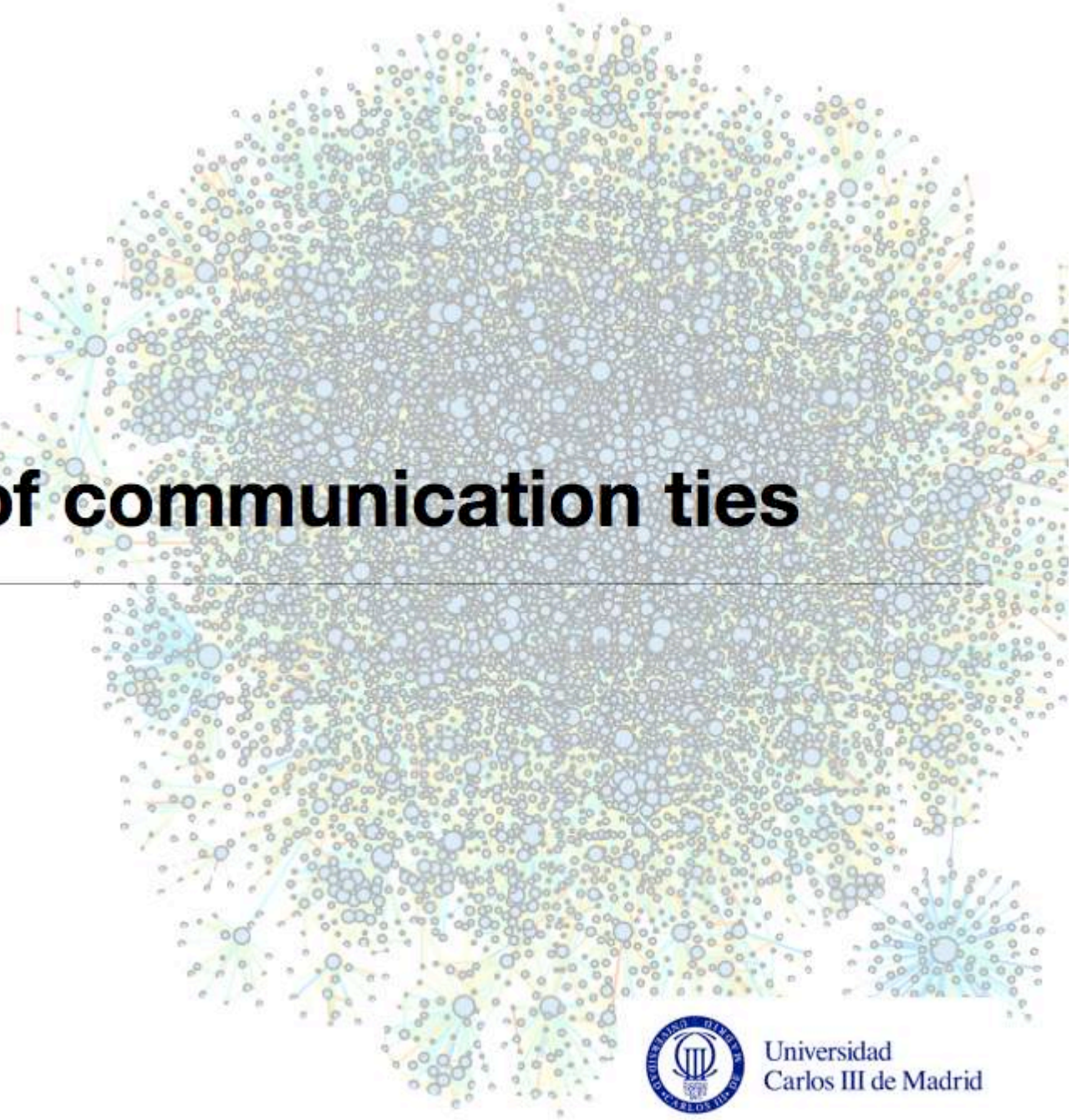

The evolution of communication ties

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Giovanna Miritello (TID)
Rubén Lara (TID)

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Sept. 2012

Motivation

- **Temporal networks**
  - Nodes appear/disappear
  - Edges decay/form
  - Bursty activity in edges/node
  - Co-evolution
  - ...

    Holme & Saramäki, arXiv:1108.1780

  - Dynamical strength of ties
    Miritello, Moro & Lara PRE (2011)
  - Time as a limited resource
    Miritello, Moro, Lara, Robers and Dunbar
    submitted (2012)

