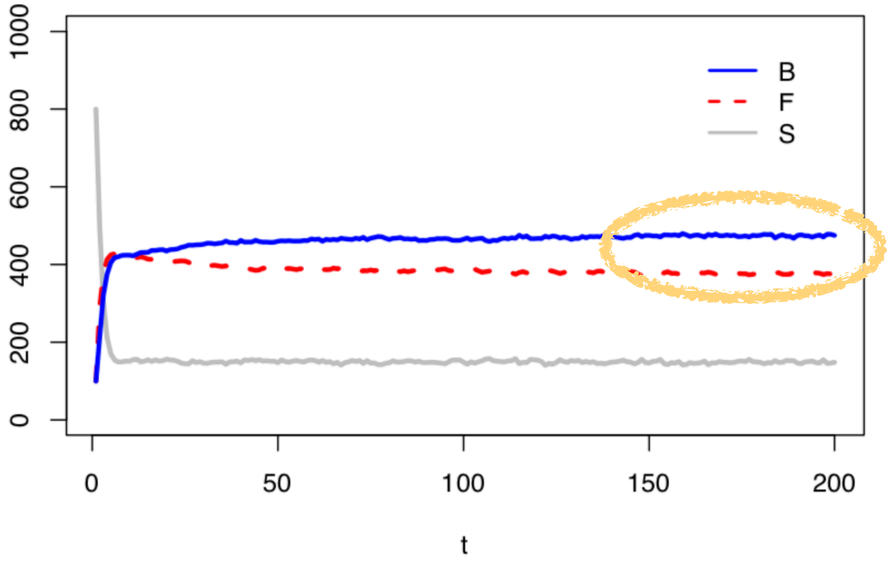
skeptical group:

- α: 0.3
- ~~seeders FC: 10%~~
- **HUBS are eFC!**

Simulation start



Simulation results



better

Bridges as eternal fact-checker

Setting

segregation: 0.92 (high)

forgetting: 0.1 (low)

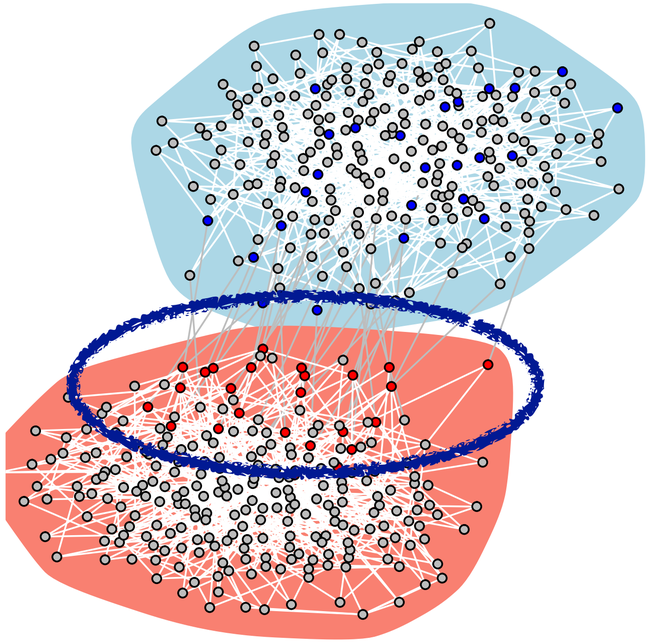
gullible group:

- α: 0.8
- seeders B: 10%

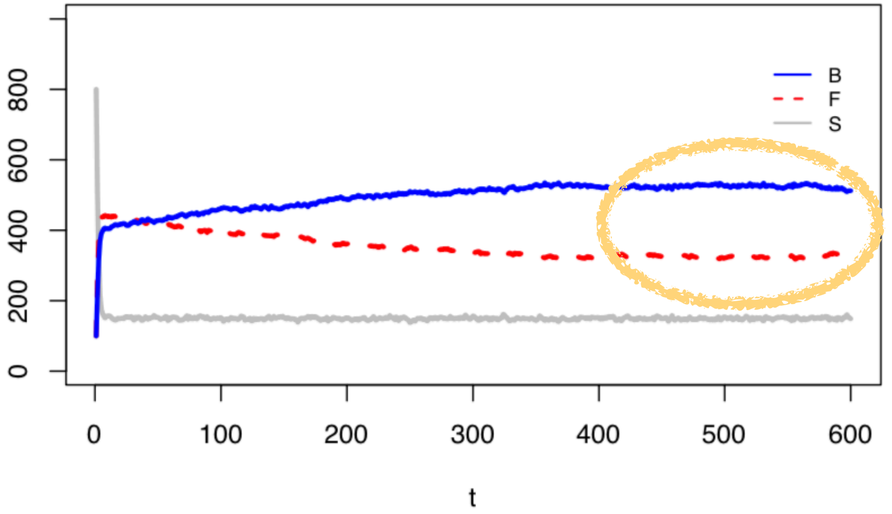
skeptical group:

