Dynamics of communication

in a mobile phone social network

- first results

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Social networks: from friendships to the scale of societies

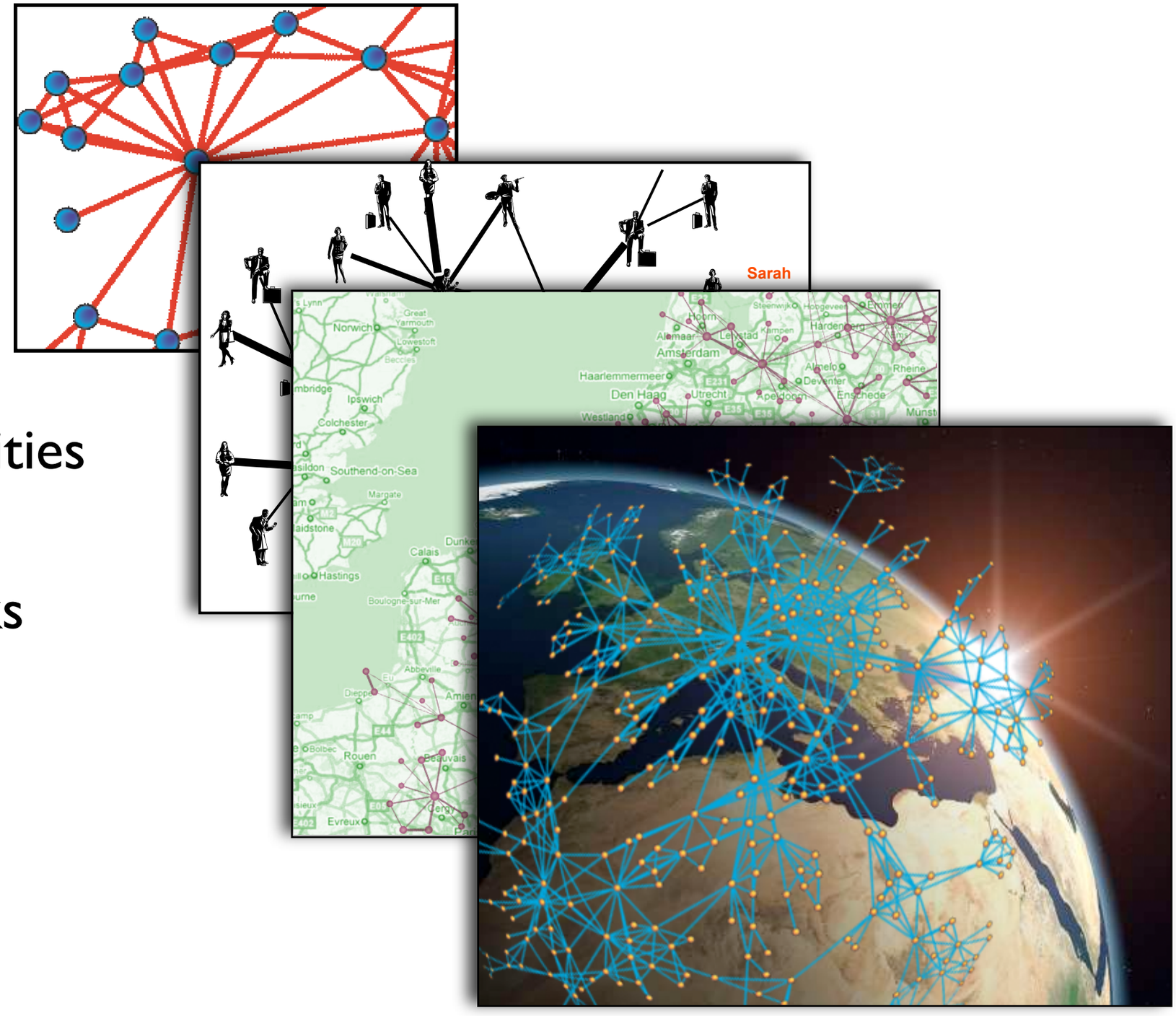
friendships

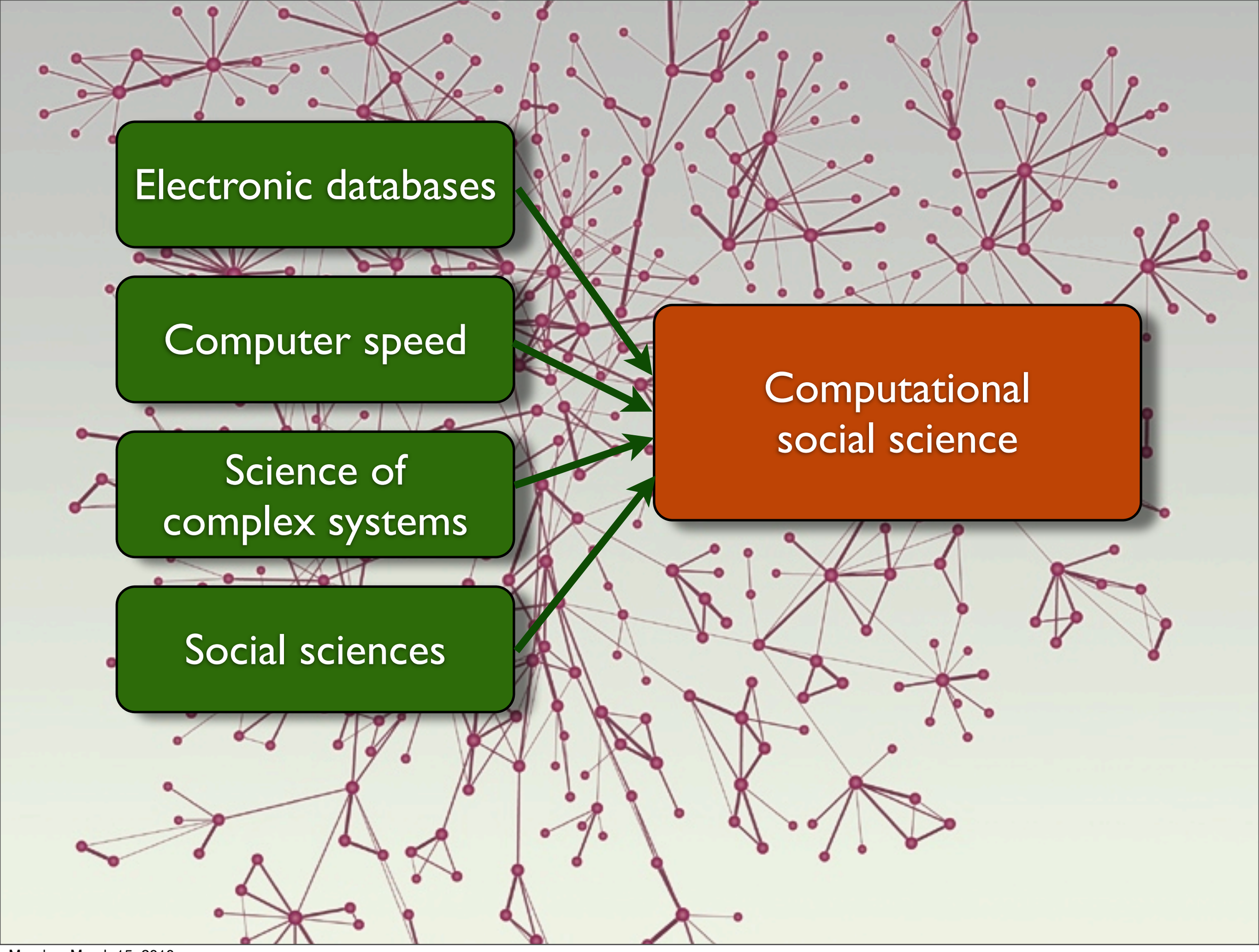
groups, communities

networks of communities

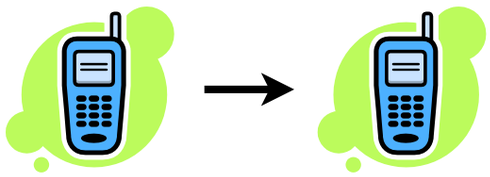
societal-level networks

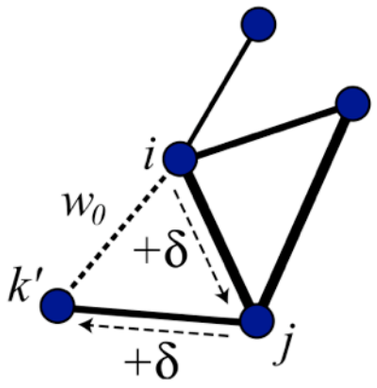
world-wide networks

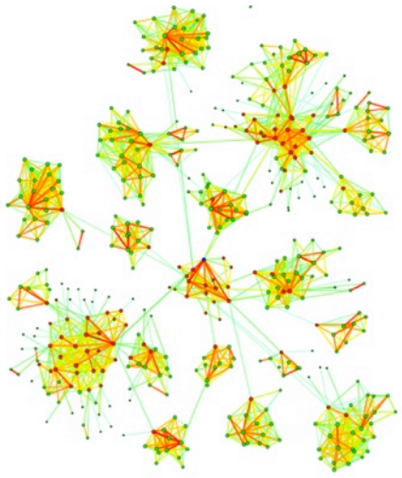


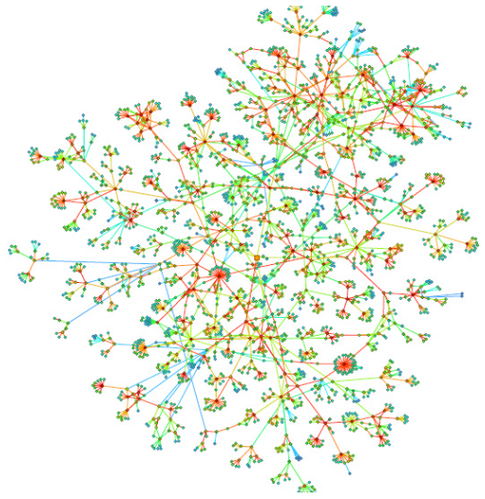

Electronic databases
Computer speed
Science of complex systems
Social sciences
Computational social science