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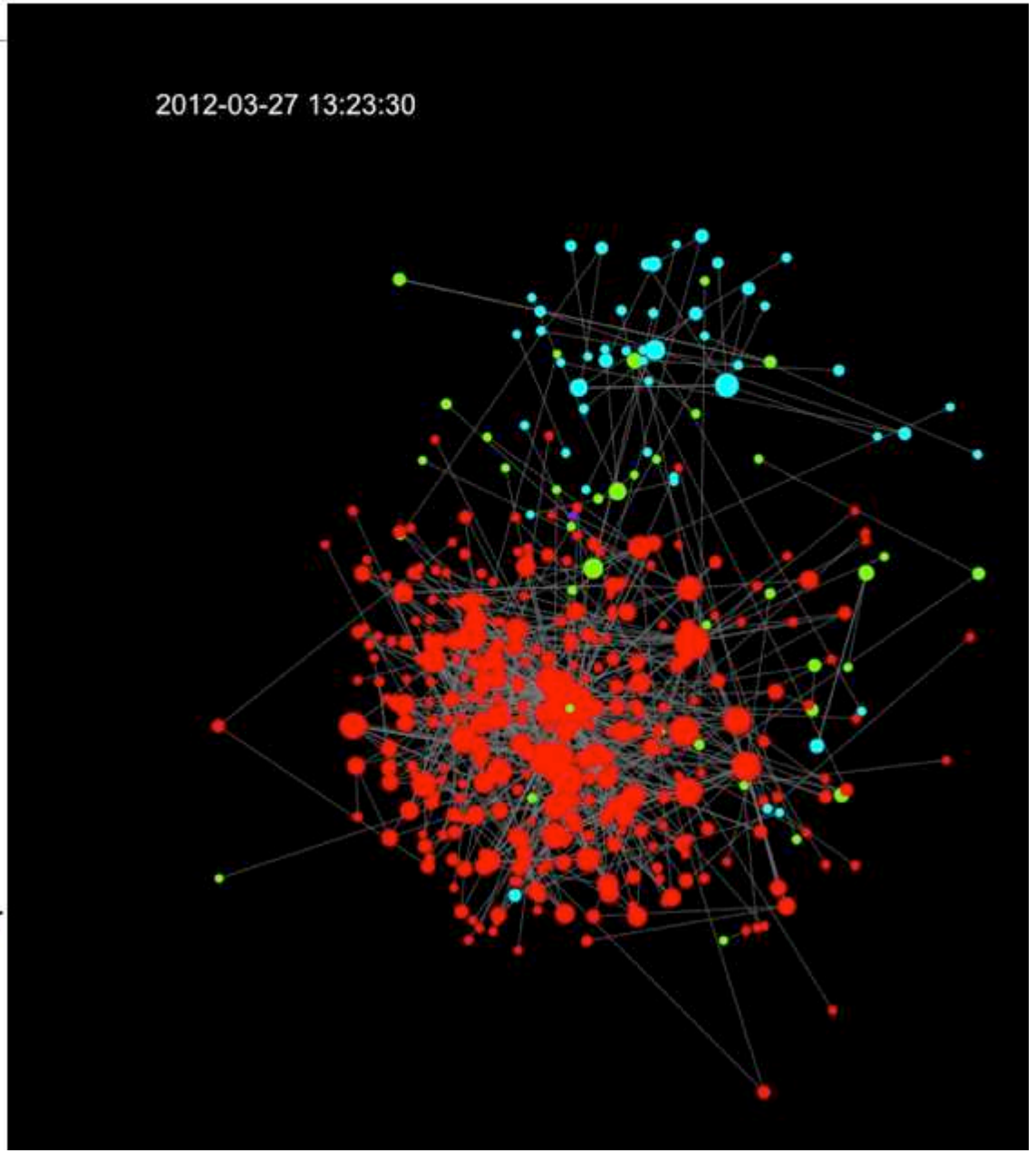
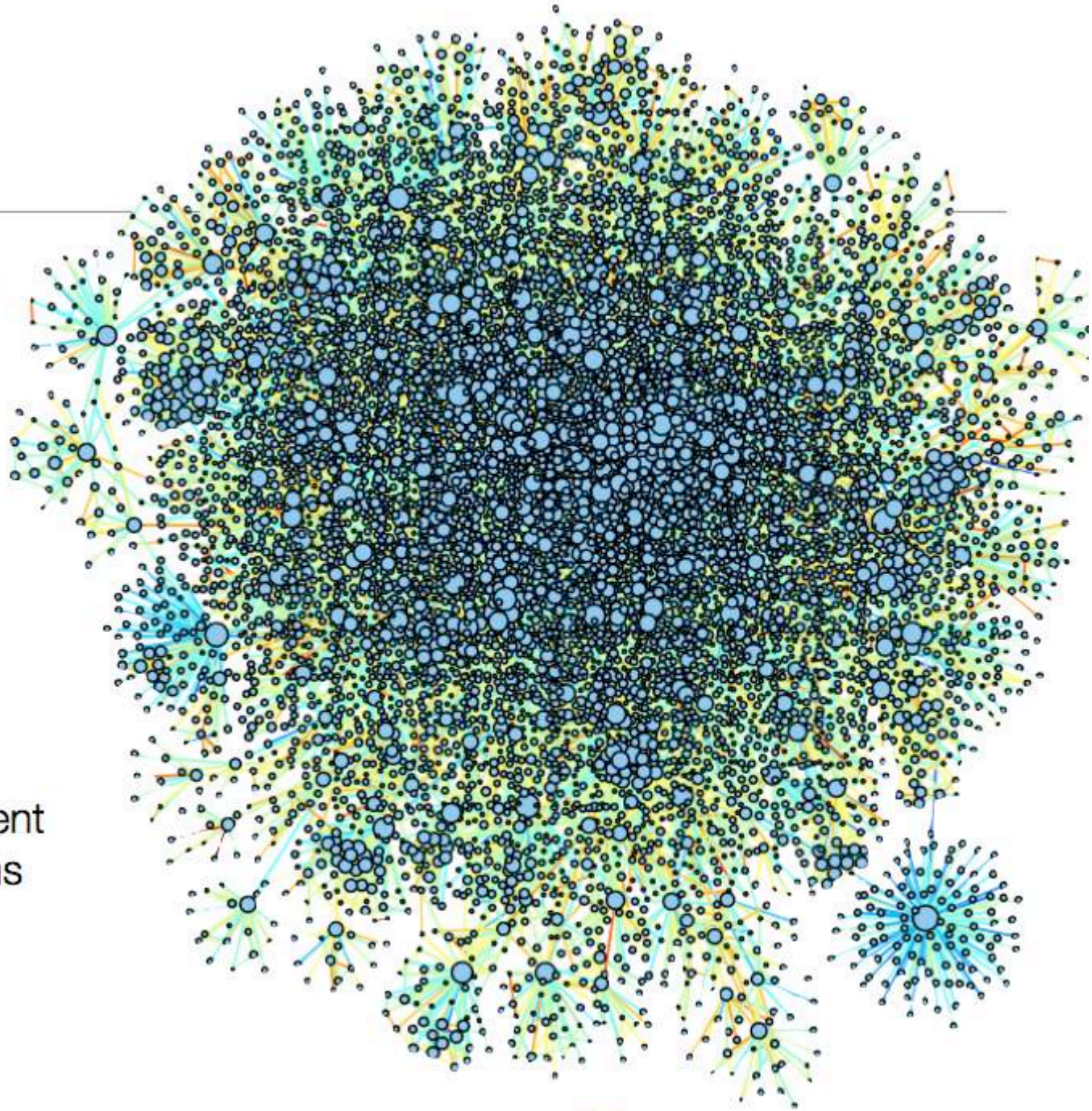


Motivation

- **Tie dynamics**
  - **Growth of networks**: Preferential attachment (coupled to node appearance) (Leskovec, Backstrom, Kumar & Tomkins '08)
  - **Tie formation** (Rivera, Soderstrom, Uzzi '10)
    - Homophily
    - Reciprocity
    - Triadic closure
    - Proximity and Social Foci
    - ...
  - **Tie decay** (Burt '00, '02)
    - Tie persistence: 40% of ties decay in one month (Hidalgo, Rodríguez-Sickert '08)

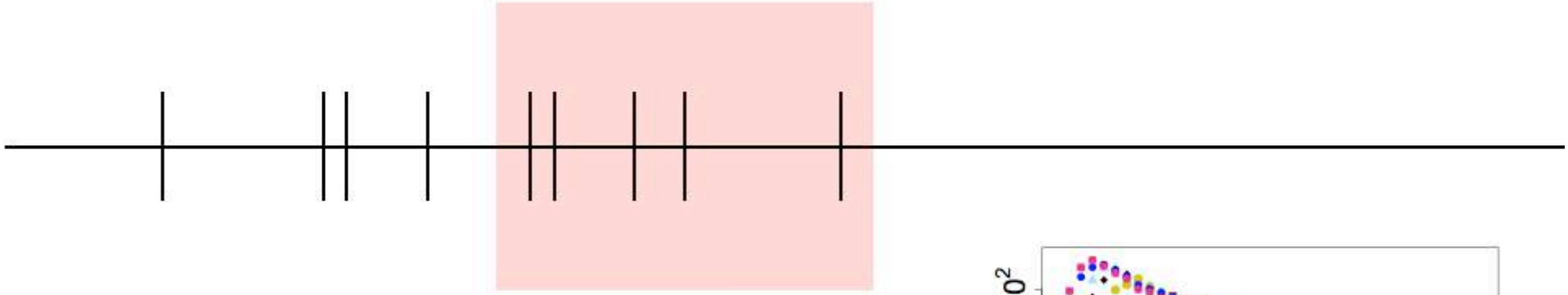
Data

- CDR (Call Detail Record)
  - 19 months of data
  - 23M people
  - 9000M calls
  - 700M ties
- Only reciprocal ties
- Only users who are present throughout the 19 months

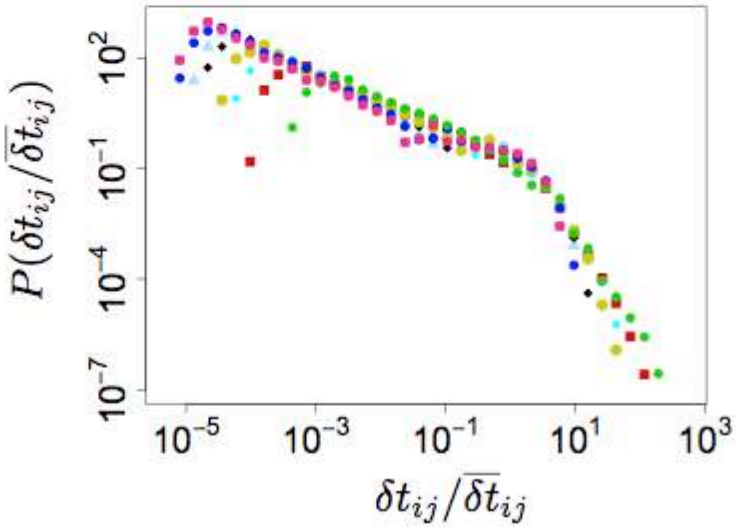


Detecting tie presence - formation/decay

- Detecting presence (formation/decay) **is coupled** to the burstiness of interaction