- α: 0.3
- ~~seeders FC: 10%~~
- **BRIDGES are eFC!**

Simulation start

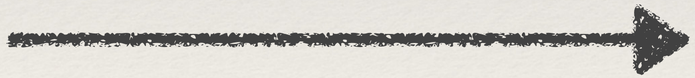


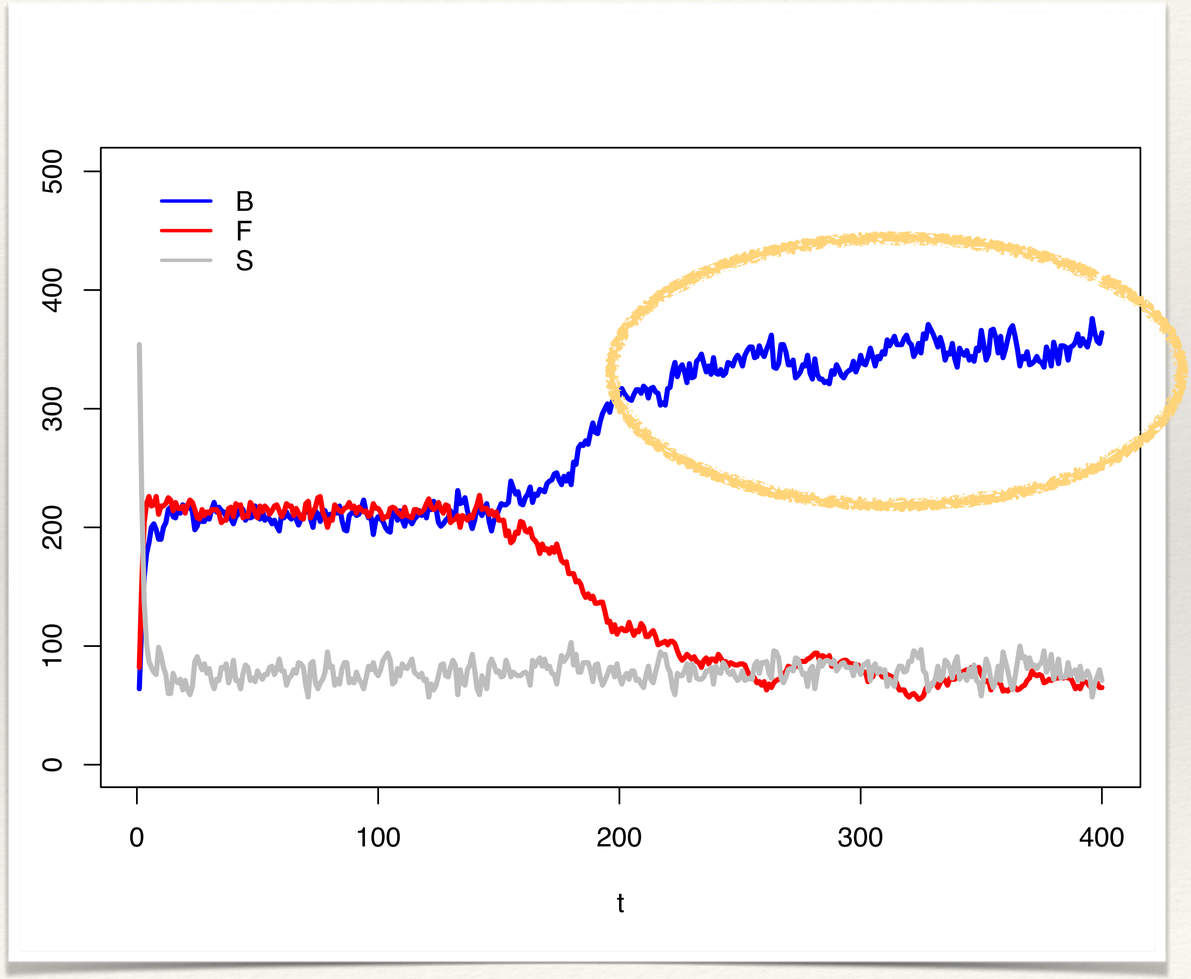
Simulation results



comparable, more realistic

Beware of results based on realizations!

- Simulations results are based on many different stochastic realizations of the model
- Plots show (statistically significant) averages
- That means that **some** realizations may diverge
- Realizations as  are unlikely, but still possible when we target bridges instead of hubs!



