Uncovering the structure and dynamics of information flow on the Telegram network

Thomas Louf, Aurora Vindimian, Riccardo Gallotti

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UNIVERSITÀ DI TRENTO | Dipartimento di Matematica

FONDAZIONE BRUNO KESSLER

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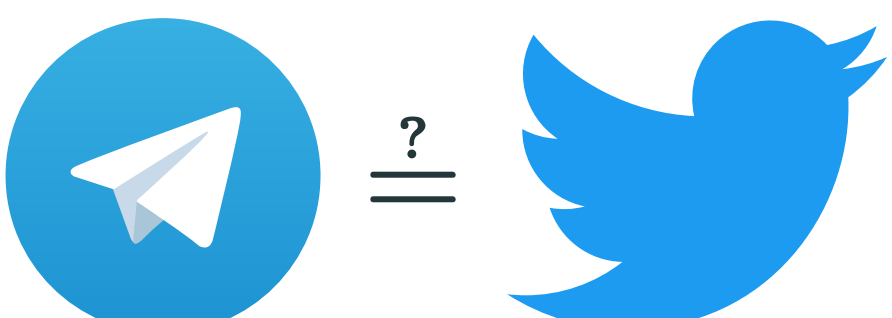
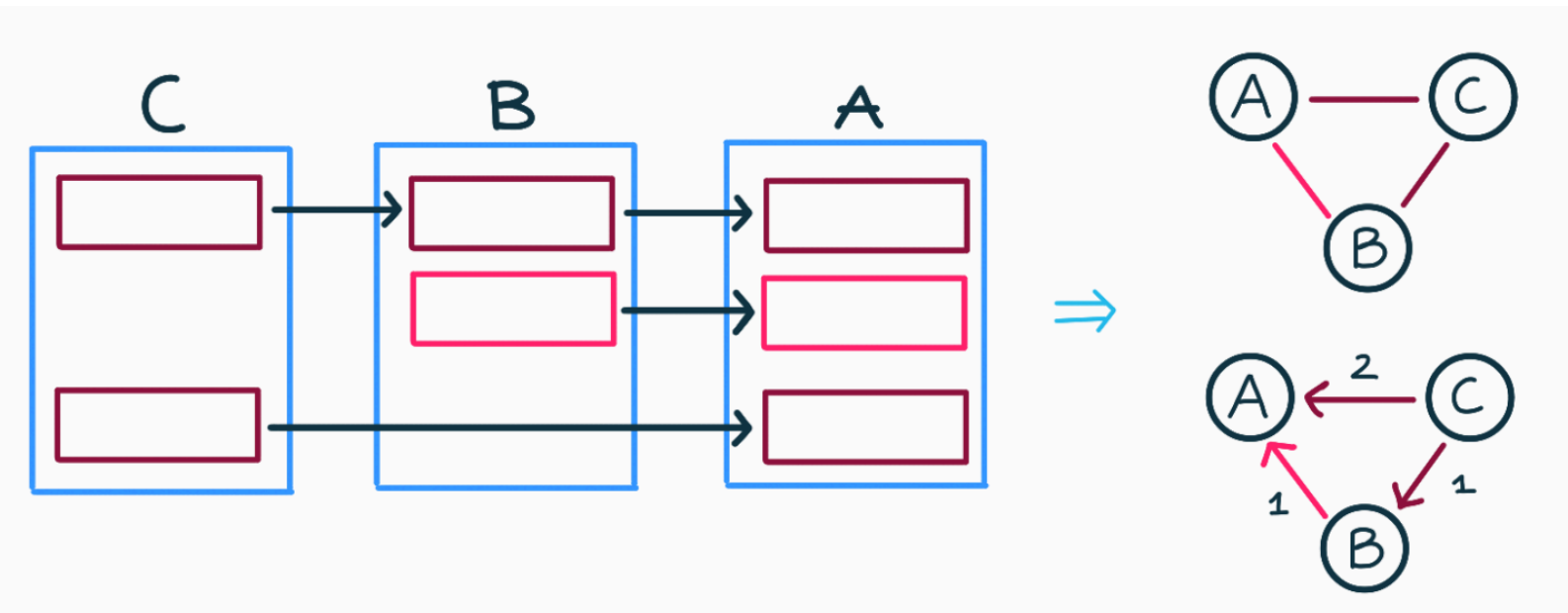
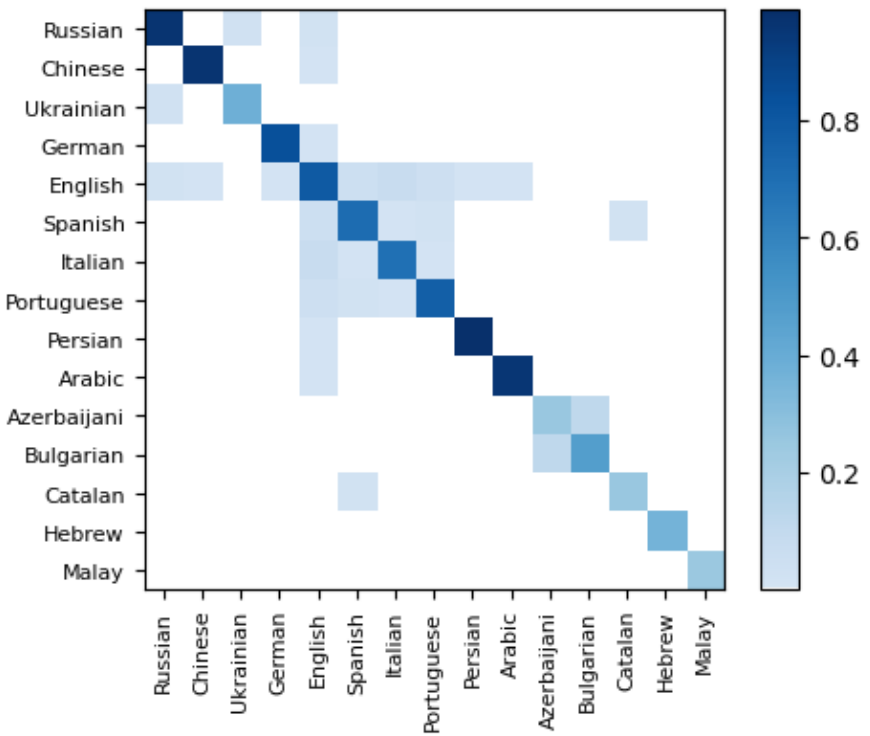
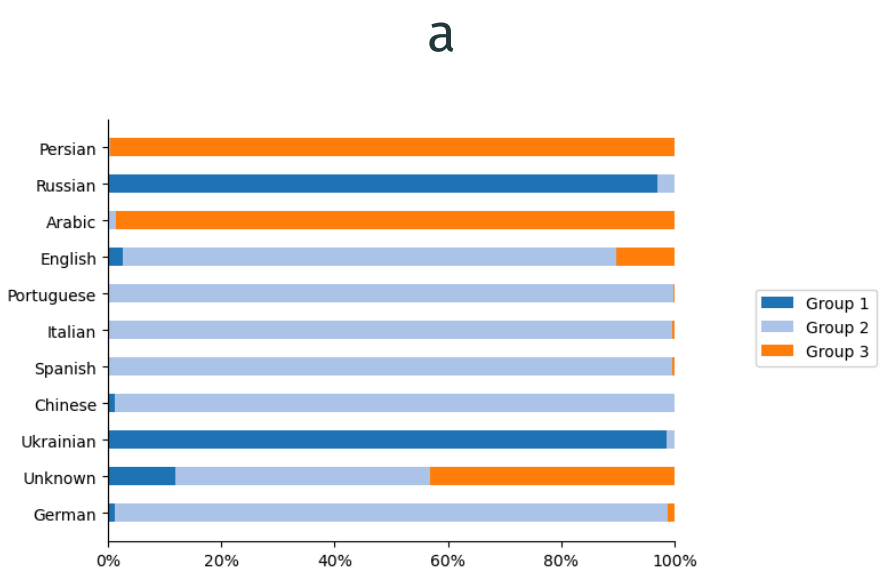