Time scales in social networks



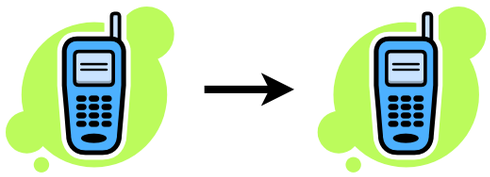


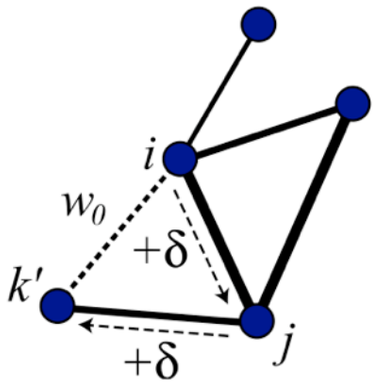


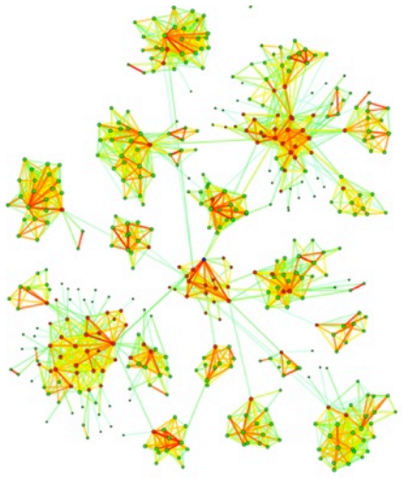


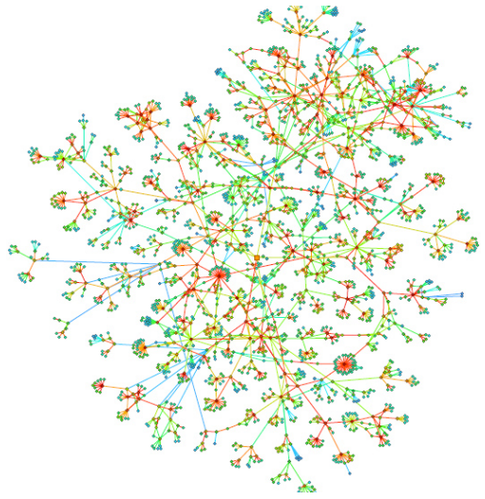
Social interaction events → Dynamics of ties → Dynamics of groups → Network-level dynamics

Time scales in social networks









Social interaction events ⇨ Dynamics of ties ⇨ Dynamics of groups ⇨ Network-level dynamics

"How does the microscopic translate into the macroscopic?"

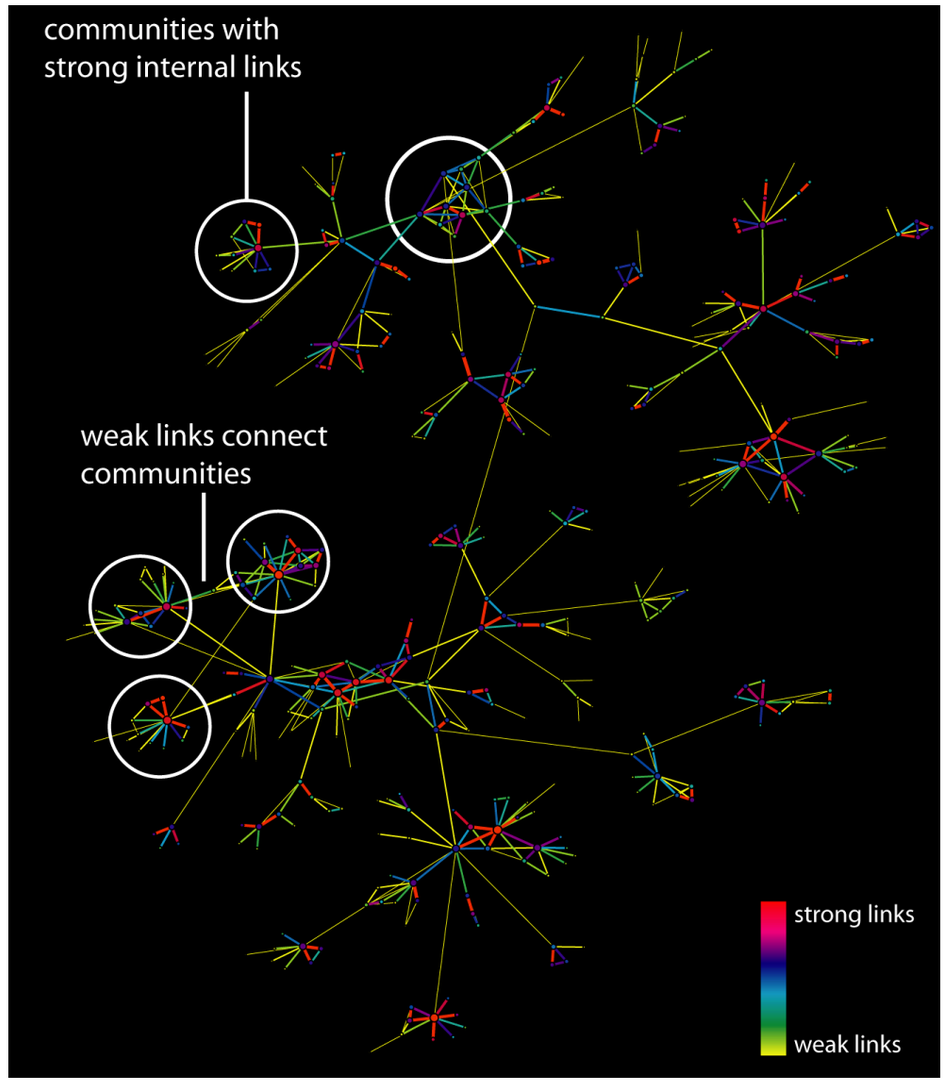
New possibilities for research

- **Individual social interaction events = the "atoms" of human relationships**
- Electronic databases where interactions (calls, emails, etc) are time-stamped allows studying the dynamics of these atoms
- From a macroscopic point of view, how do the dynamics of communication events affect the whole social network?

Our data

- **Mobile telephone call records of ~7 million individuals**
  - Caller/callee, SMS sender/recipient
  - Time stamp
  - Only customers in the operator's base (market share ~20%)
  - **ANONYMIZED**

- **Earlier network observations:**
  - Weak links crucial for connectivity
  - Strong links associated with dense neighbourhoods (communities)
  - This structure slows down information spreading