Lessons learned and observations

- **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

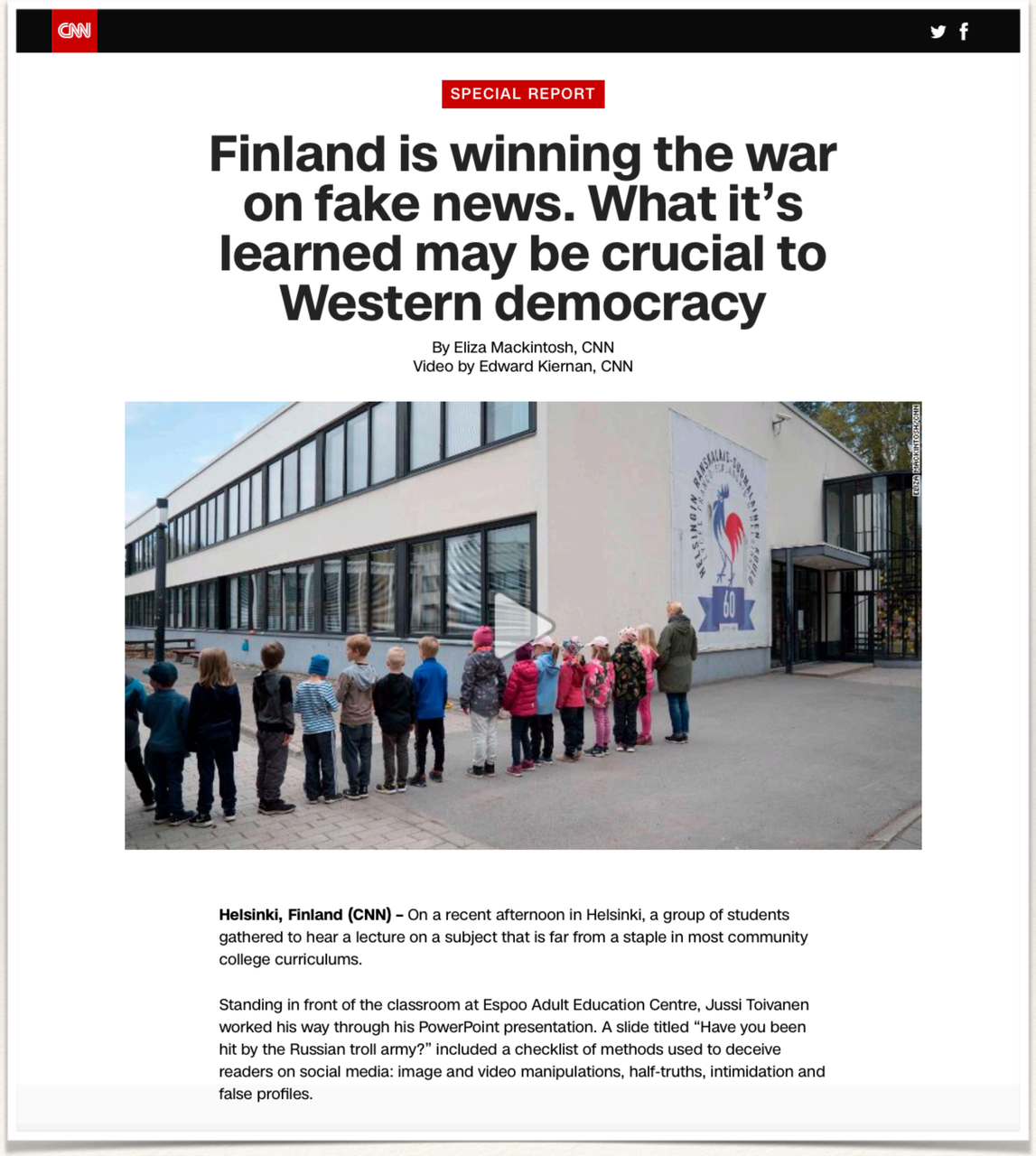
M Tambuscio, G. Ruffo, Fact-checking strategies to limit urban legends spreading in a segregated society, *likely* to appear in Applied Network Science Journal, Springer

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

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.