Average interevent time: 14 days
20% of interevent times larger than 2 months



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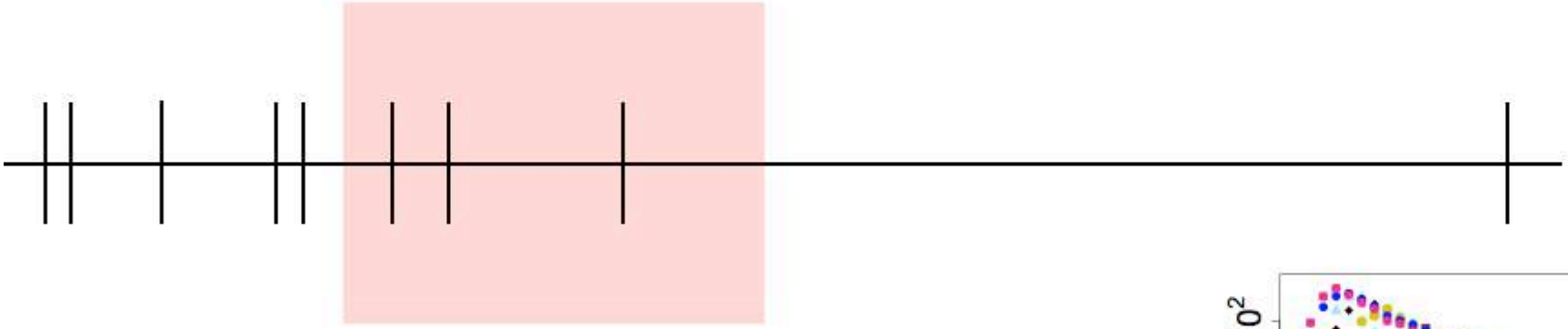

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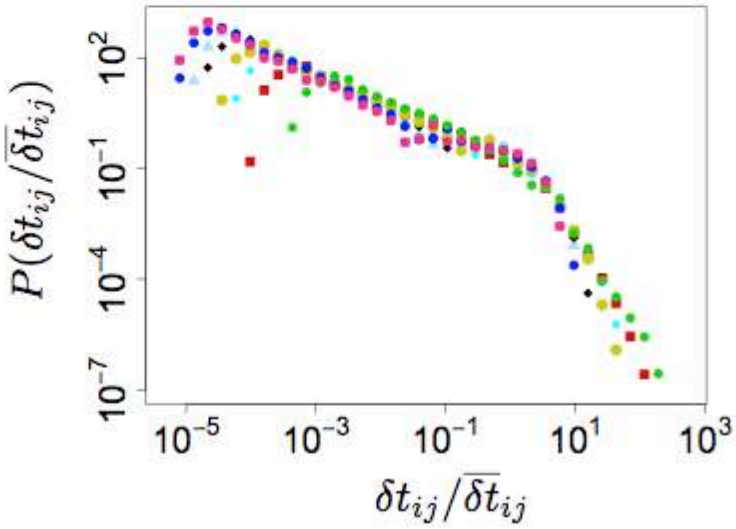
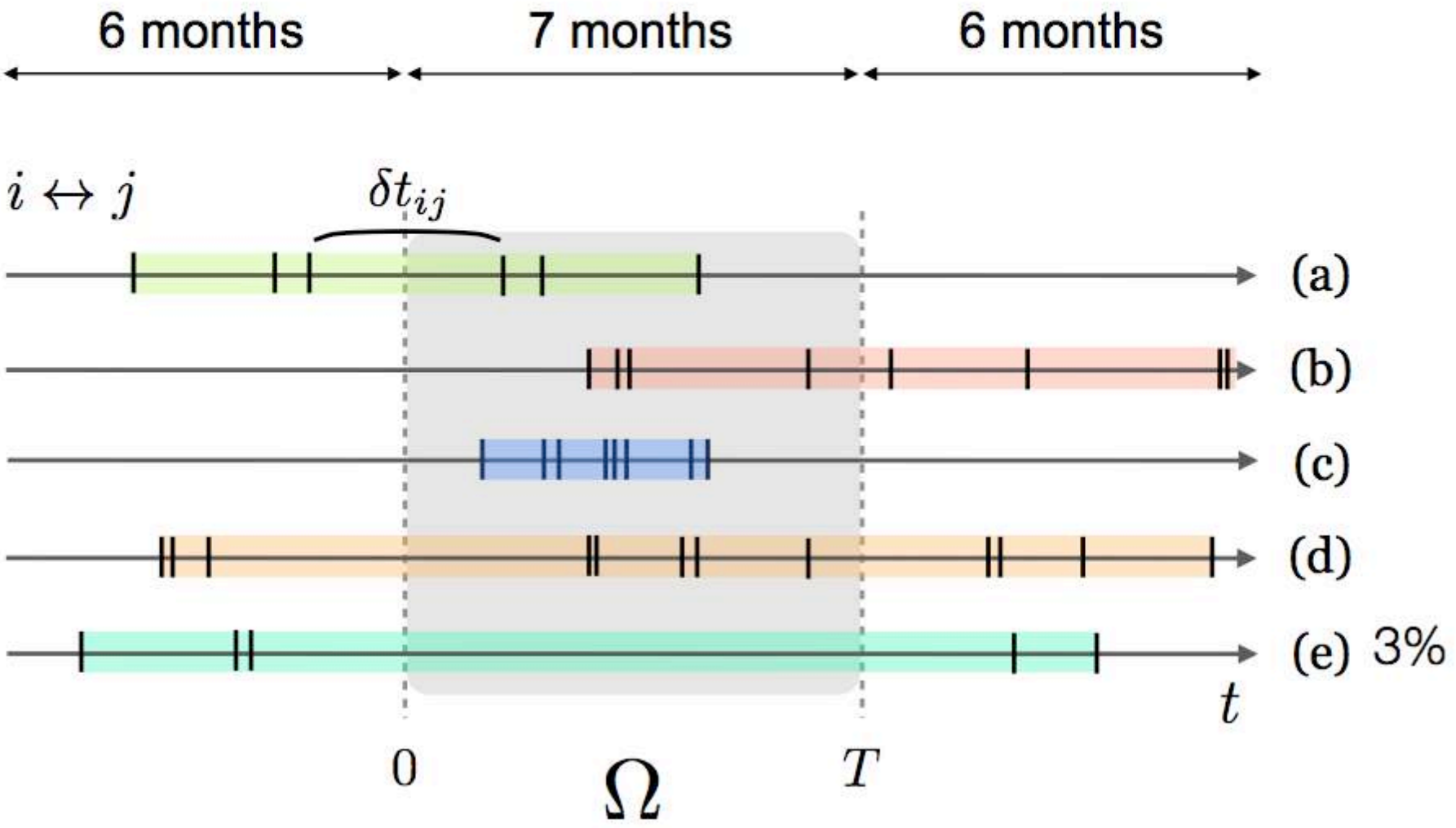