- Nodes: $29\,609$ channels
- Edge from B to A when A forwards a message from B → $501\,897$ directed edges



Structural analysis › Assortativity



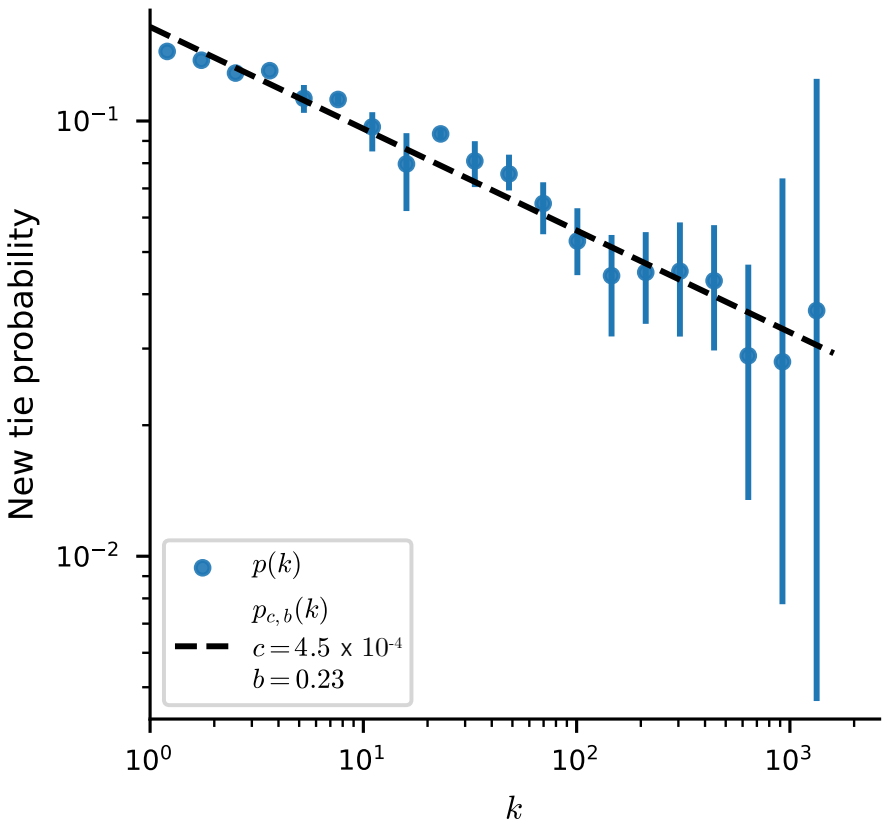


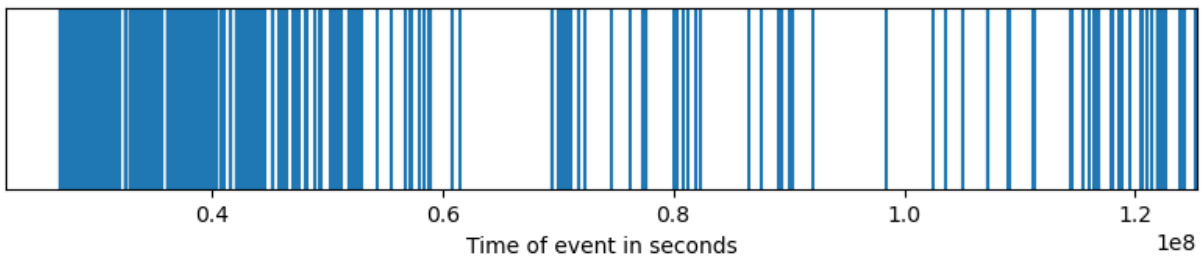
Aversion to form too many ties

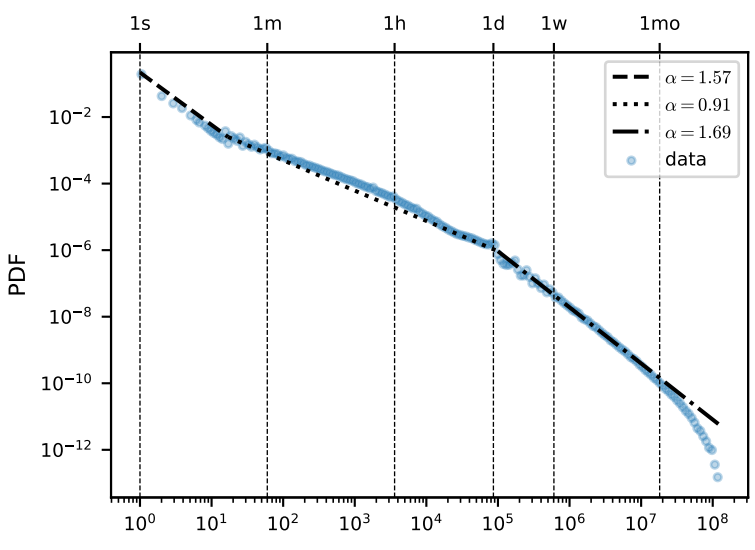