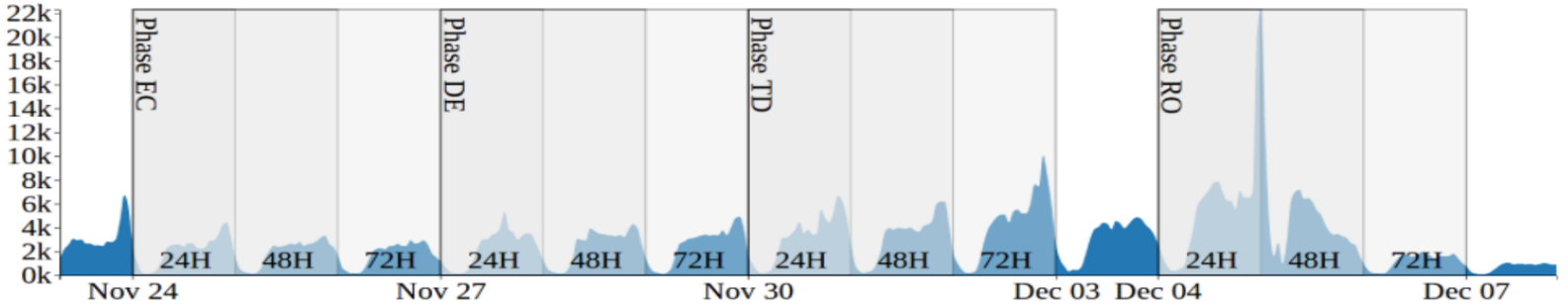
Language and network structure

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

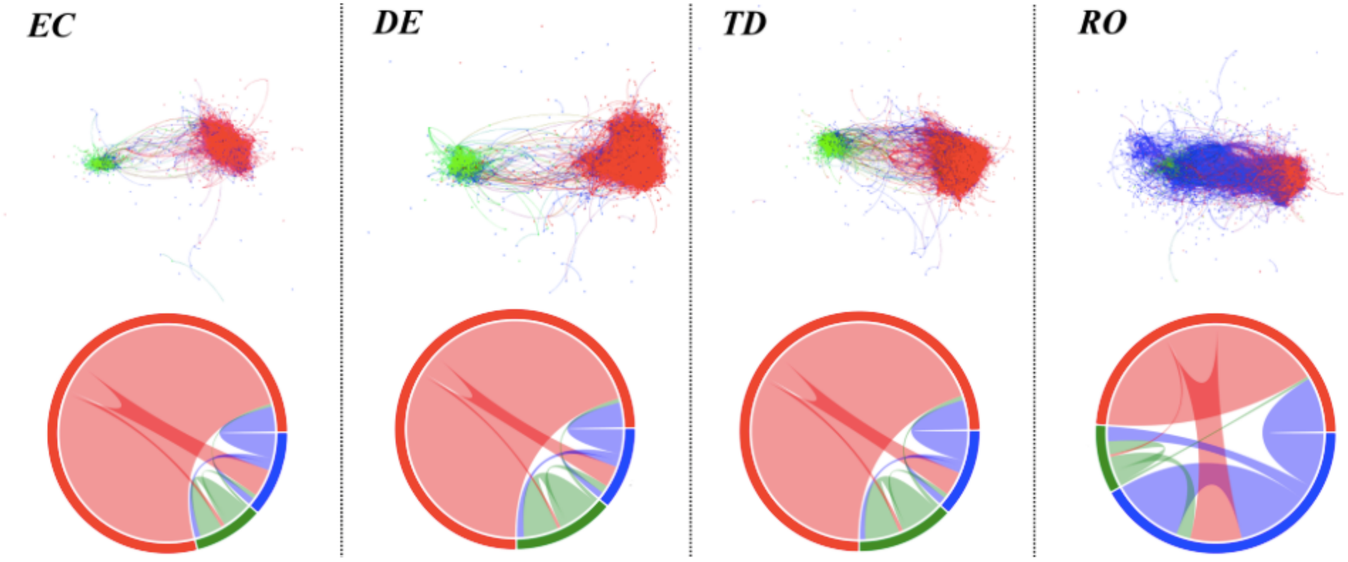
Collected Tweets



stance detected as **AGAINST**

stance detected as **IN FAVOR**

stance detected as **NONE**

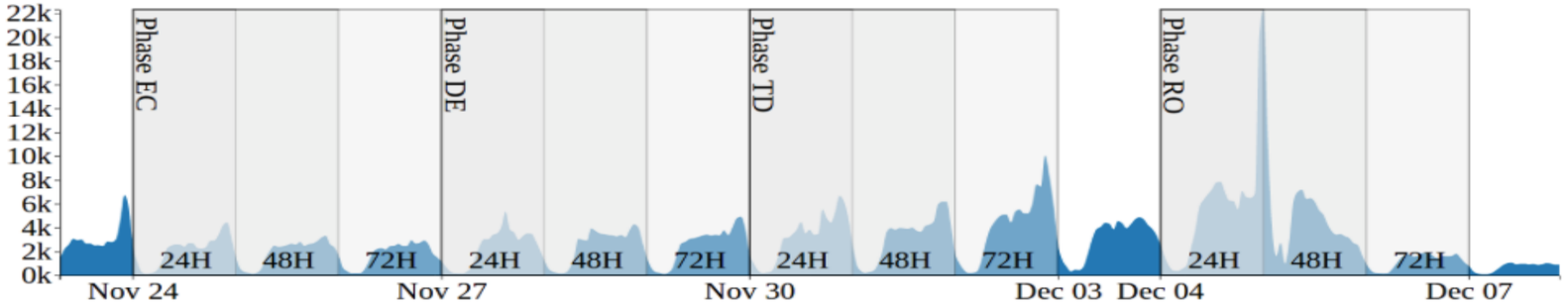


Retweet Network

strong signal of **homophily**

Italian 2016 Constitutional Referendum