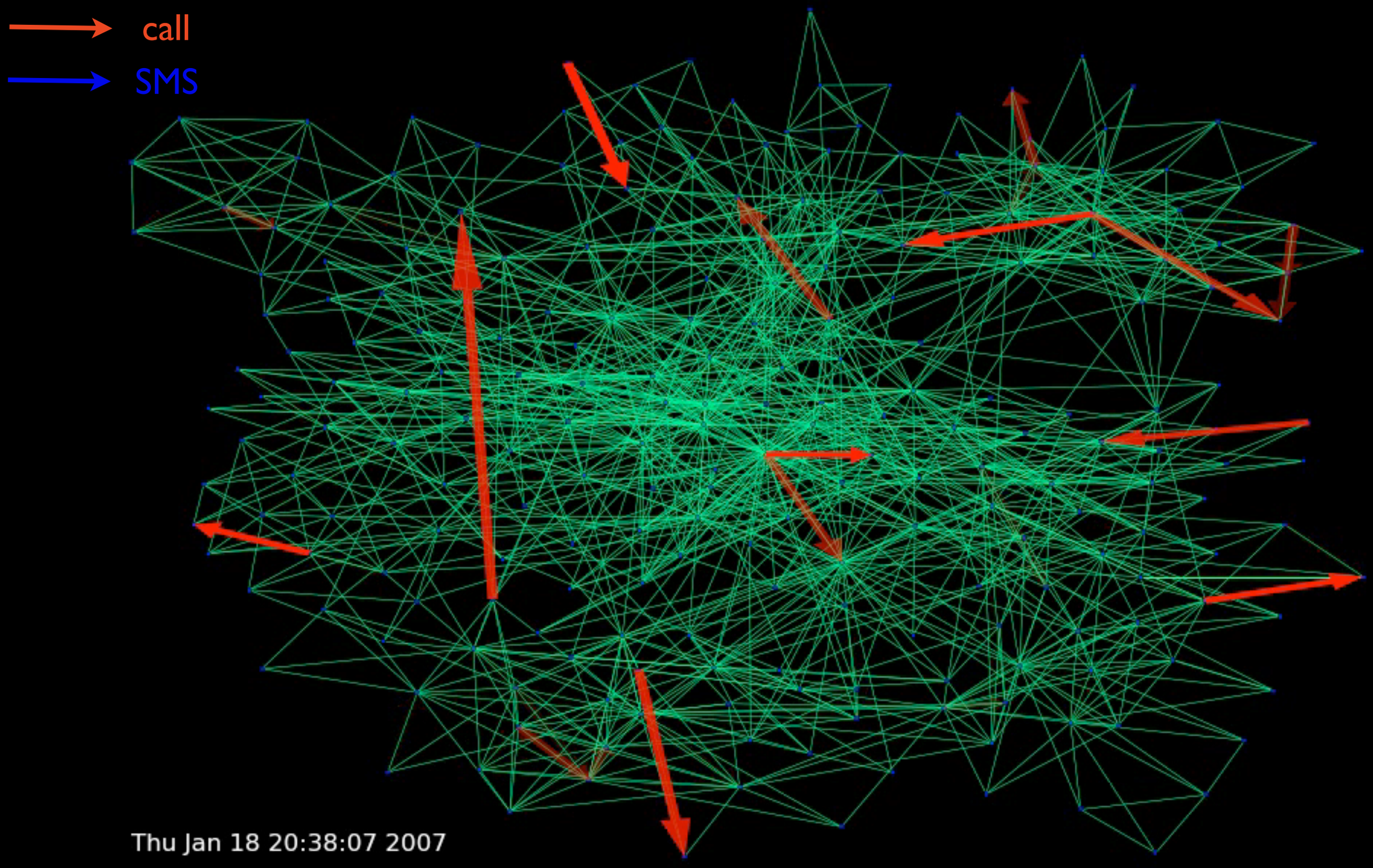
- Proc. Natl. Acad. Sci (USA) **104**, 7332 (2007), New J. Phys. **9**, 179 (2007)

Calls and text messages within a social group

call

SMS

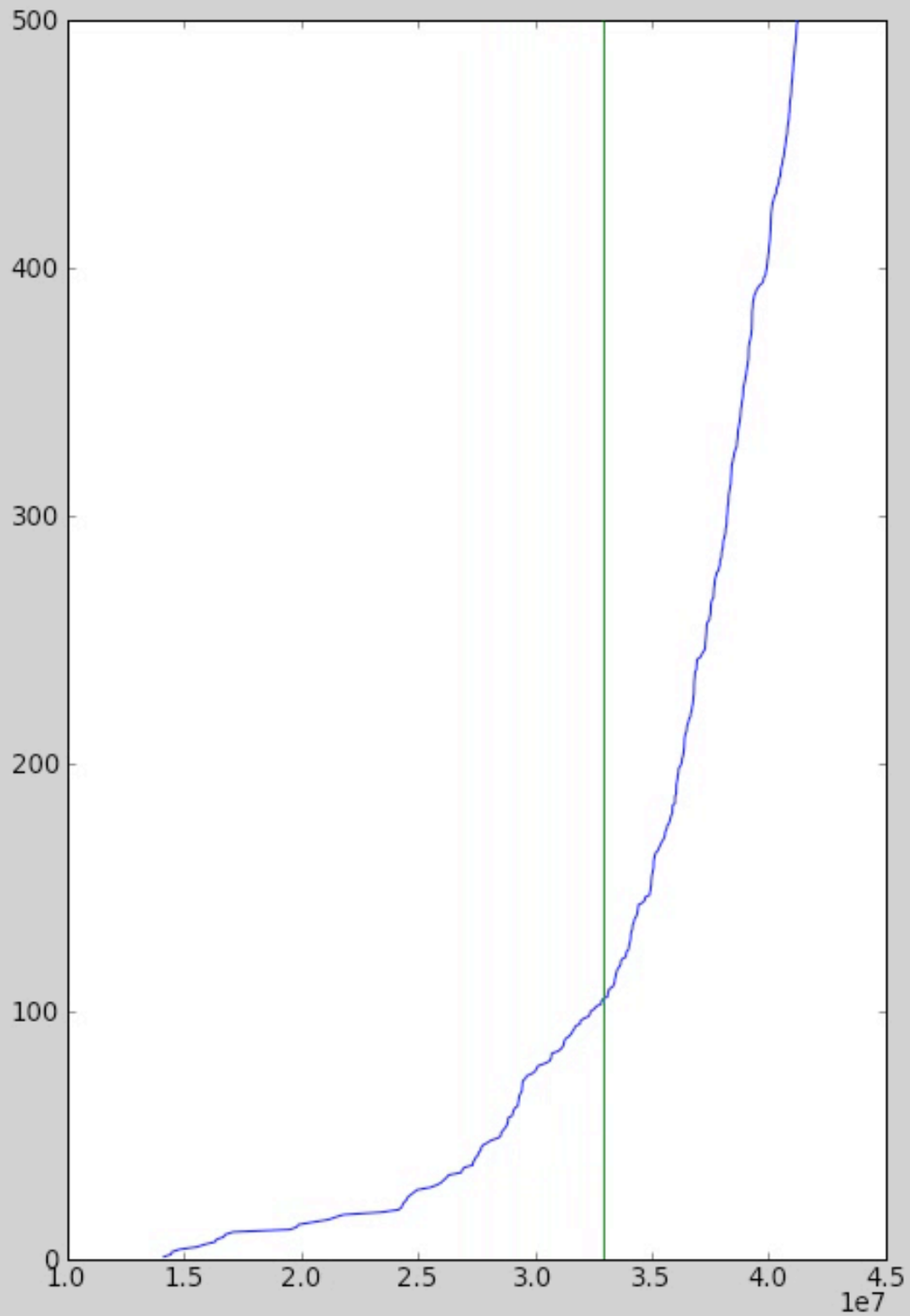
Calls and text messages within a social group



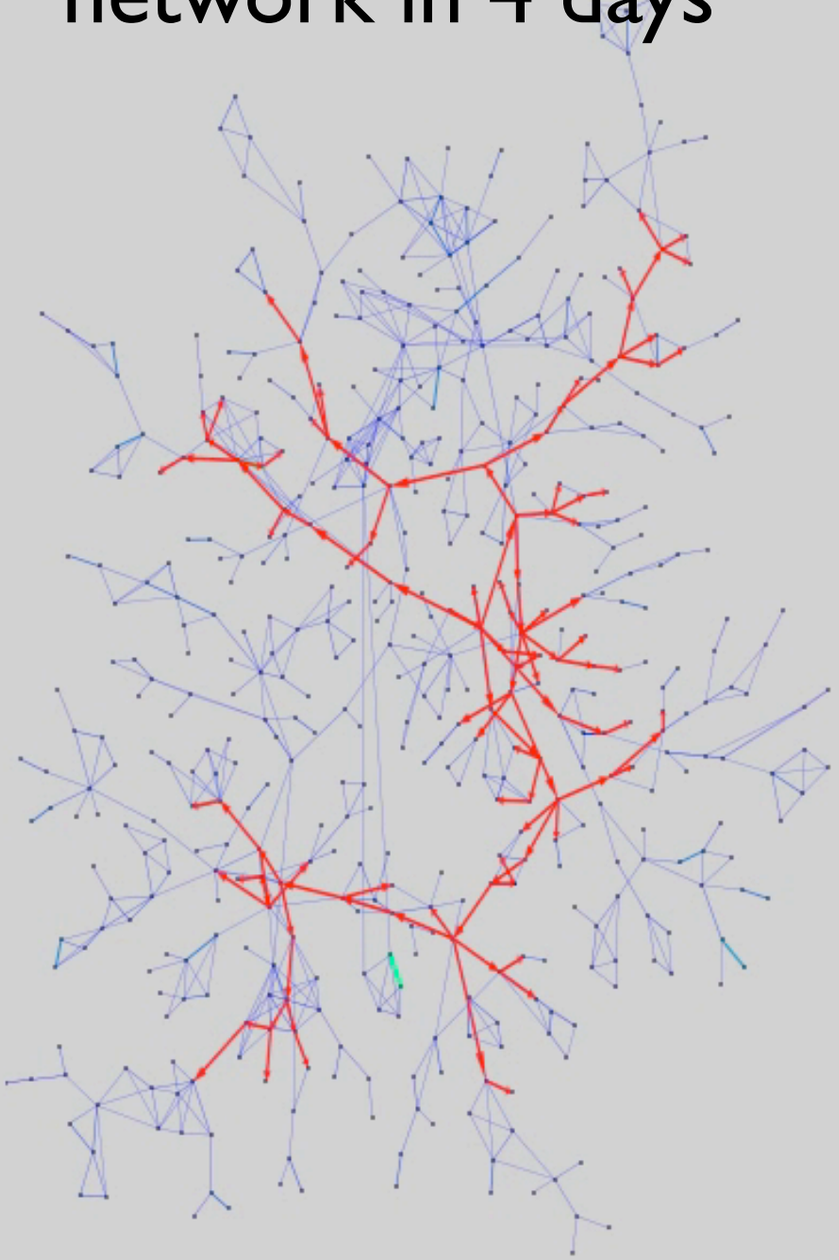
Simulation: rumour spreading in part of the network