Disentangling bursty interaction from edge dynamics



(Egocentric) dynamical social strategy

- Aggregated (revealed) connectivity

$$k_i(t)$$

- Social capacity

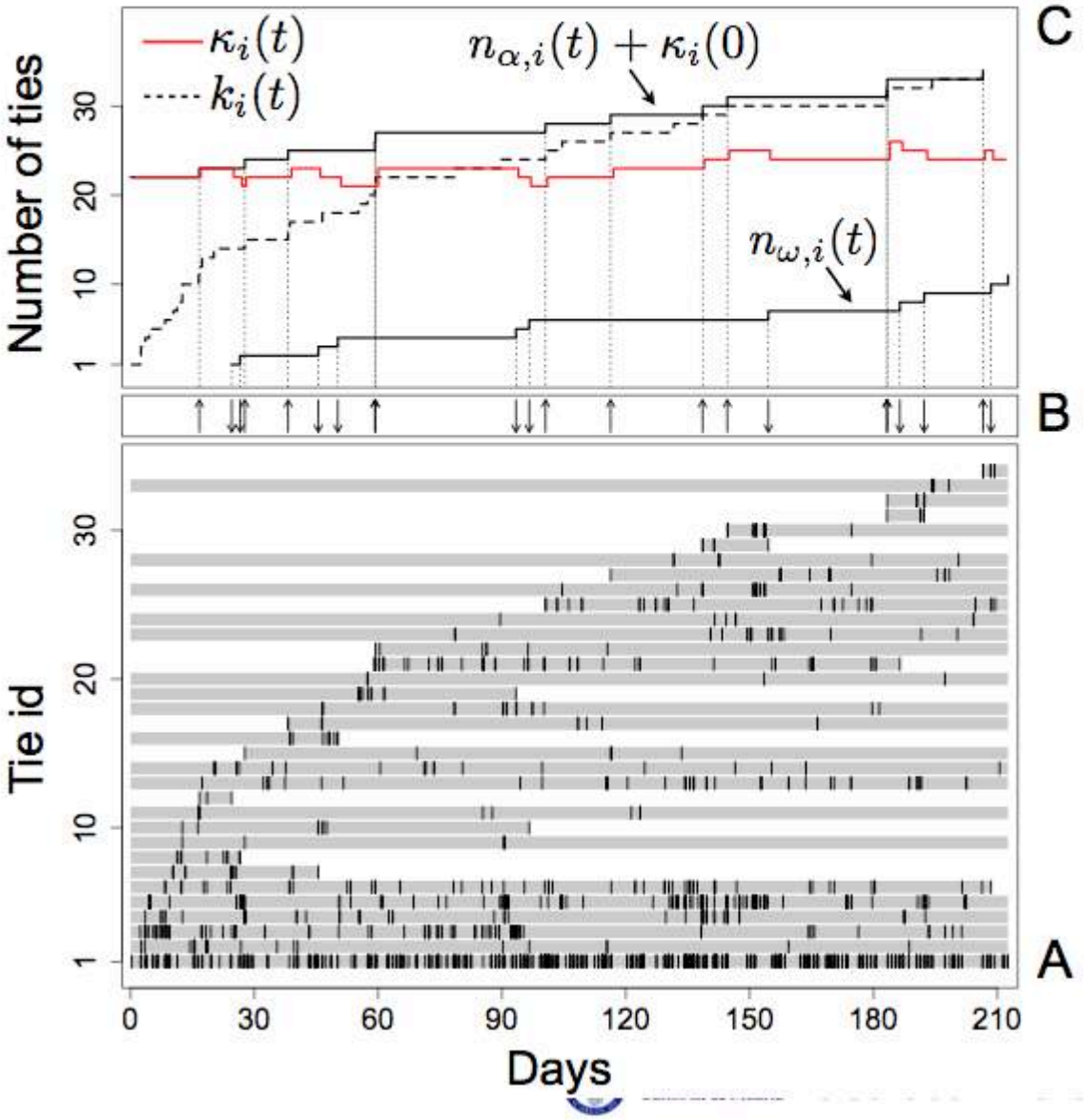
$$\kappa_i(t)$$

- Agg. Number of added/removed ties

$$n_{\alpha,i}(t) \quad \uparrow\uparrow\uparrow\uparrow$$
$$n_{\omega,i}(t) \quad \downarrow\downarrow\downarrow$$

- Thus

$$k_i(T) = \kappa_i(0) + n_{\alpha,i}(T)$$



Dynamical social strategy

- Very heterogeneous tie evolution
  - Mean

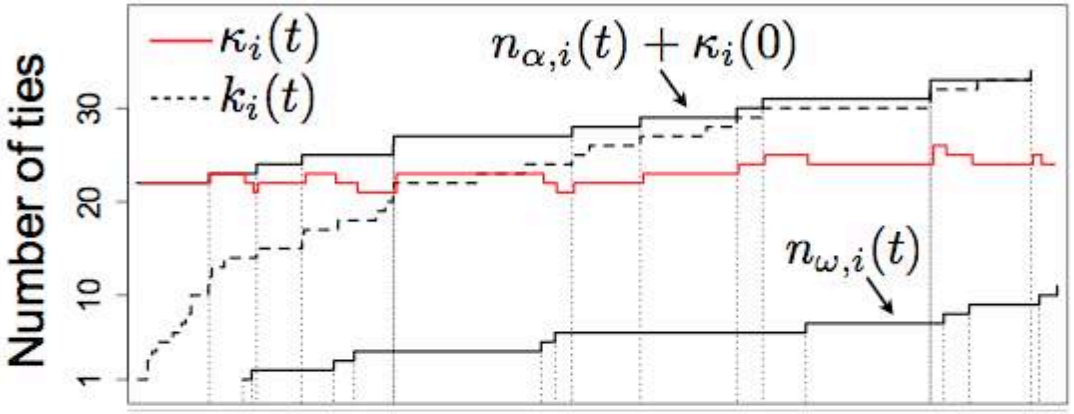
$$\langle n_{\alpha,i} \rangle \simeq \langle n_{\omega,i} \rangle \simeq 8$$
$$\langle k_i \rangle \simeq 16$$