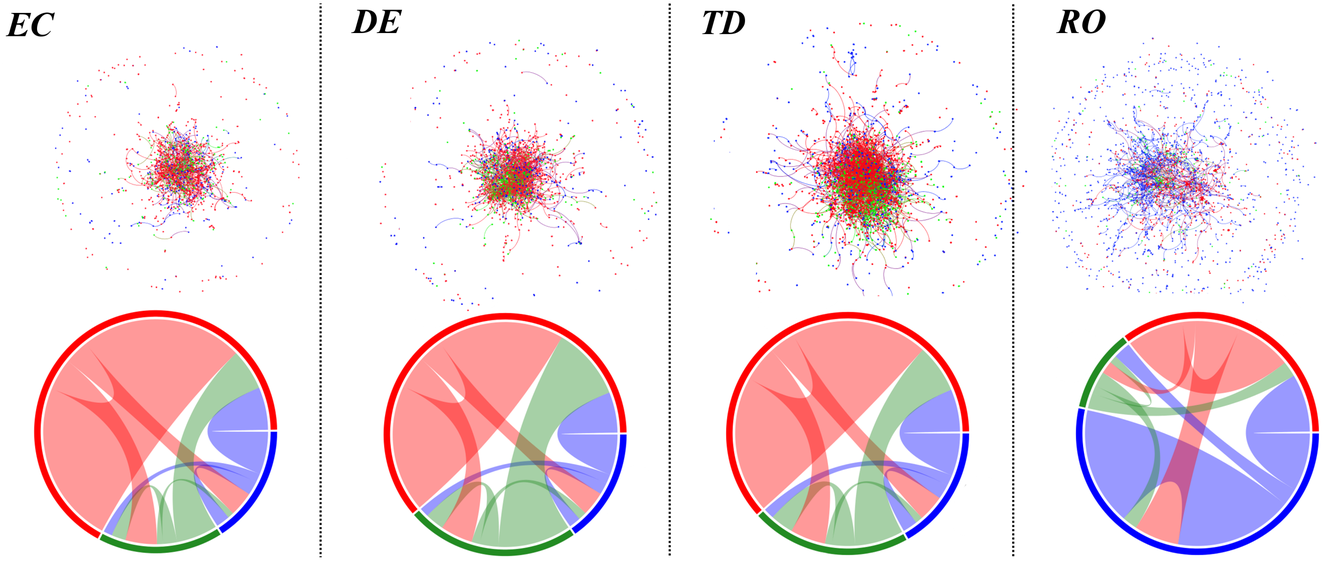
Collected Tweets



stance detected as **AGAINST**

stance detected as **IN FAVOR**

stance detected as **NONE**



Reply-to Network

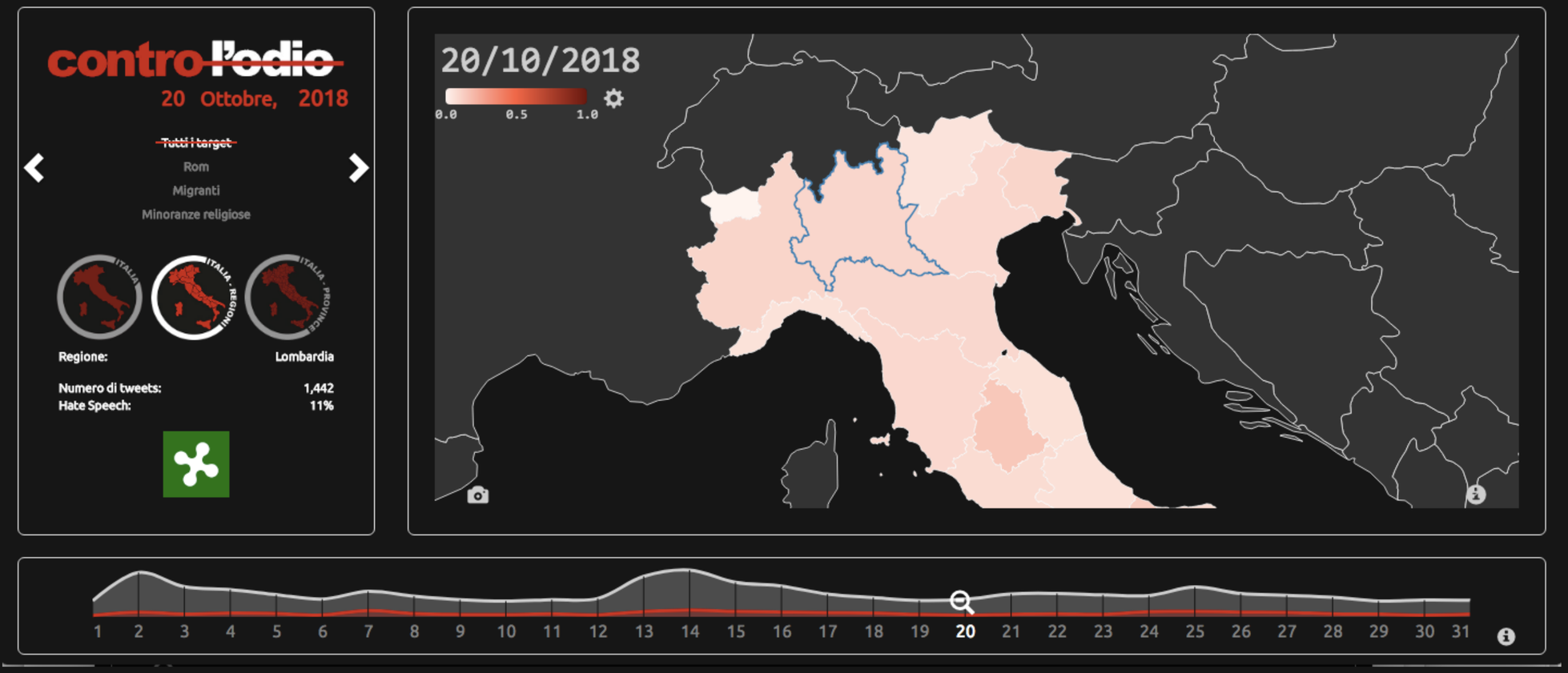
signal of **inverse homophily**

Stance detection and Network Homophily

- 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 "egg wars", **dig the reply-to messages**