"The rumour" spreads through this part of the network in 4 days

Simulation: rumour spreading in part of the network



"The rumour" spreads through this part of the network in 4 days



Ongoing work: motivation

- Focus on dynamics of "social atoms", i.e. individual calls and text messages

- Detect and characterize short-time-scale patterns and correlations

- Begin with the level of individuals

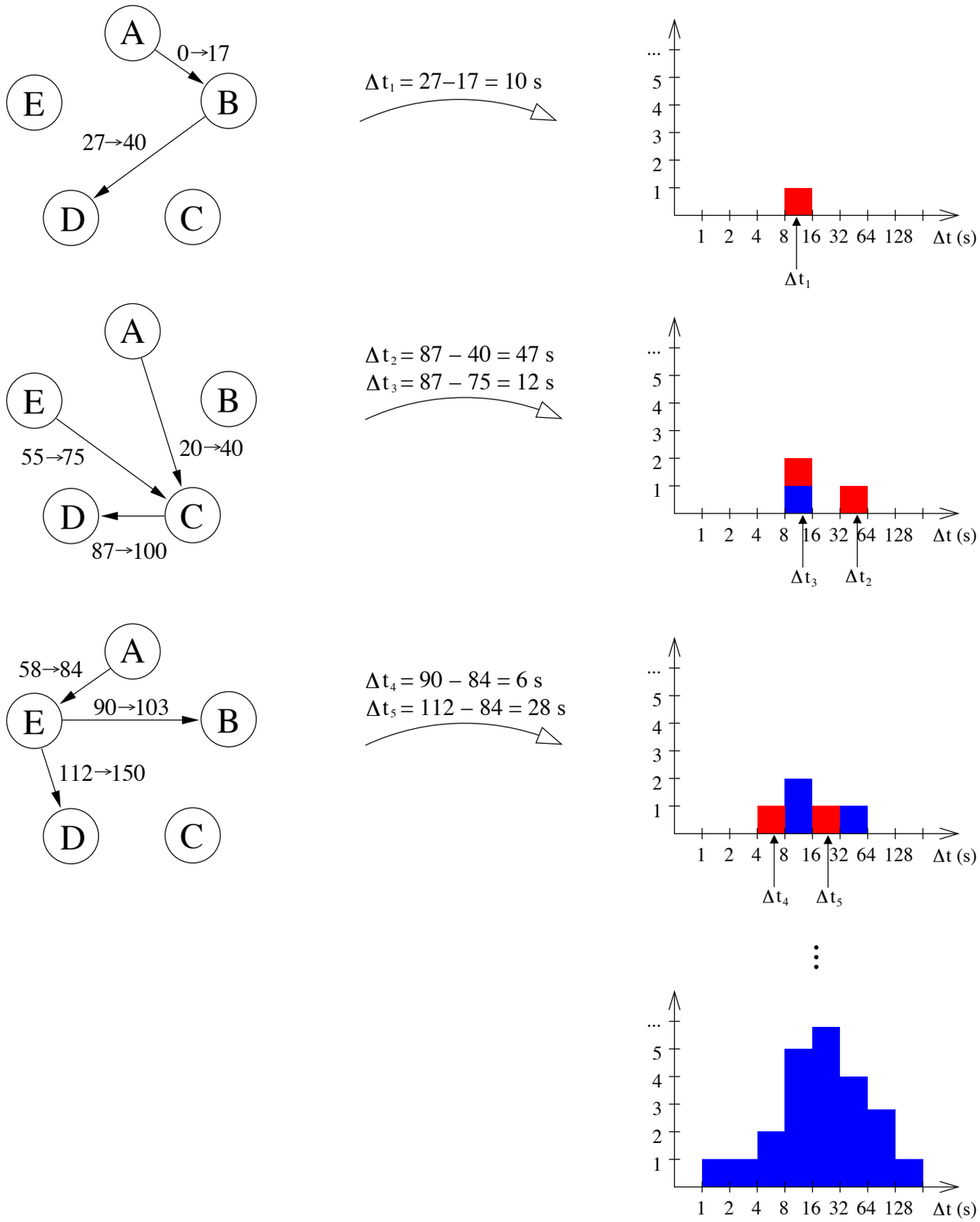
- Then link observations to group structure and dynamics

- Also link observations to network-scale dynamics

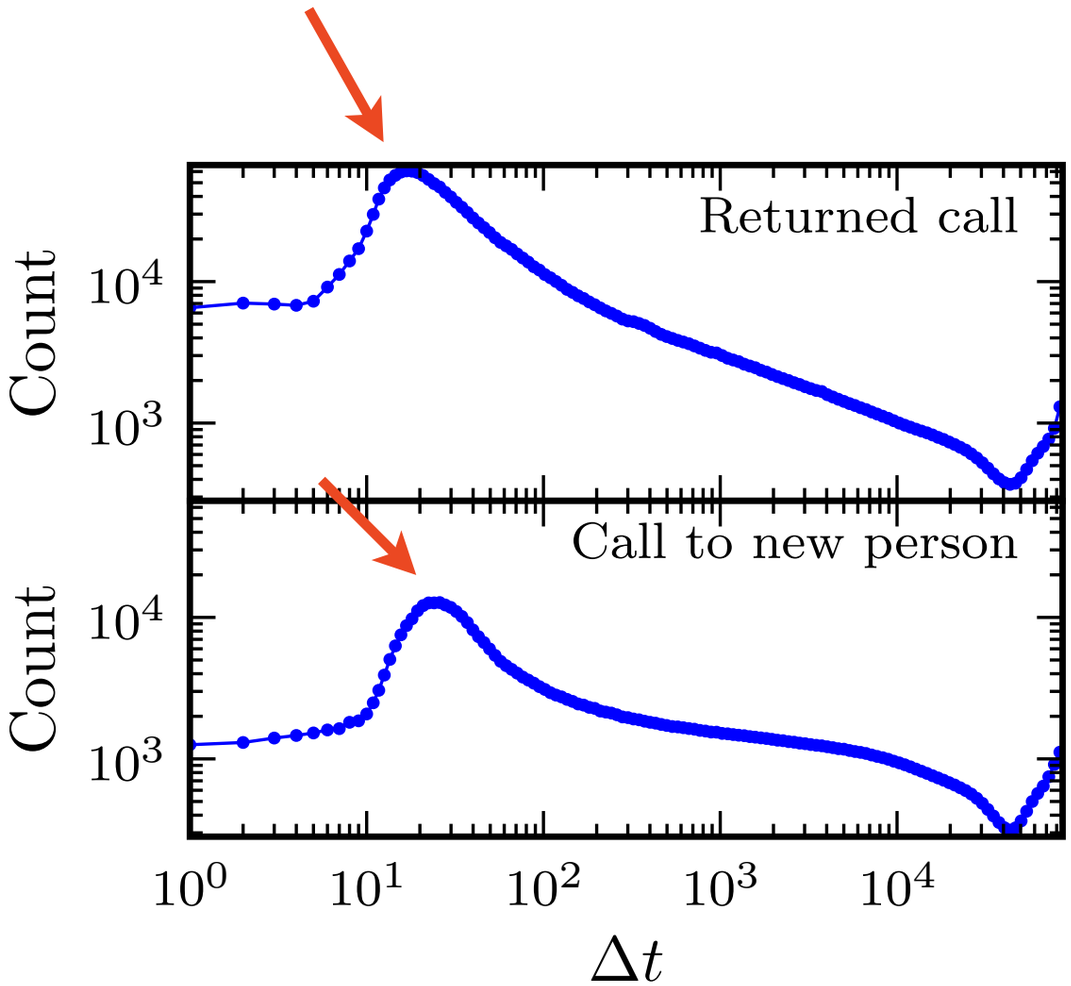
Q1:
Are the actions of individuals related?