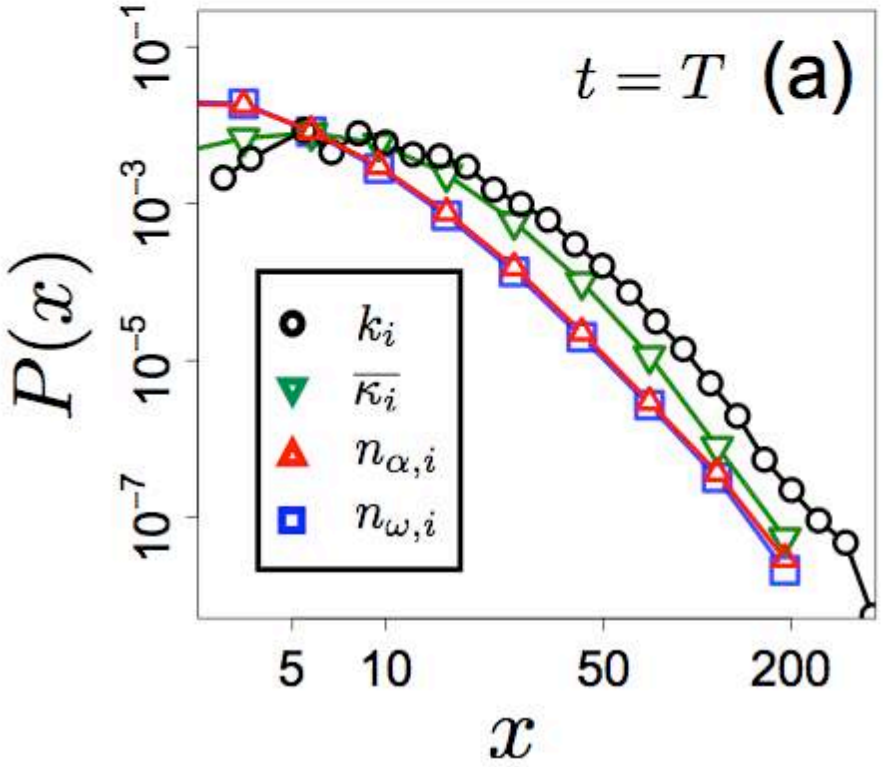
  - But

$$n_{\alpha,i} > 15$$

    for 20% of nodes

  - Aggregated connectivity typically overestimate sociability by 100%

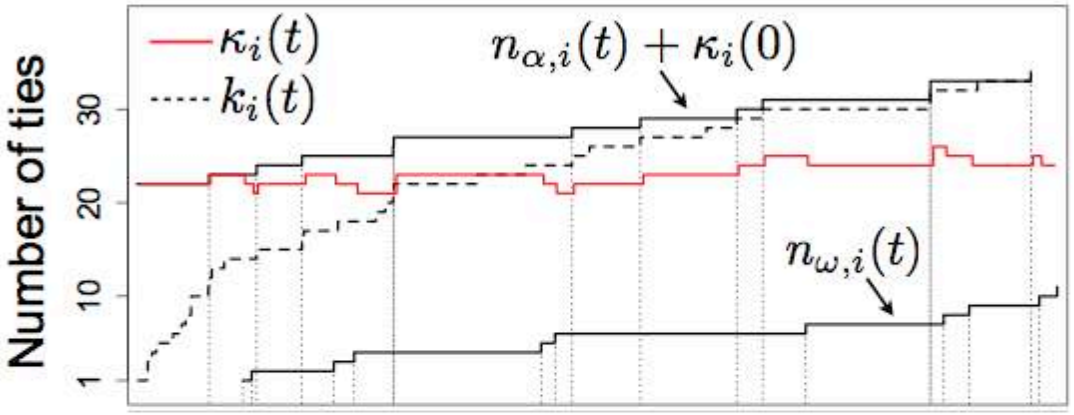




Dynamical social strategy

- Balanced tie formation/destruction

$$n_{\alpha,i} \simeq n_{\omega,i}$$

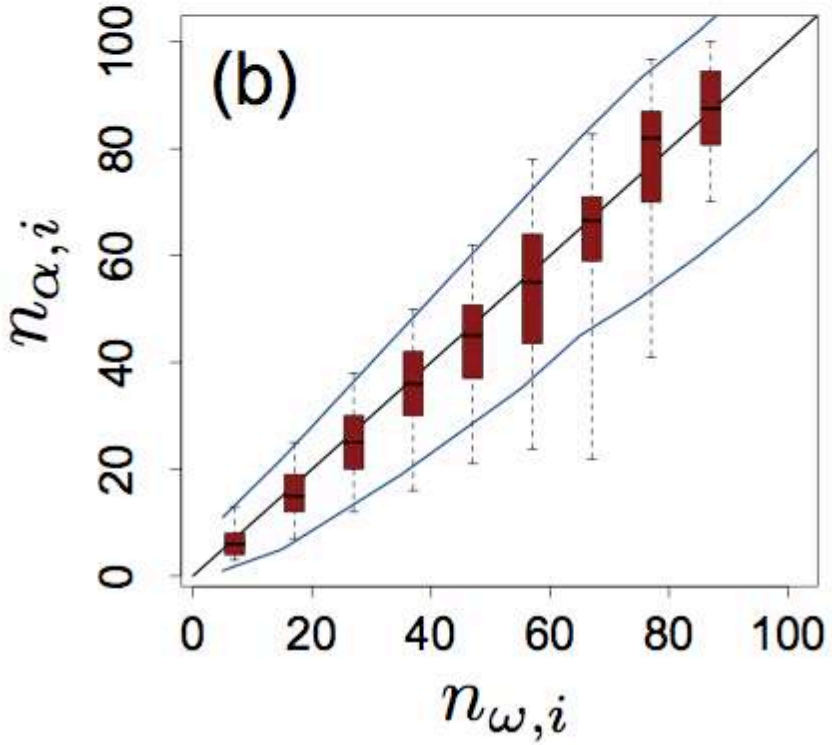


- Since

$$\kappa_i(T) = \kappa_i(0) + n_{\alpha,i}(T) - n_{\omega,i}(T)$$

- Thus

$$\kappa_i(T) \simeq \kappa_i(0)$$



Dynamical social strategy

- Linear tie formation/decay evolution
- For 80% of users we find

$$n_{\alpha,i}(t) \simeq \alpha_i t$$

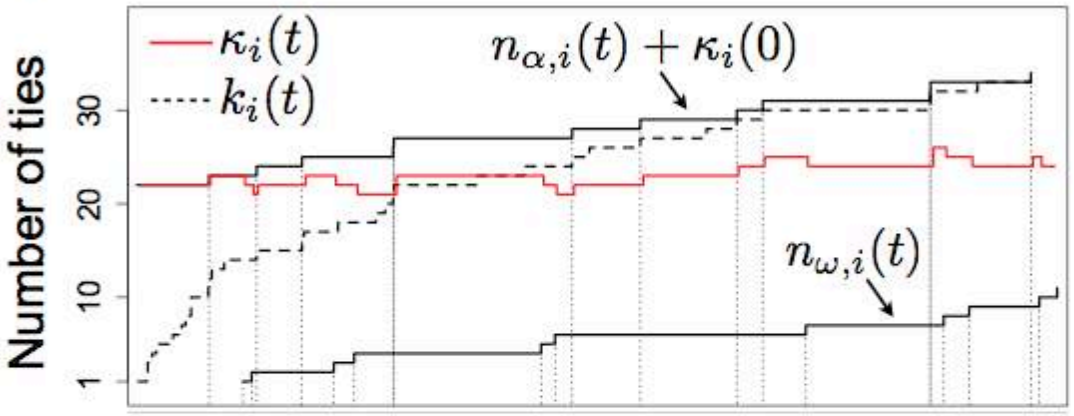
$$n_{\omega,i}(t) \simeq \omega_i t$$

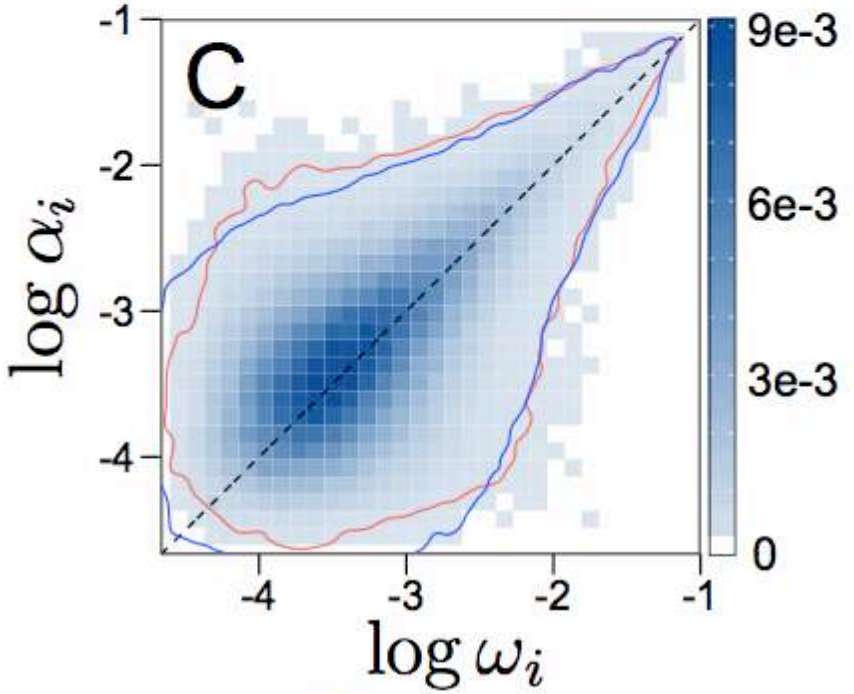
- And $\alpha_i \simeq \omega_i$
- Since

$$\kappa_i(t) = \kappa_i(0) + n_{\alpha,i}(t) - n_{\omega,i}(t)$$

- Thus

$$\kappa_i(t) \simeq \kappa_i(0)$$





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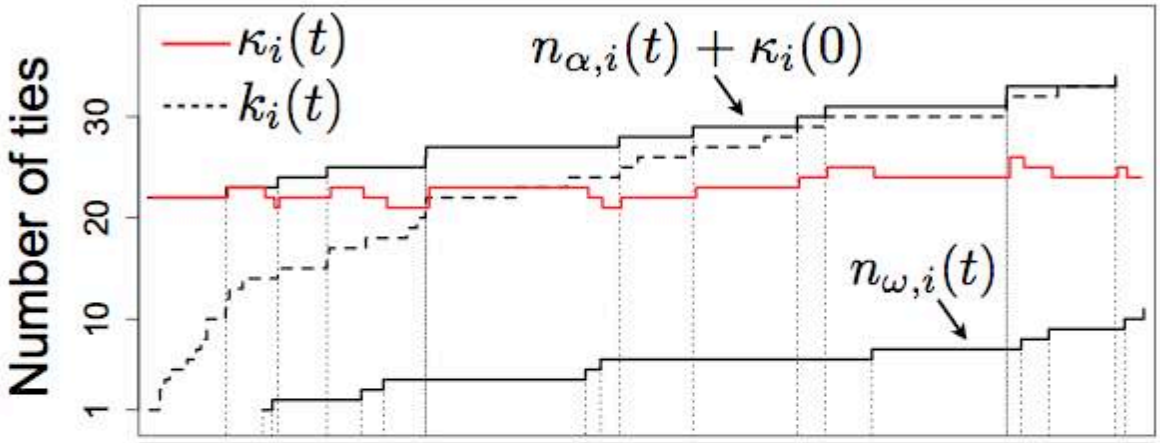
Dynamical social strategy