→ probability to form new ties should decrease with in-degree k_{in}.

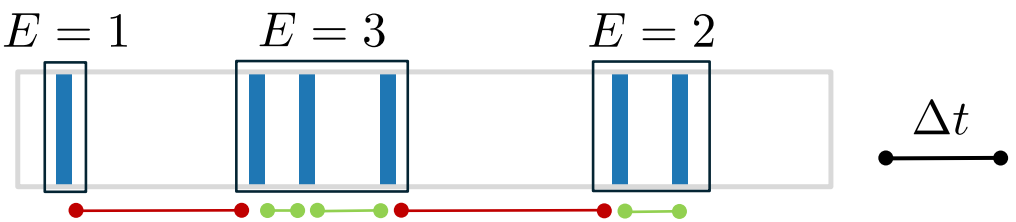
Model from (Ubaldi et al., 2016)

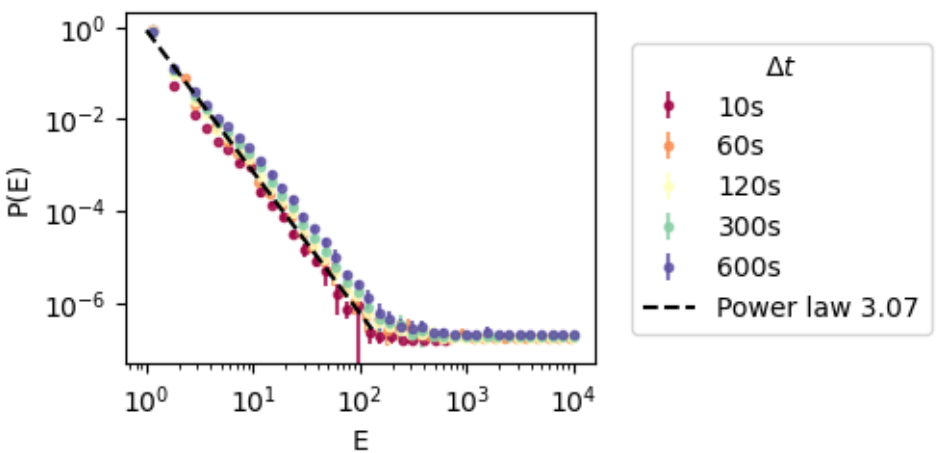
$$p_{\text{new}}(k_{\text{in}}) = \left(1 + \frac{k_{\text{in}}}{c}\right)^{-b}$$