Action triggers

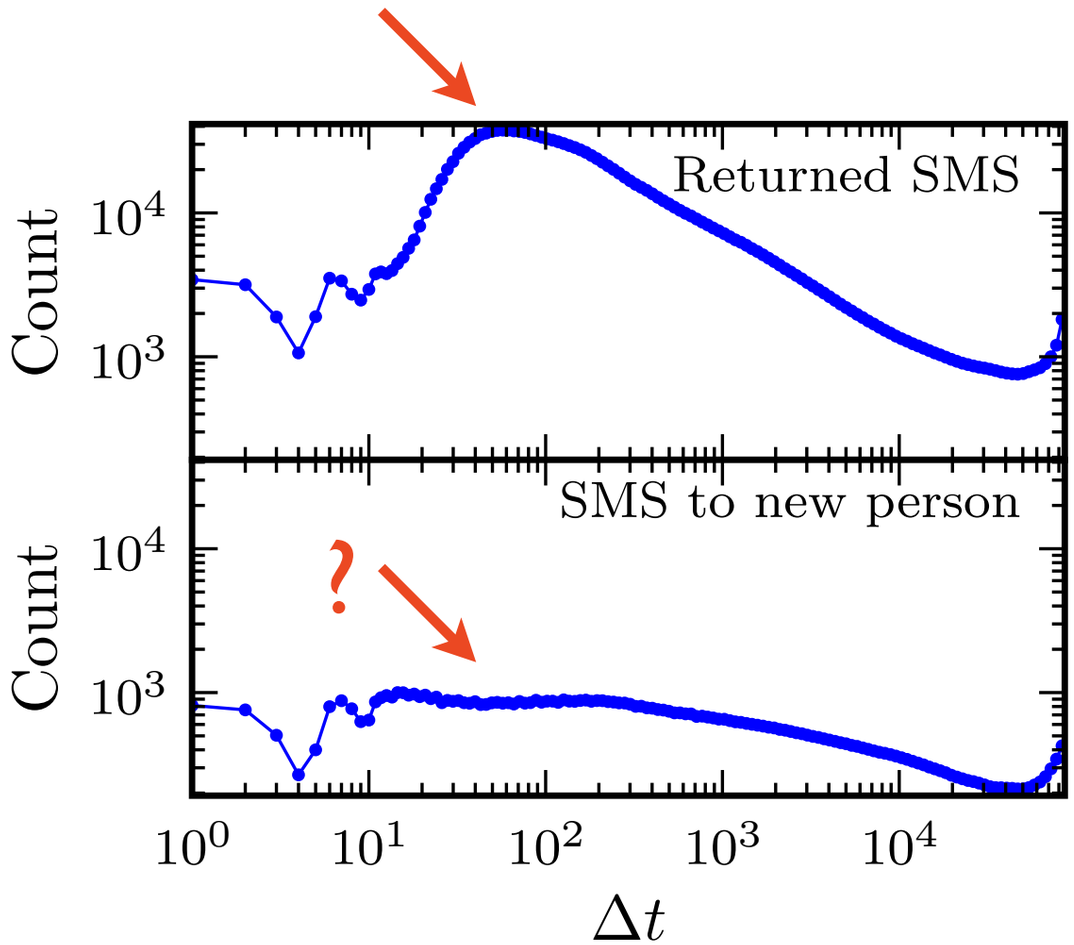
- Motivation: detect "causal" chains of A calling B, who then calls A or C
- Construction:
  i) take an outgoing event (t=t_2),
  ii) take earlier incoming event(s) (t=t_1),
  iii) increase event counter at $\Delta t = t_2 - t_1$
- Do this for all outgoing events



Action triggers: results

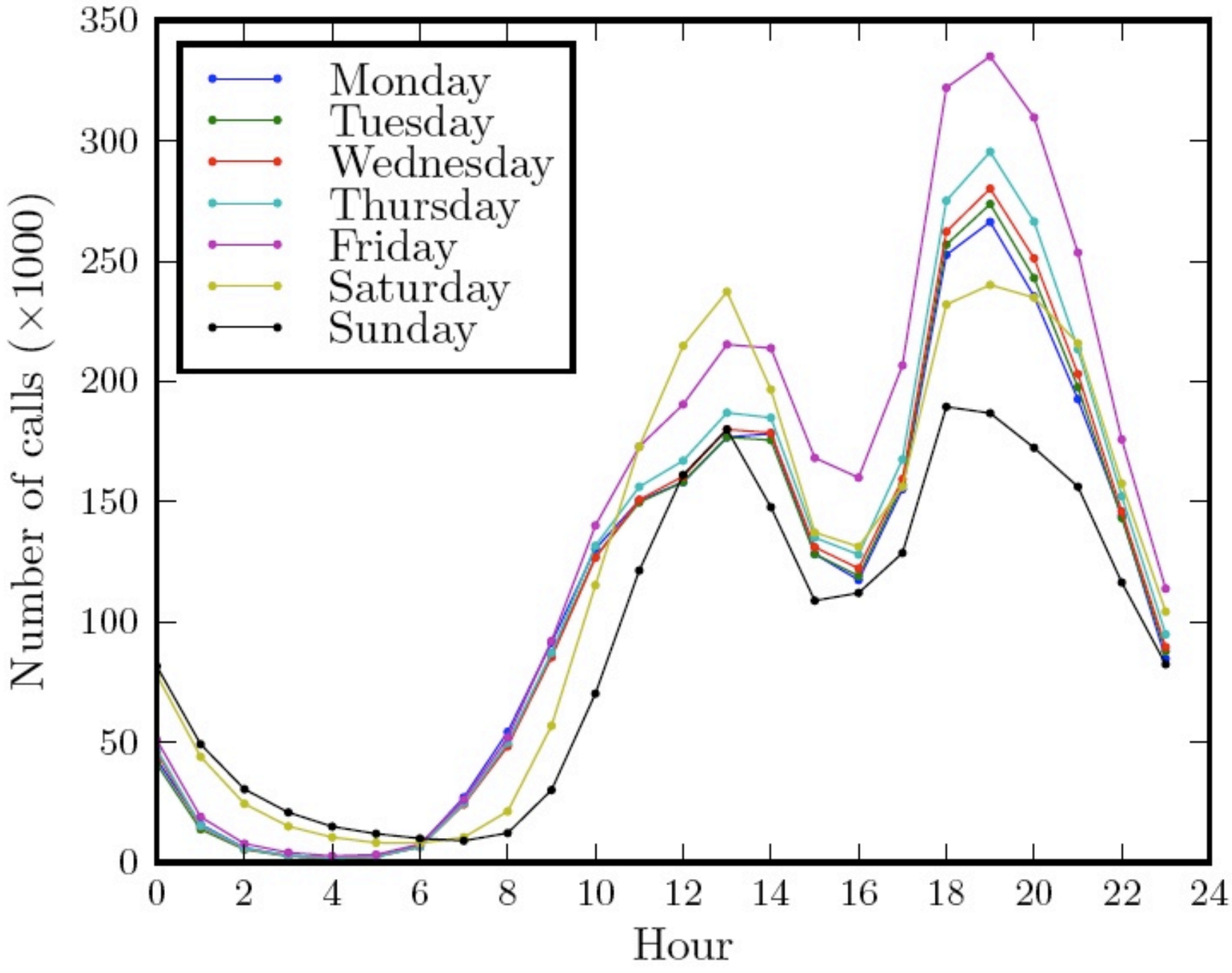


Calls trigger calls,
peak ~ 20 - 30 seconds



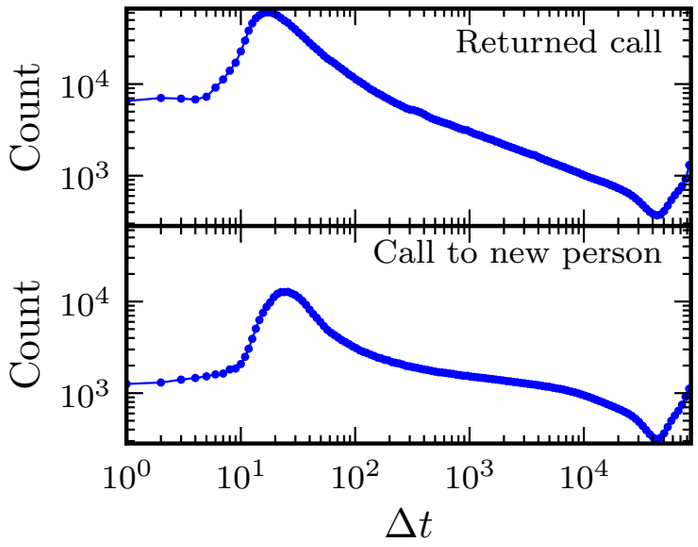
Txt msgs mainly trigger
returned msgs

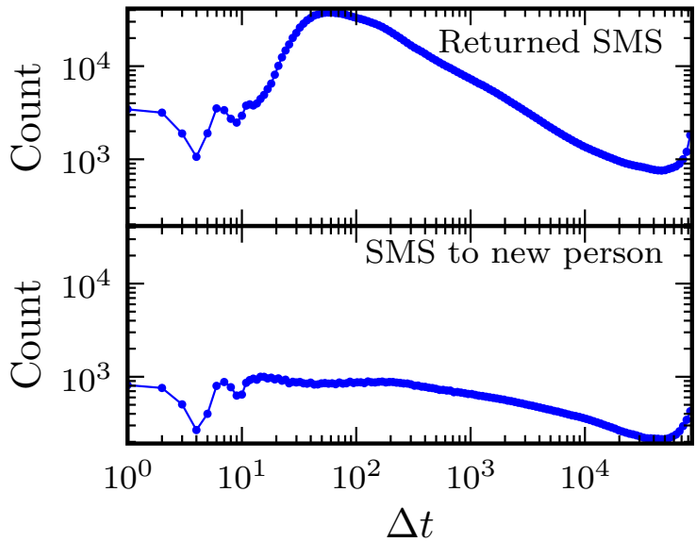
Daily variations: a possible cause?