M Lai, M Tambuscio, V Patti, P Rosso, G. Ruffo, Stance Polarity in Political Debates: a Diachronic Perspective of Network Homophily and Conversations on Twitter, Data & Knowledge Engineering Journal, online: September 2019
https://www.sciencedirect.com/science/article/pii/S0169023X19300187

Hate speech monitoring (Contro l'Odio)



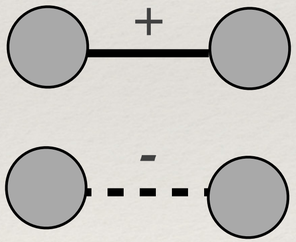
A T E Capozzi, V Patti, G Ruffo, and C Bosco. 2018. A Data Viz Platform as a Support to Study, Analyze and Understand the Hate Speech Phenomenon. In Proceedings of the 2nd International Conference on Web Studies (WS.2 2018), ACM

Balance in networks: algorithms and visualization

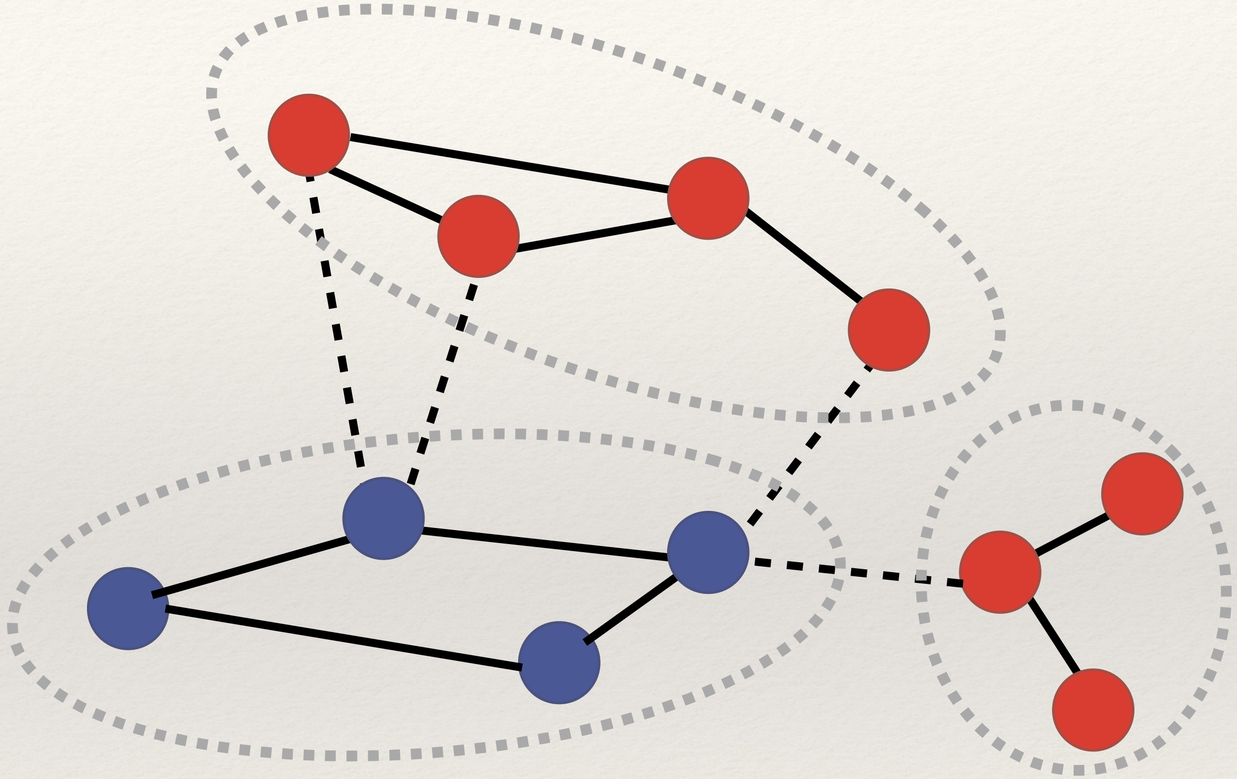
Signed nets

lilliputians from **lilliput**

lilliputians from **blefuscu**