0.4
0.6
0.8
1.0
1.2
Time of event in seconds
1e8

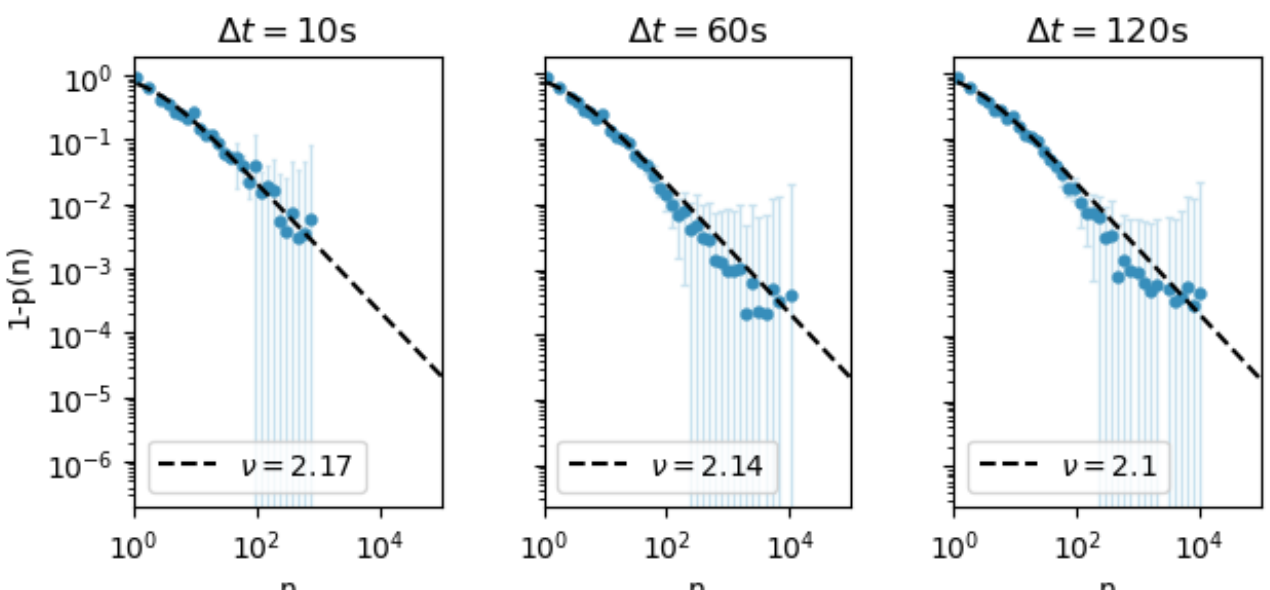

1s
1m
1h
1d
1w
1mo
$\alpha = 1.57$
$\alpha = 0.91$
$\alpha = 1.69$
data
PDF
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
τ


$E = 1$
$E = 3$
$E = 2$
Δt


P(E)
E
10^0
10^{-2}
10^{-4}
10^{-6}
10^0
10^1
10^2
10^3
10^4
Δt
10s
60s
120s
300s
600s
Power law 3.07

Train size distribution generated from memory process (Karsai et al., 2012)

$$p(E) \sim E^{-\beta} \Leftrightarrow p(n) = \left(\frac{n}{n+1}\right)^{\nu} \qquad \text{with } \nu \approx \beta - 1$$