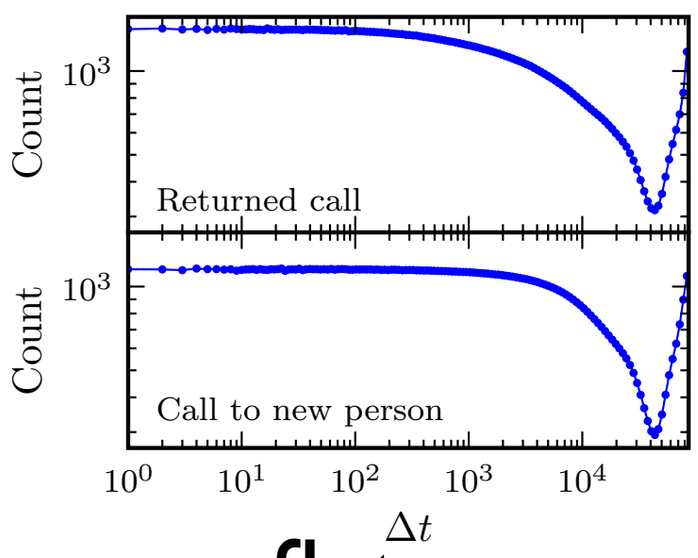
Action triggers: reference

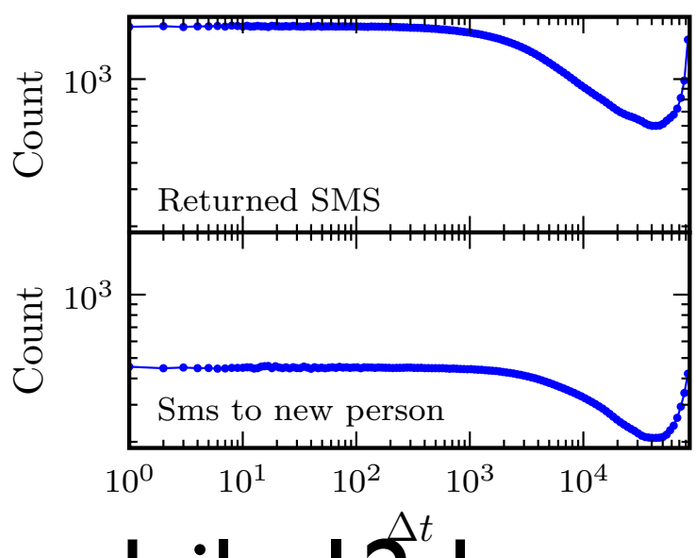
Actual





Reference: days randomized, times kept





References flat except for daily 12-hour-cycle so daily patterns are not the cause.

Further observations

- There is a statistically significant number of patterns involving many phone users: A calls B calls C calls A etc
- One can view these patterns (ABCA etc) as evidence of information being processed and transmitted in the network
- Such patterns have very important effects on HOW information flows through the network
- ...details to be published later...

Q1:
Are the actions of individuals related?

Yes, incoming calls/texts trigger outgoing calls/texts in very short time

Q2:
Are social ties balanced in terms of communication?

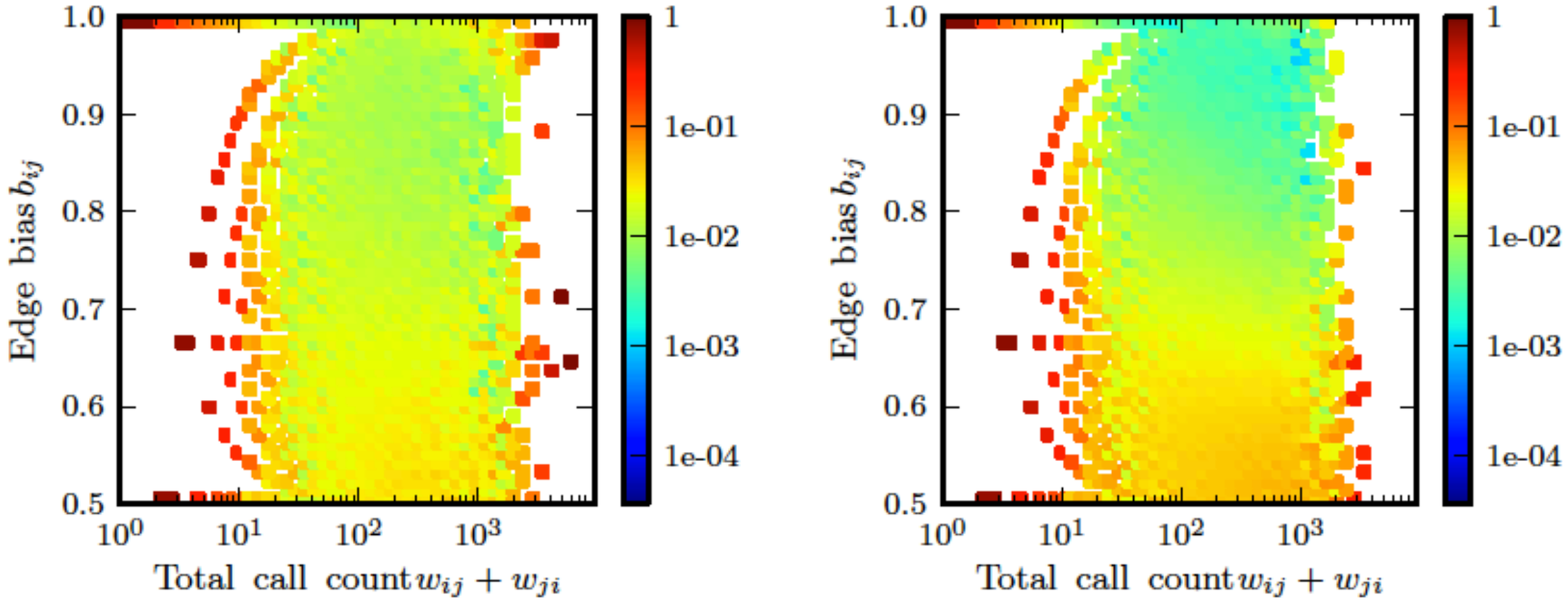
Reciprocity of ties

- In a social relationship, who initiates communication?
- Does one party call the other more frequently than the other?
- Define w_{ij} as the # of calls from i to j, and w_{ij} as the # of calls from j to i
- The *bias* of a tie can be written as

$$b_{ij} = \frac{w_{ij}}{w_{ij} + w_{ji}}$$

Reciprocity of mobile phone calls, L. Kovanen, J. Saramäki, and K. Kaski, *Dynamics of Socio-Economic Systems*, in press (2010), arXiv:1002.0763