- Social capacity is conserved (or varies in a larger time scale)

$$\kappa_i(t) \simeq \overline{\kappa}_i$$

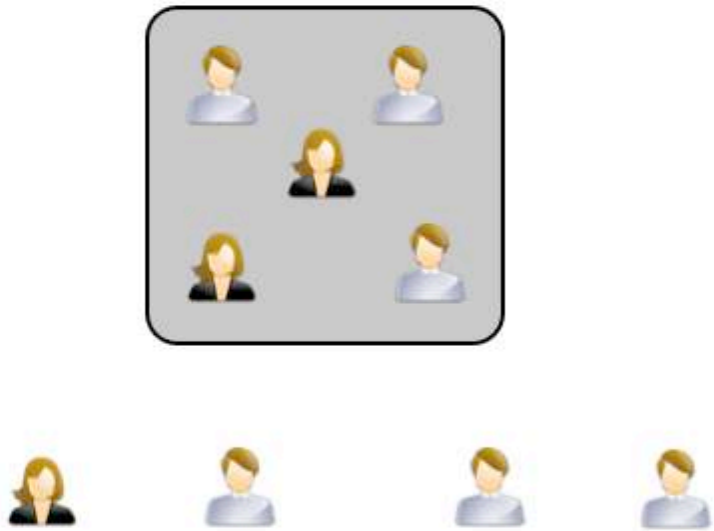
- Thus in a given time interval

$$k_i \simeq \overline{\kappa}_i + n_{\alpha,i}$$



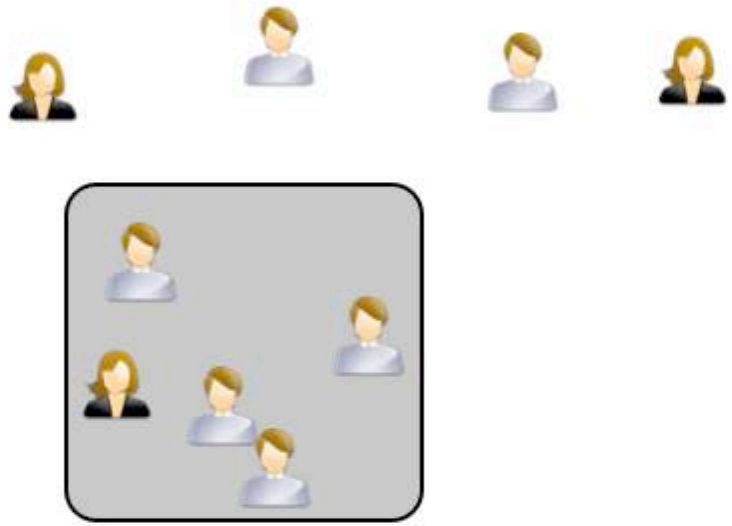
- Each individual strategy has two different dynamical properties
  - Social capacity $\overline{\kappa}_i$
  - Social activity $n_{\alpha,i}$ (or α_i)

Dynamical social strategy



- Dynamical Dunbar number?

Dynamical social strategy



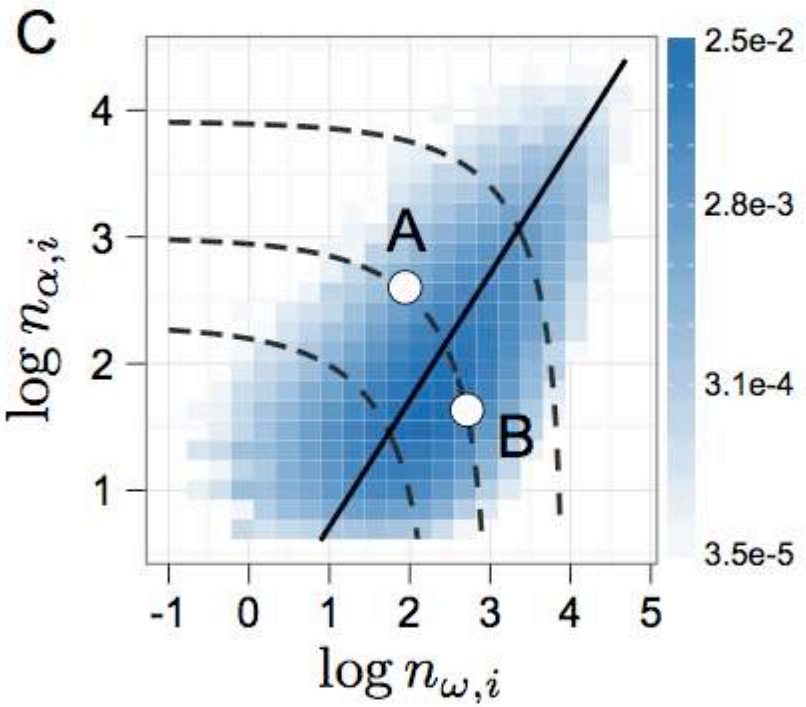
- Dynamical Dunbar number?

Characterizing dynamical social strategies

- Social capacity and activity are not independent

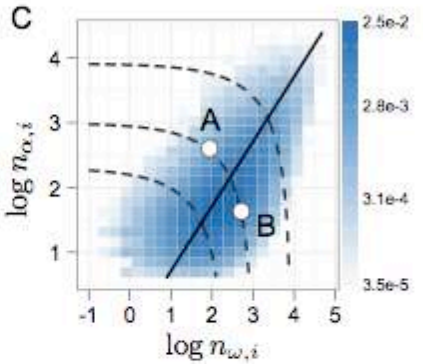
$$n_{\alpha,i} \propto \overline{\kappa}_i$$

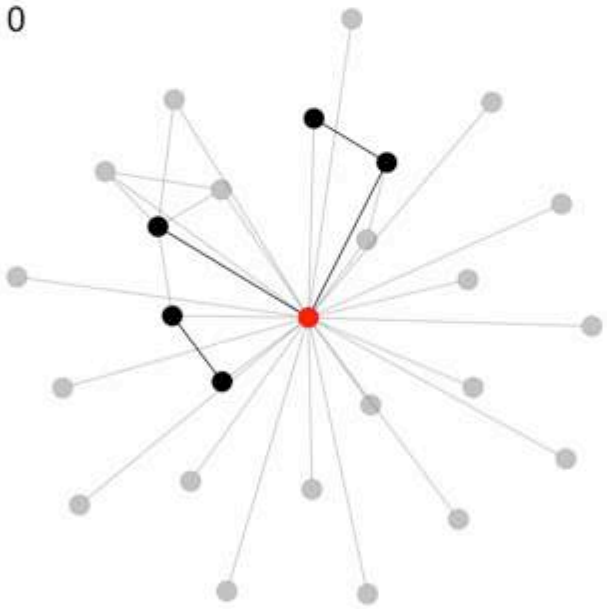
- For a given k_i we have
  - Social wanderers **(3)** $n_{\alpha,i} \gg \overline{\kappa}_i$
  - Balanced **(2)** $n_{\alpha,i} \simeq \overline{\kappa}_i$
  - Social keepers **(1)** $n_{\alpha,i} \ll \overline{\kappa}_i$



Characterizing dynamical social strategies

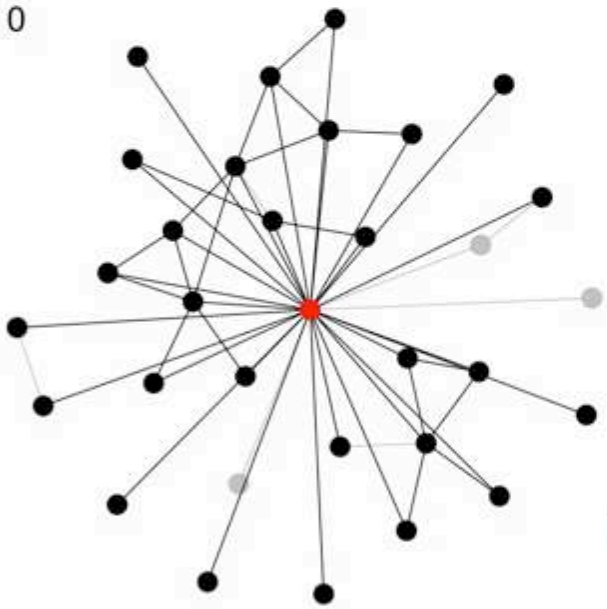
- Social explorers are socially more diverse
- Social keepers have larger (aggregated) clustering