signs make explicit the type of the relationship

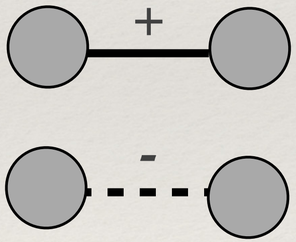


Balanced

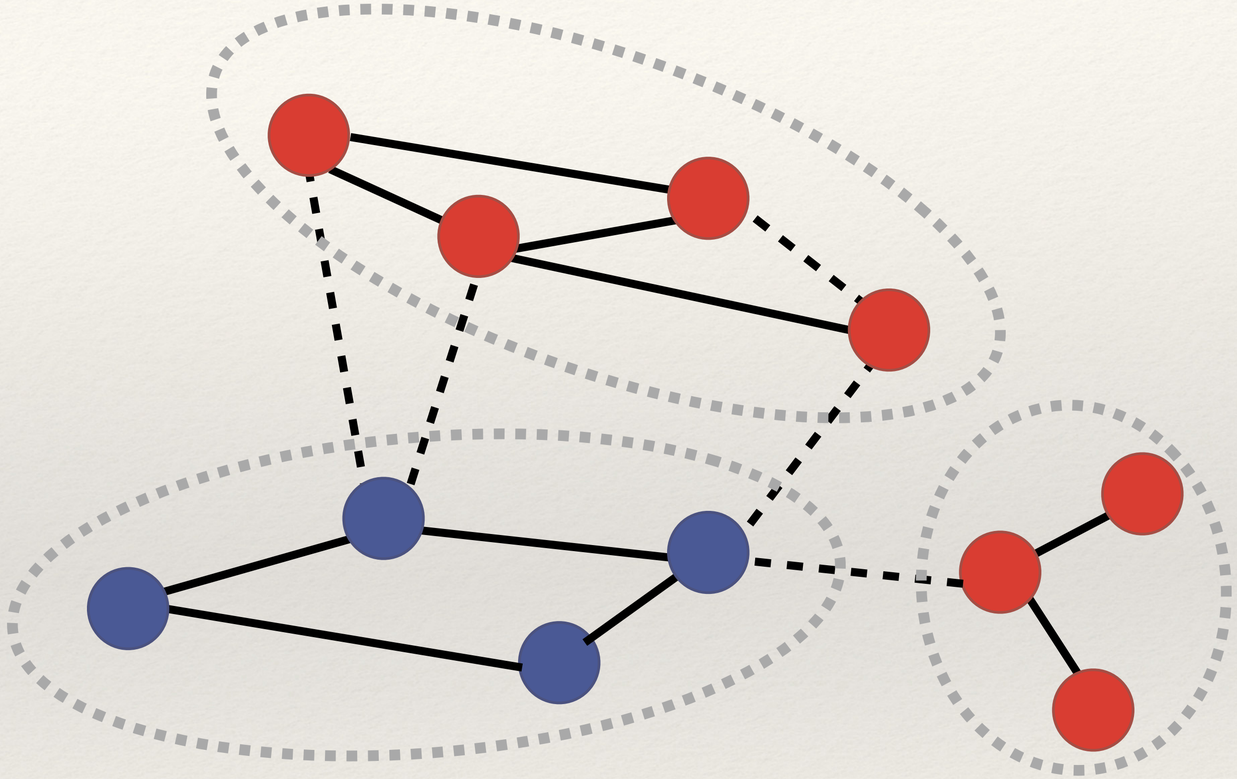
Signed nets

lilliputians from **lilliput**

lilliputians from **blefuscu**



signs make explicit the type of the relationship

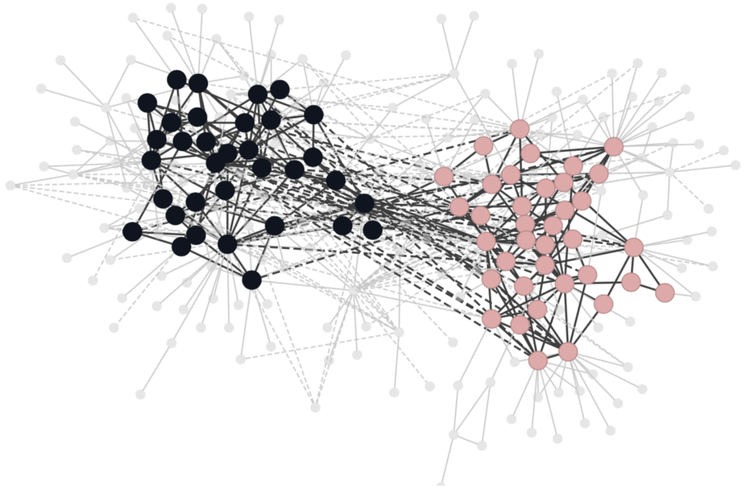


Not balanced

Balance in networks

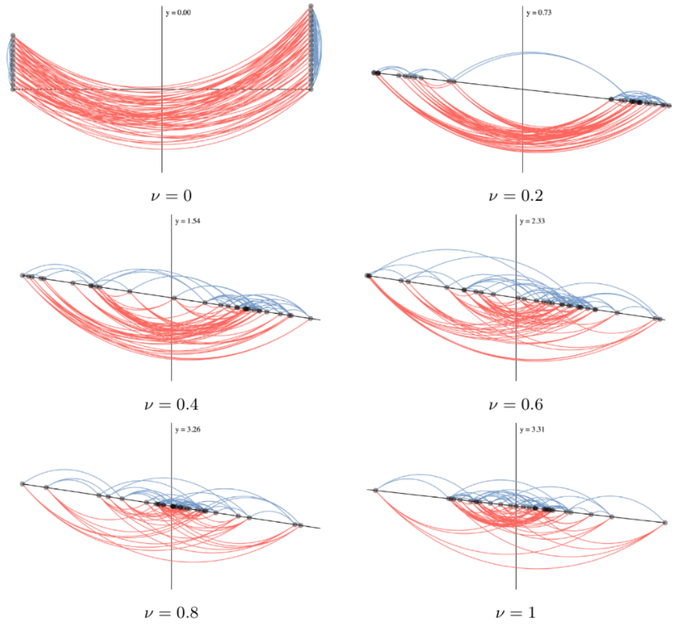
- Balance is not always good: Lilliput and Blefuscu world was perfectly balanced!
- There are different levels of balance when few negative edges cross boundaries
- Partial balance is a measure of polarization (or to predict a forthcoming egg war?) - *frustration index problem*
- Probably a great framework, not fully exploited so far, to better understand polarization and segregation dynamics in socio-political systems