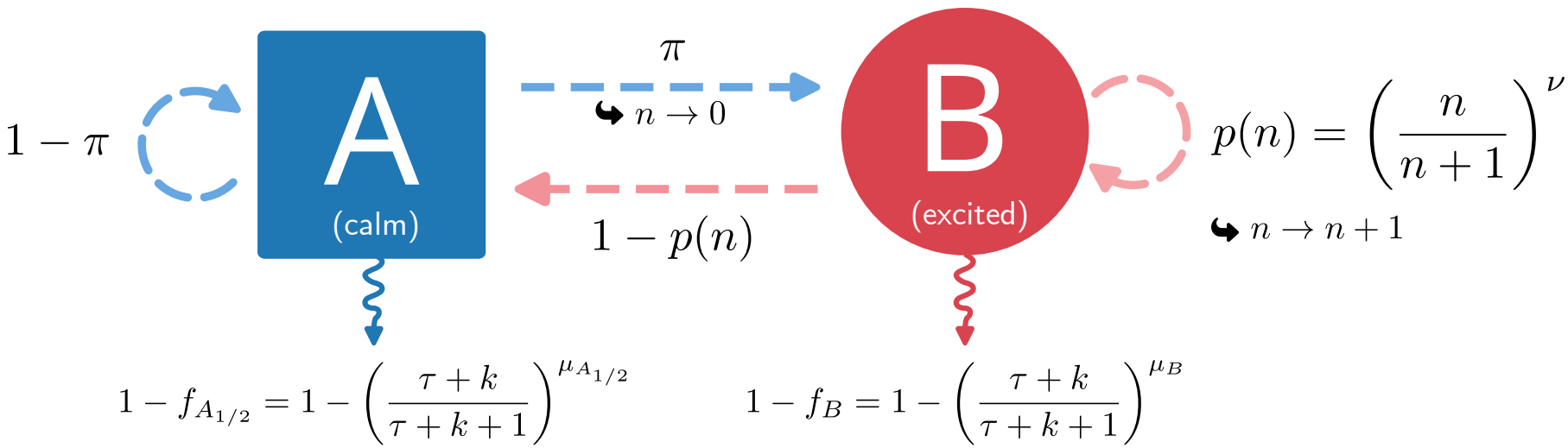


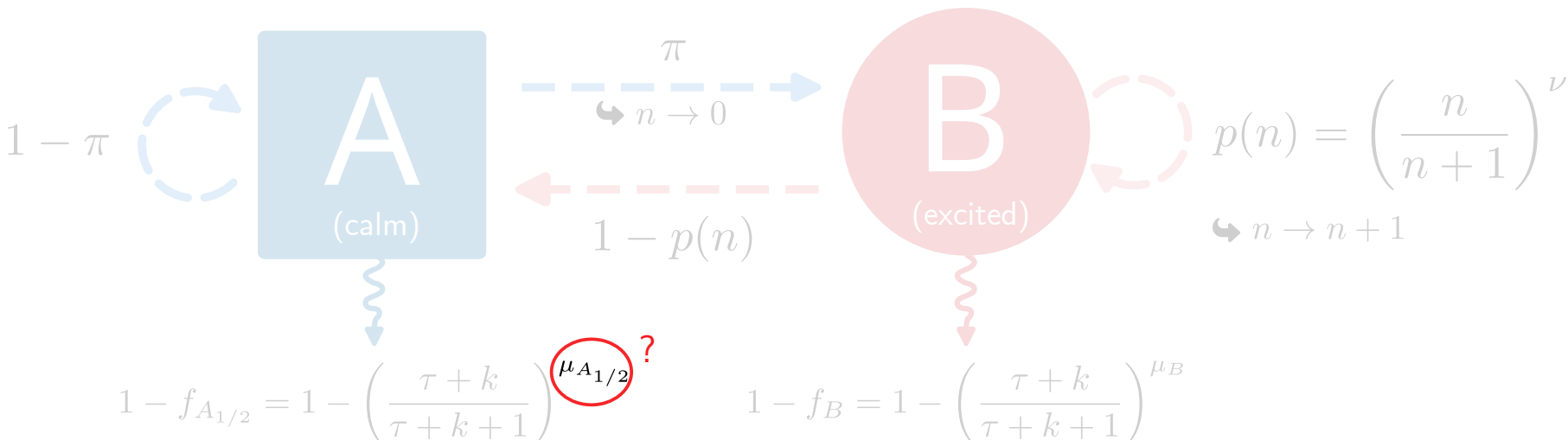
Modelling

Simple-enough model that can reproduce these properties?

↪ can simulate contagion model or equivalent and test effect of interventions on synthetic networks

Existing model to reproduce clustering, strength distribution, assortativity and burstiness? *No!*