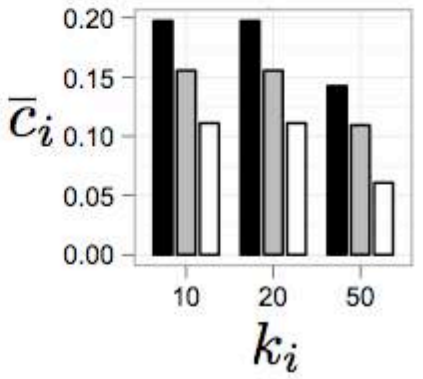
$n_{\alpha,i} = 23, \overline{\kappa}_i = 4$

Social explorer



$n_{\alpha,i} = 3, \overline{\kappa}_i = 24$

Social keeper



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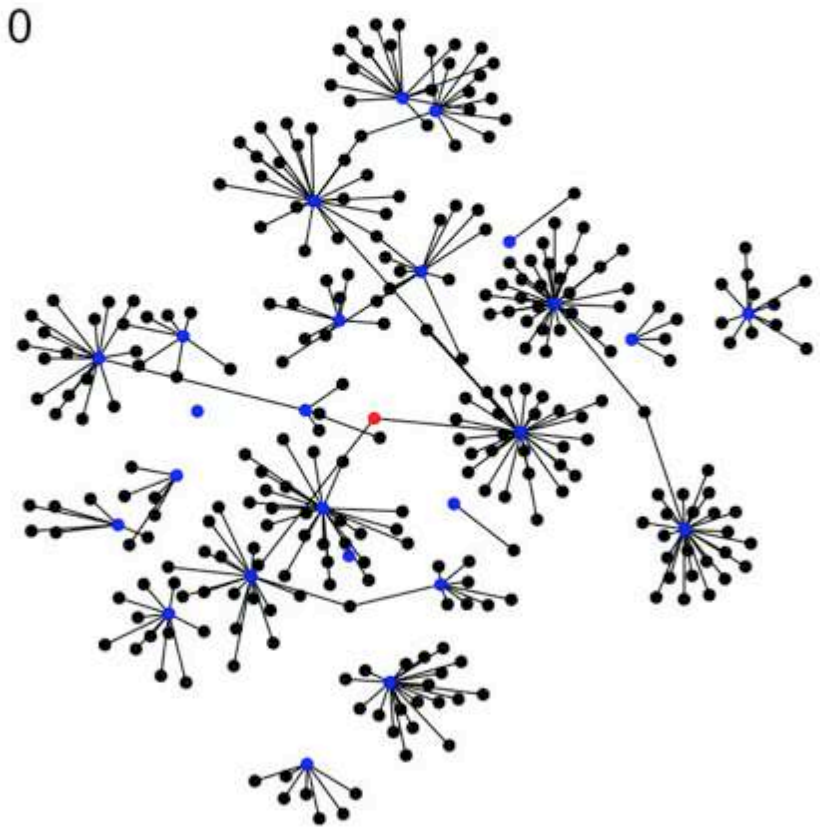
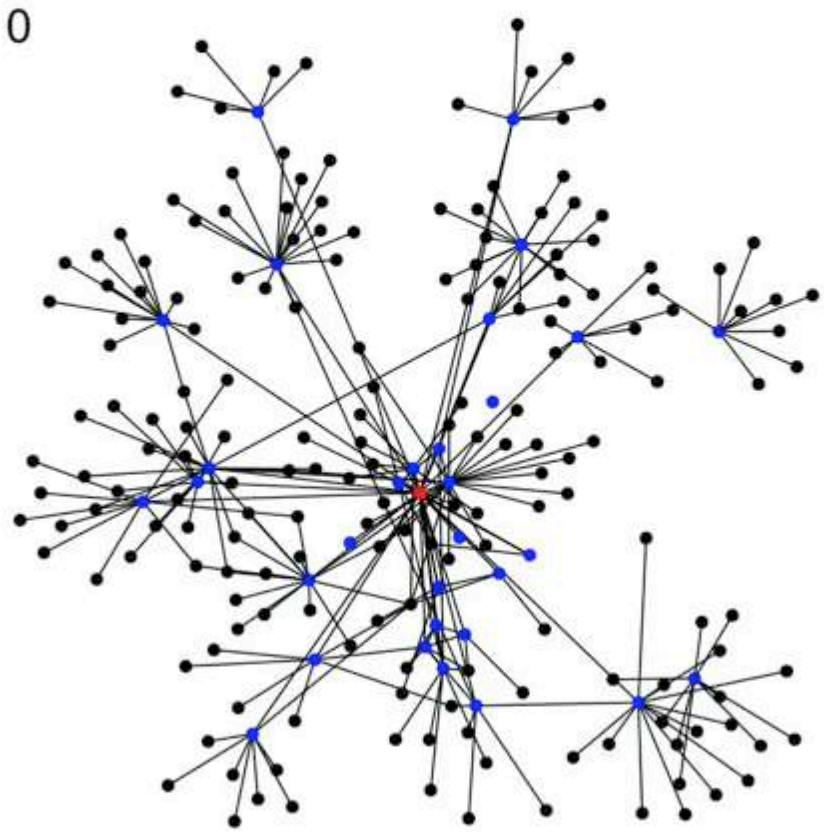
Characterizing dynamical social strategies

- Dynamical social strategies are assortative



Social explorer



Social keeper

Characterizing dynamical social strategies

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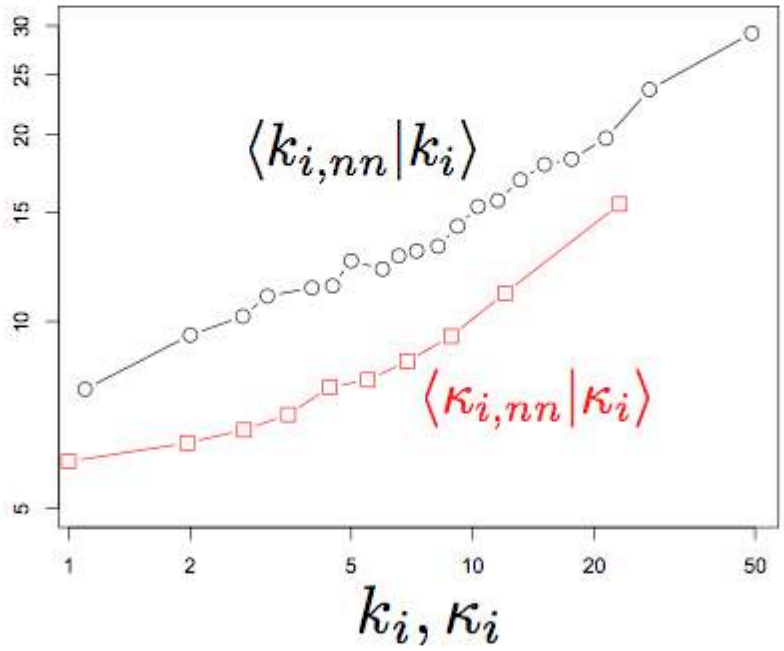
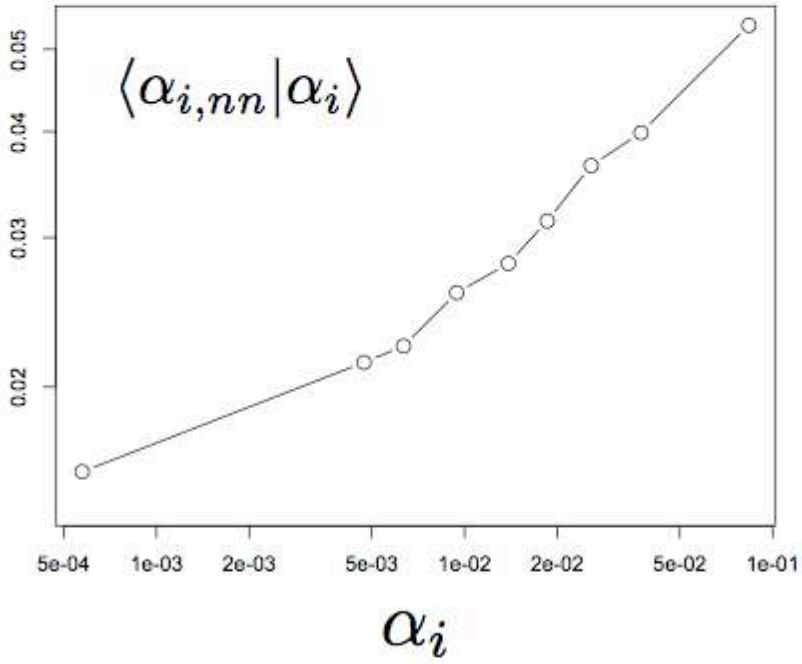