Algorithms for communities detection and visualization



2-Polarized-Communities: an algorithm based on spectral properties of the graph

F Bonchi, E Galimberti, A Gionis, B Ordozgoiti and G Ruffo, Discovering polarized communities in signed networks, to appear in Proc. of CIKM 2019 (Beijing, China)



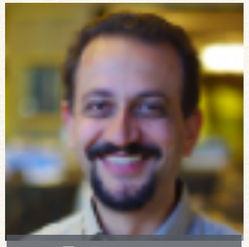
Stuctural-balance-viz: spectral properties used to emphasize balance/unbalance

E Galimberti, C Madeddu, F Bonchi, and G Ruffo, Visualizing structural balance in signed networks, to appear in Proc. of COMPLEX NETWORKS 2019 (Lisbon, Portugal)

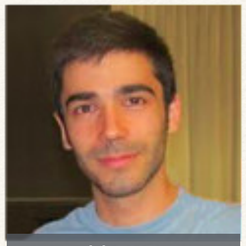
Recap

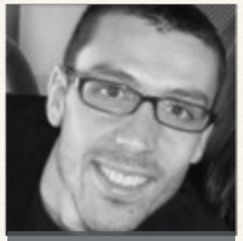
- **Structural segregation** (as in Lilliput and Blefuscu islands) may be one of the main triggers of opinion **polarization**
- **Fake-news spreading**, especially when partisanship and antagonistic behavior reinforce the debate, is **facilitated** in segregated networks
- Fact-checking is needed and 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
- **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

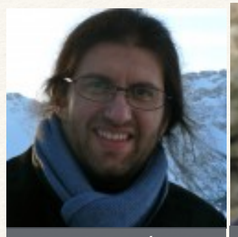
di.unito.it

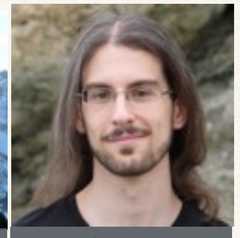

Giancarlo Ruffo

Marcella Tambuscio


Mirko Lai


Rossano Schifanella


André Panisson


Luca Aiello

Viviana Patti

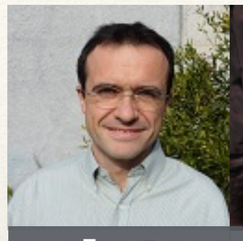
Arthur Capozzi

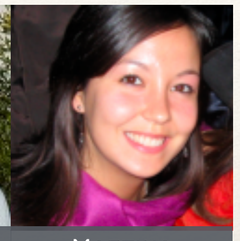
EDoardo Galimberti

Alfonso Semeraro

Alessandra Urbinati

Salvatore Vilella


Emilio Sulis


Martina Deplano

Cristina Bosco

ARC²S: Applied Research on Computational Complex Systems

Thanks!

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

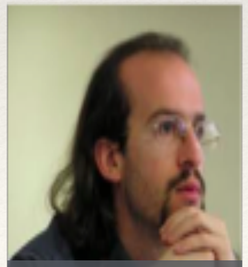
Paolo Rosso

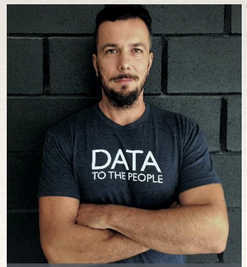
Universidad del Desarrollo

Leo Ferres

INSTITUTE FOR SCIENTIFIC INTERCHANGE FOUNDATION

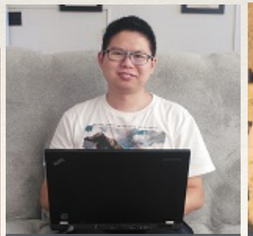
Ciro Cattuto

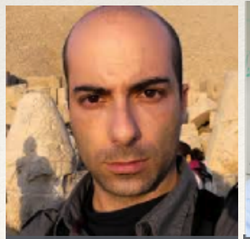

Alain Barrat

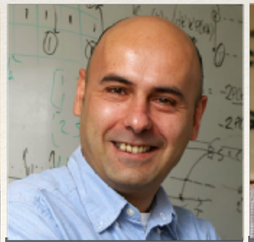


Francesco Bonchi

Daniela Paolotti


Chengcheng Shao


Giovanni Luigi Ciampaglia


Alessandro Flammini

Fil Menczer