$1-\pi$
A
(calm)
π
$\hookrightarrow n \to 0$
$1-p(n)$
B
(excited)
$p(n) = \left(\frac{n}{n+1}\right)^{\nu}$
$\hookrightarrow n \to n+1$
$1-f_{A_{1/2}} = 1-\left(\frac{\tau+k}{\tau+k+1}\right)^{\mu_{A_{1/2}}}$
$1-f_B = 1-\left(\frac{\tau+k}{\tau+k+1}\right)^{\mu_B}$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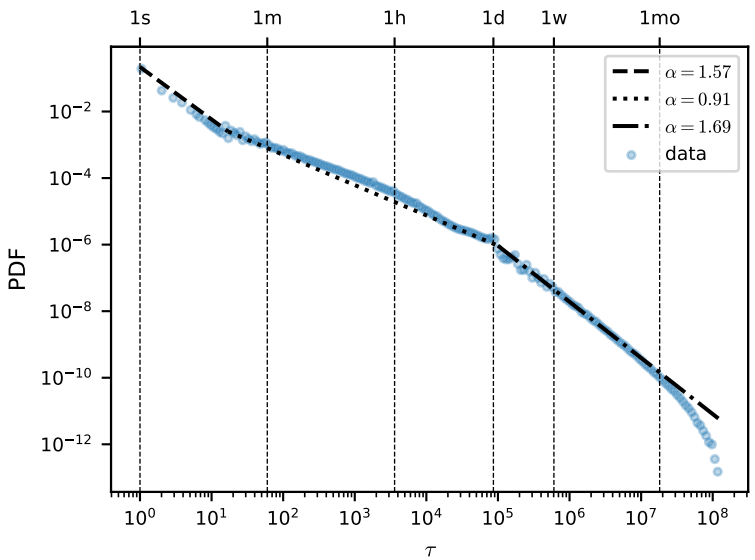
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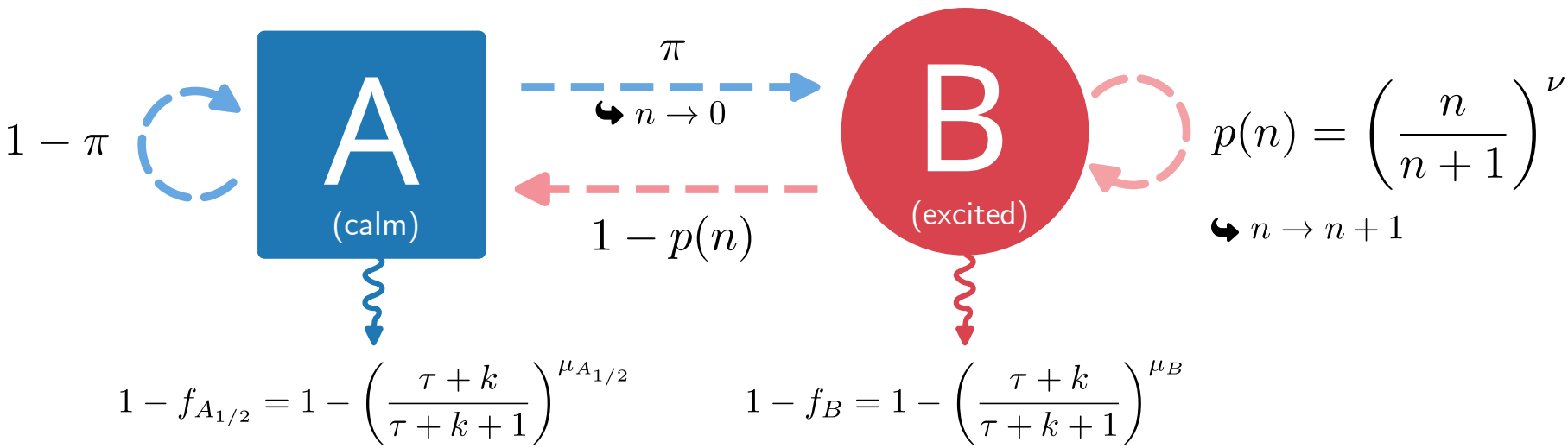
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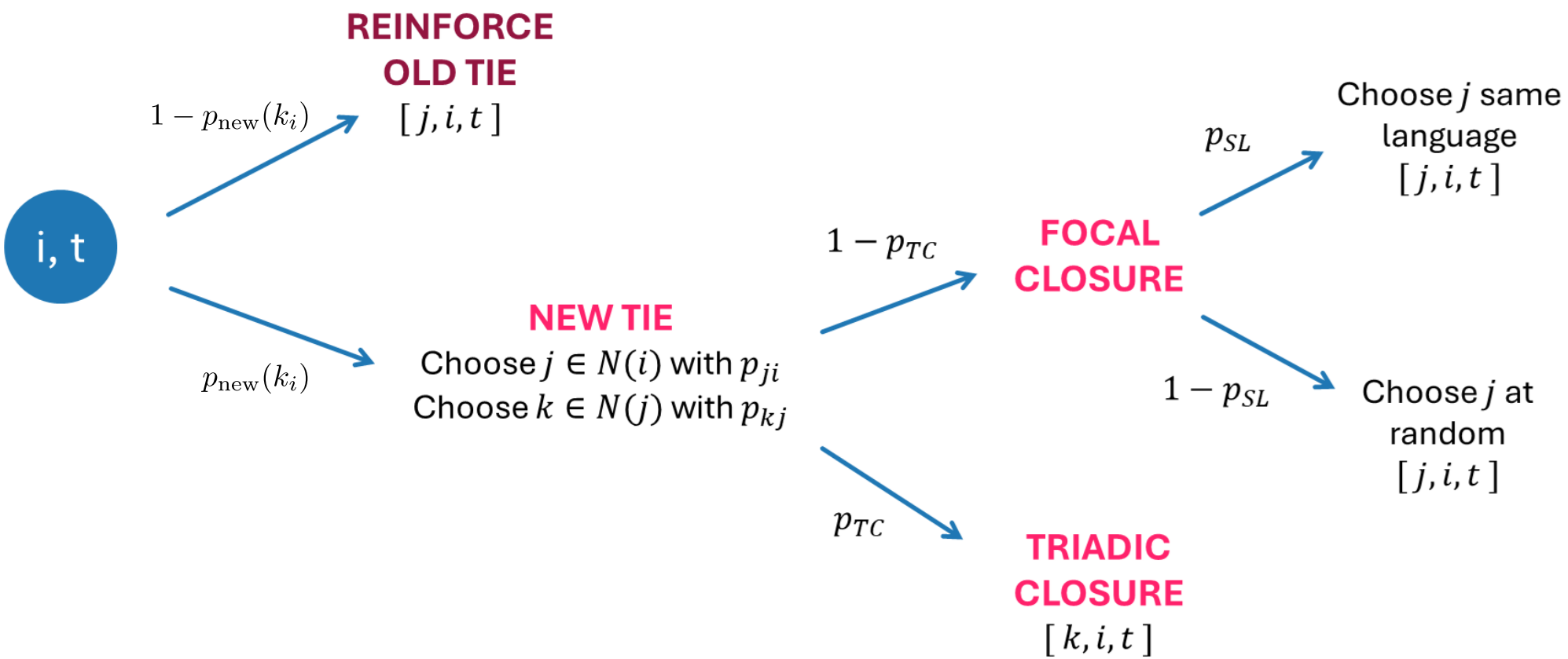
REINFORCE
OLD TIE
[j, i, t]
1 − p_new(k_i)
i, t
p_new(k_i)
NEW TIE
Choose j ∈ N(i) with p_ji
Choose k ∈ N(j) with p_kj
1 − p_TC
p_TC
FOCAL
CLOSURE
TRIADIC
CLOSURE
[k, i, t]
p_SL
1 − p_SL
Choose j same
language
[j, i, t]
Choose j at
random
[j, i, t]

What we've shown...

- Network of Telegram channels is very social-network-like
- Main mechanisms behind its emergence: tie reinforcement, clustering, language assortativity + memory process

...and what this leads to

- Model information propagation and effect of interventions
- Very global view of temporal process: what about local coordination?

Thanks for your attention 🤗

@TLouf

@TLouf

tlouf@fbk.eu

Bibliography

Karsai, M., Kaski, K., Barabási, A.-L., & Kertész, J. (2012). Universal Features of Correlated Bursty Behaviour. *Scientific Reports*, *2*(1), 397. https://doi.org/10.1038/srep00397

Ubaldi, E., Perra, N., Karsai, M., Vezzani, A., Burioni, R., & Vespignani, A. (2016). Asymptotic Theory of Time-Varying Social Networks with Heterogeneous Activity and Tie Allocation. *Scientific Reports*, *6*(1), 35724. https://doi.org/10.1038/srep35724