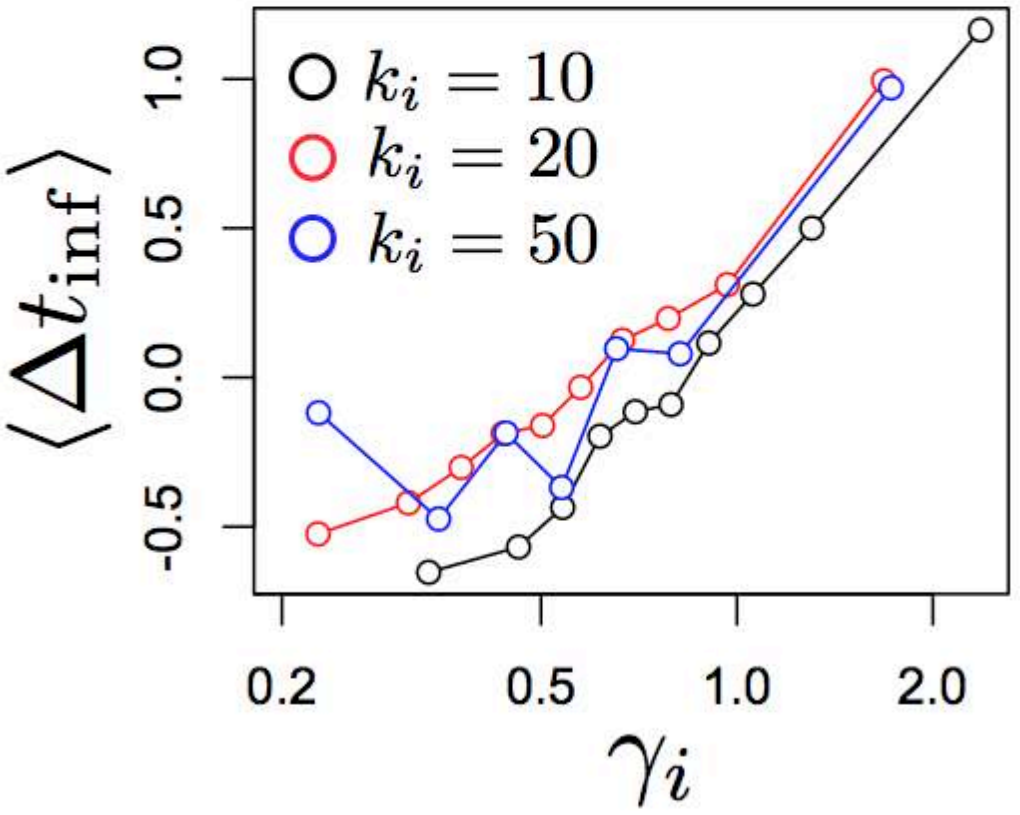
Social explorer



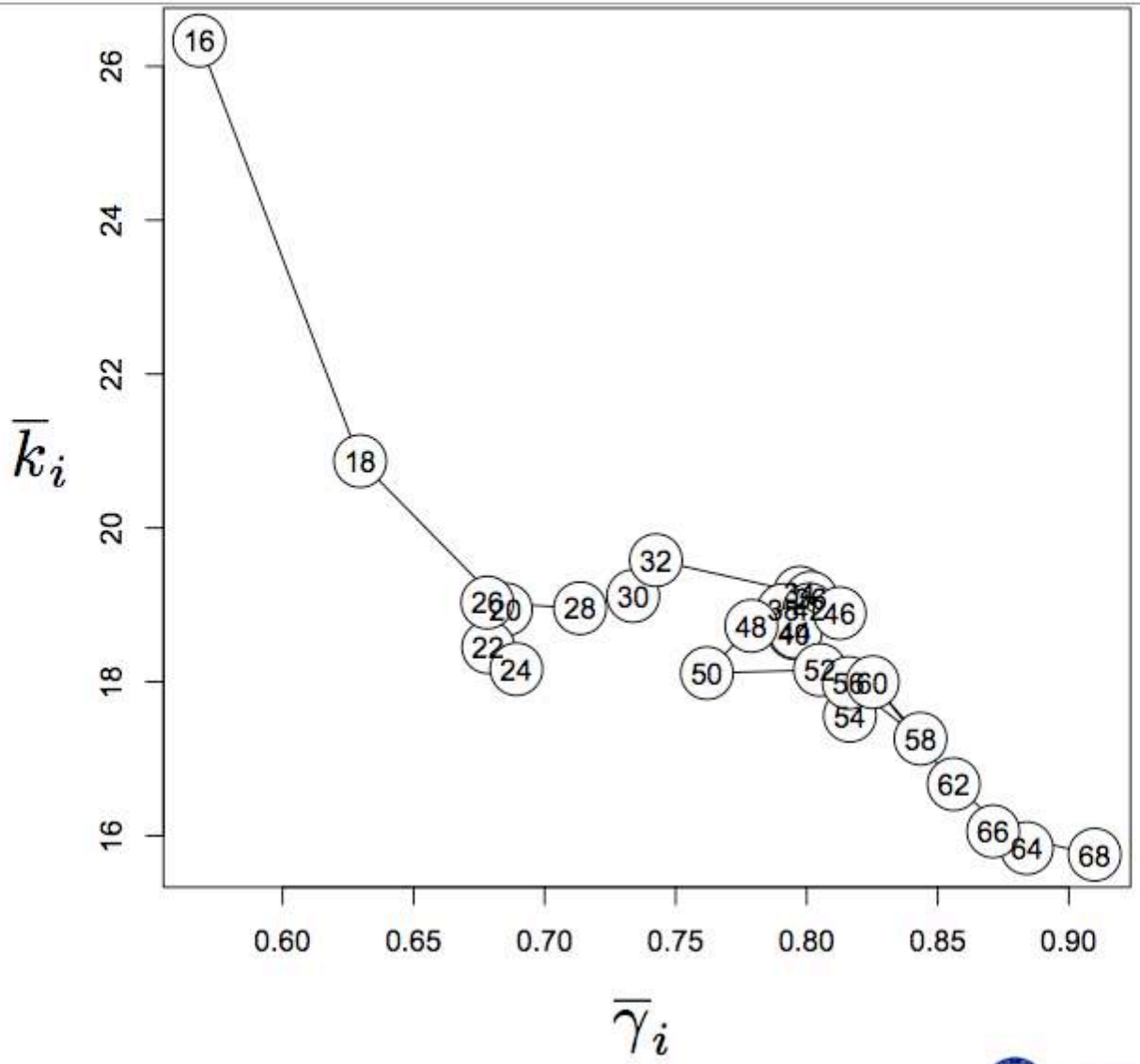
Social keeper

Characterizing social dynamical strategies

- Which strategy is better to get aware of information
- SI model using random seeds
- We measured the time to infection



Life-time trajectories



Summary

- There is no such a thing as observed social connectivity
  Observed connectivity is a result of
  - Social Capacity
  - Social activity
  - An thus depends on: time window, data, defintion of links, etc.
- Users have different dynamical social strategies
  - Social wanderes (activity >> capacity)
  - Social balanced (activity = capacity)
  - Social keepers (activity << capacity)
- Dynamical social strategies are assortative and change with age
- Best strategy to get aware of information is to be a social keeper

Summary

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Which one are you?

- Dynamical social strategies are assortative and change with age
- Best strategy to get aware of information is to be a social keeper