Reciprocity of ties: bias

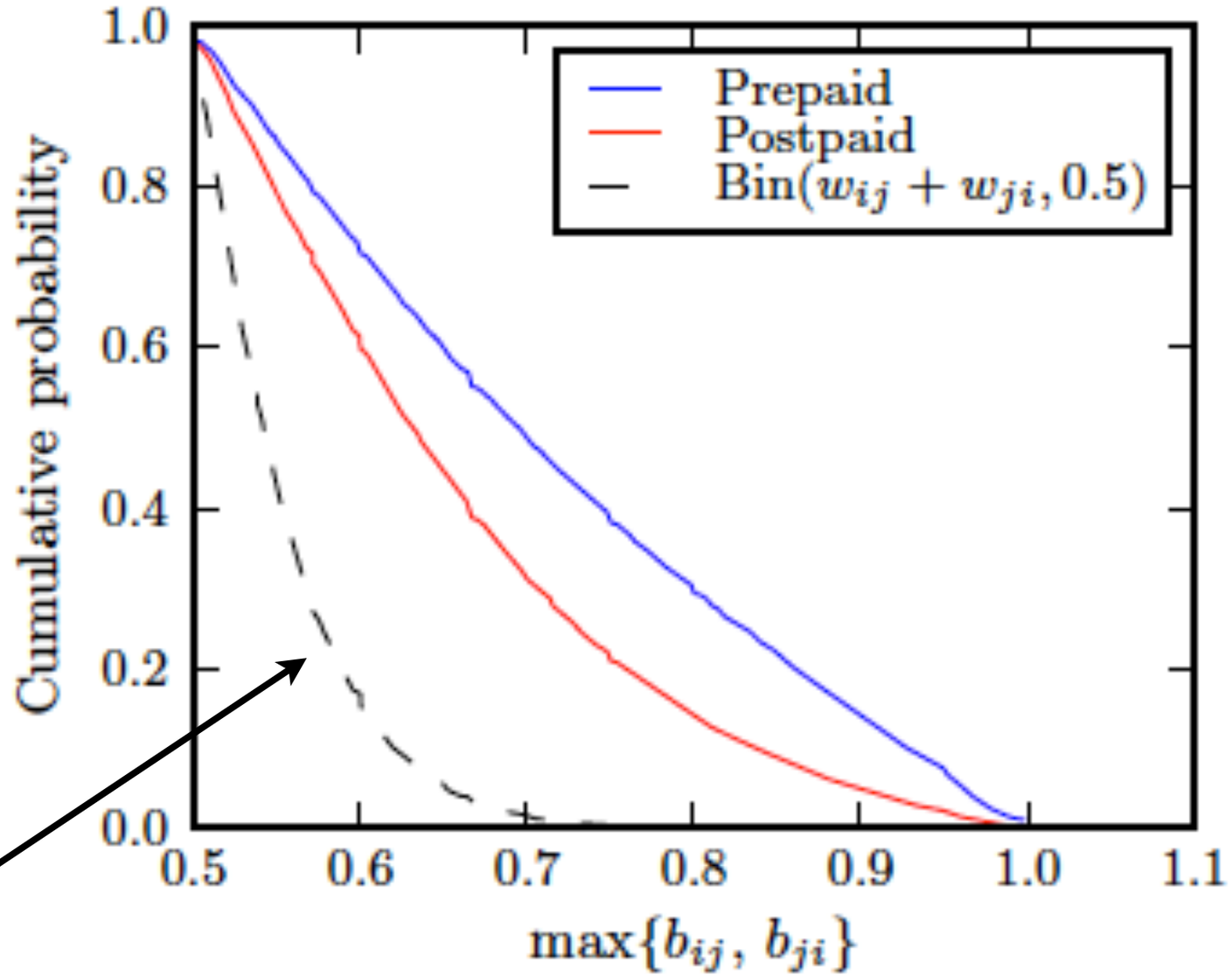


(a) Prepaid

(b) Postpaid

significant number of "uneven" ties with large bias values

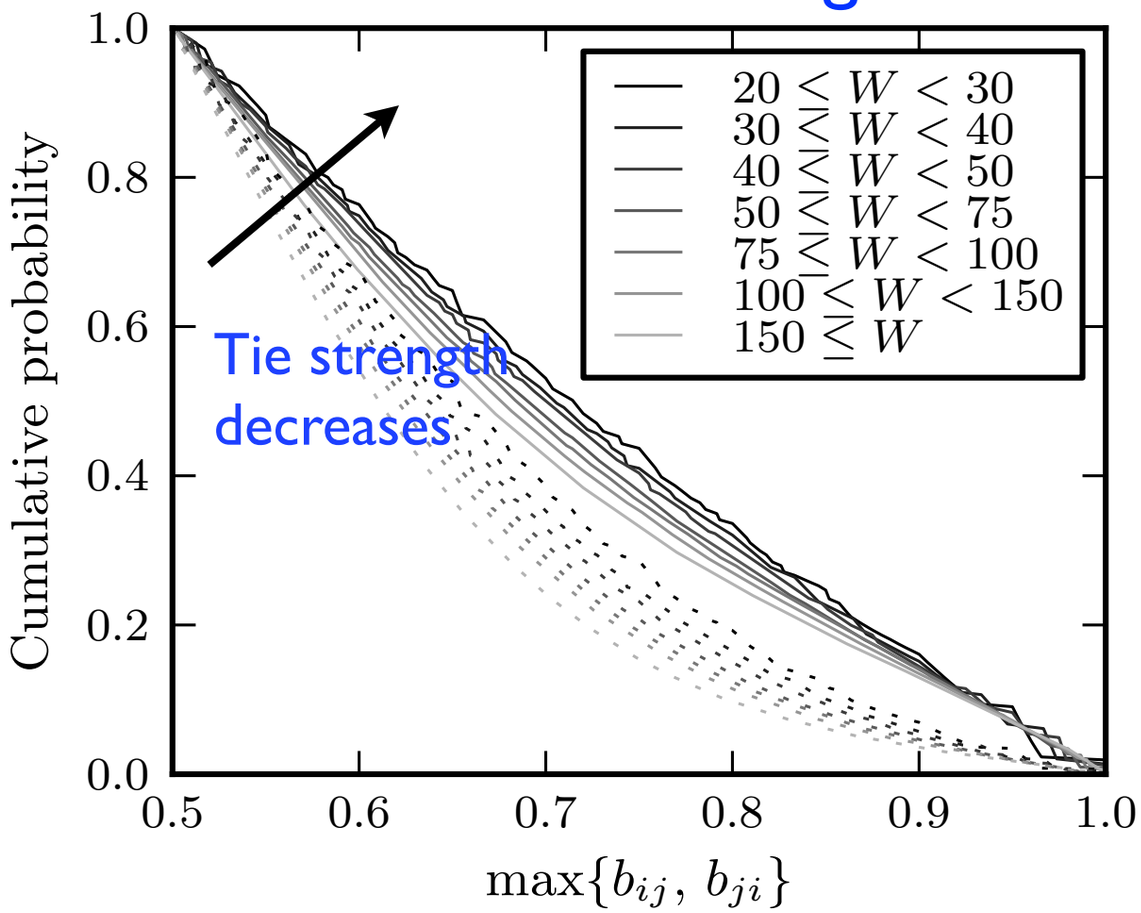
Bias vs random chance



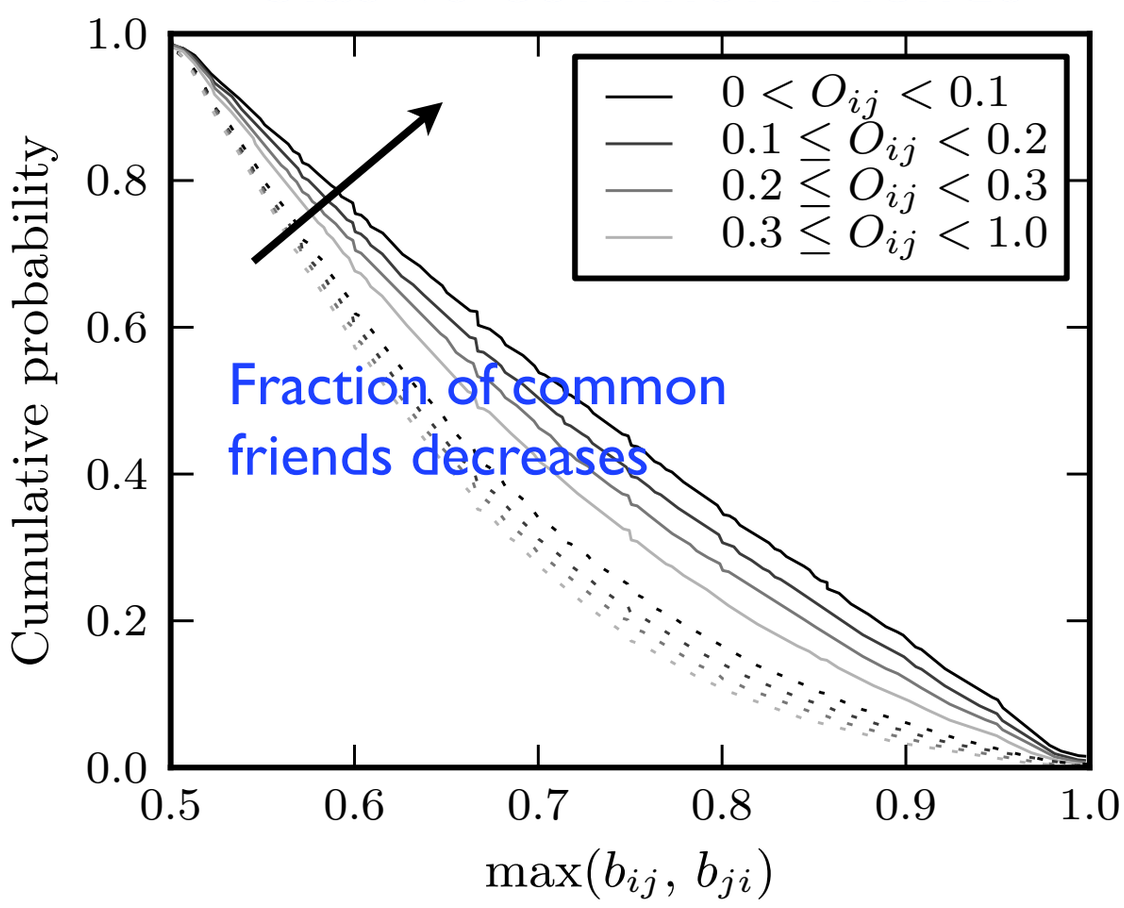
This line corresponds to people randomly initiating calls

Bias vs tie strength and common friends

bias vs tie strength

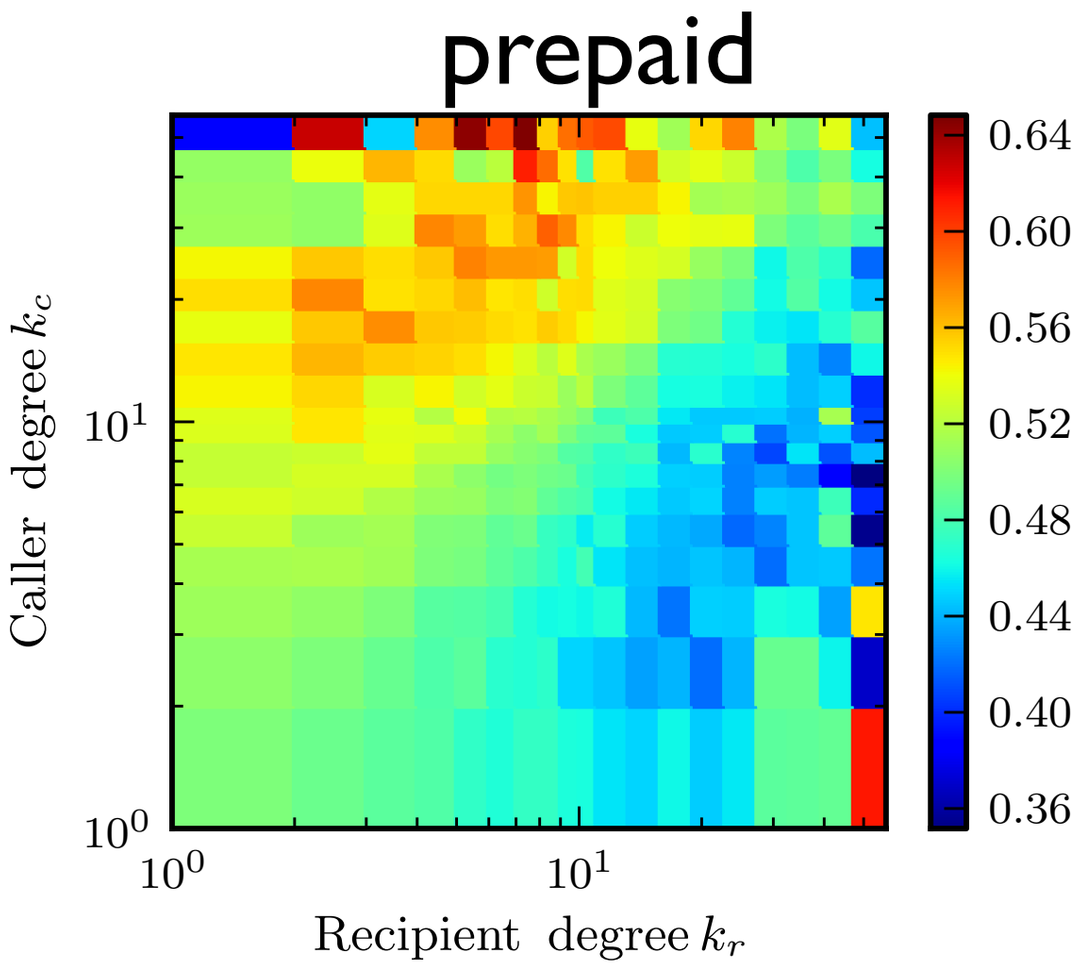


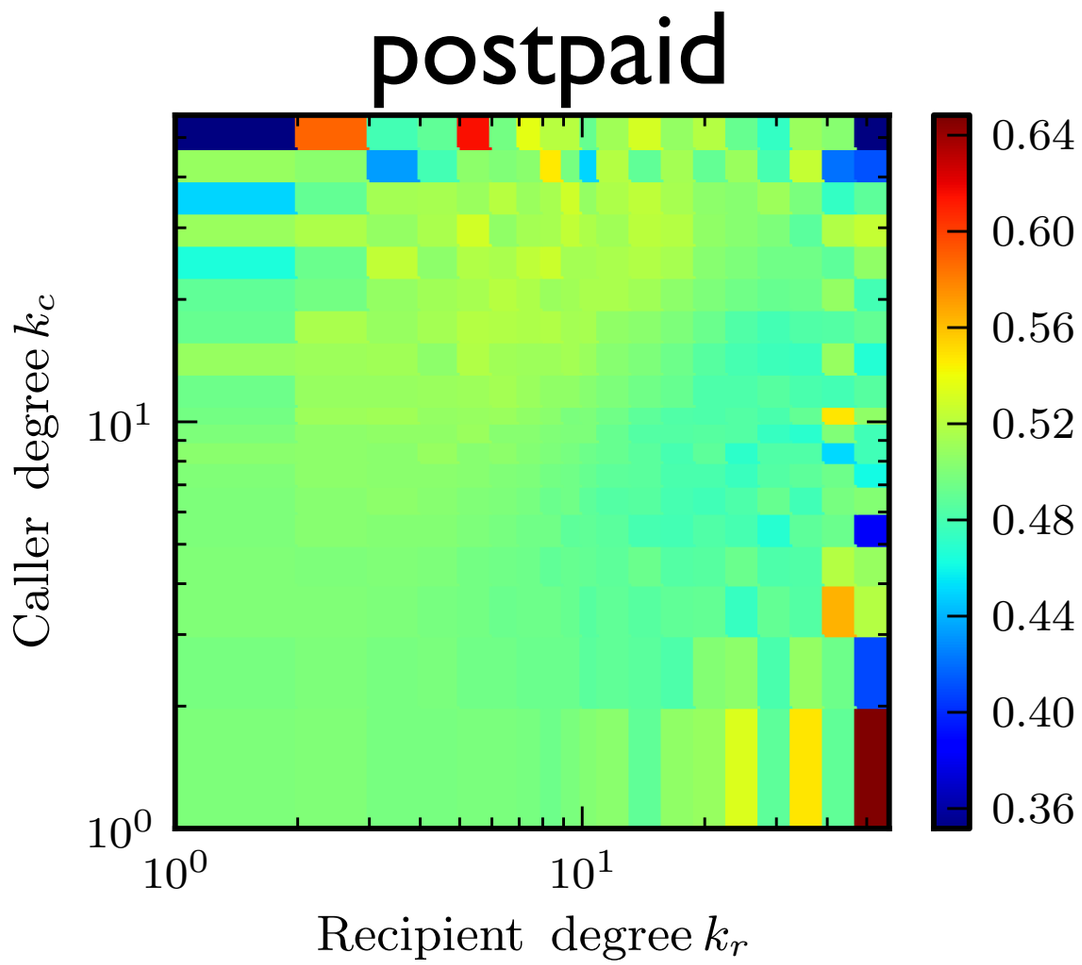
bias vs common friends



The stronger a tie and the more common friends there are, the less biased the tie is

Bias vs # of acquaintances

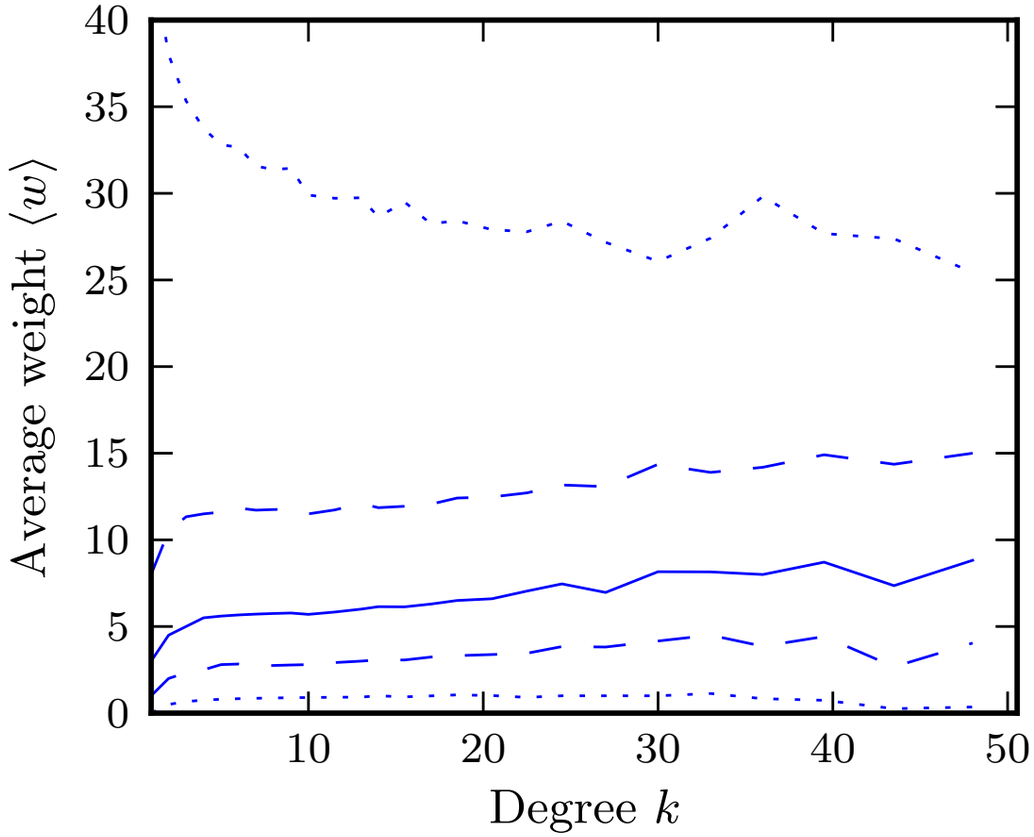




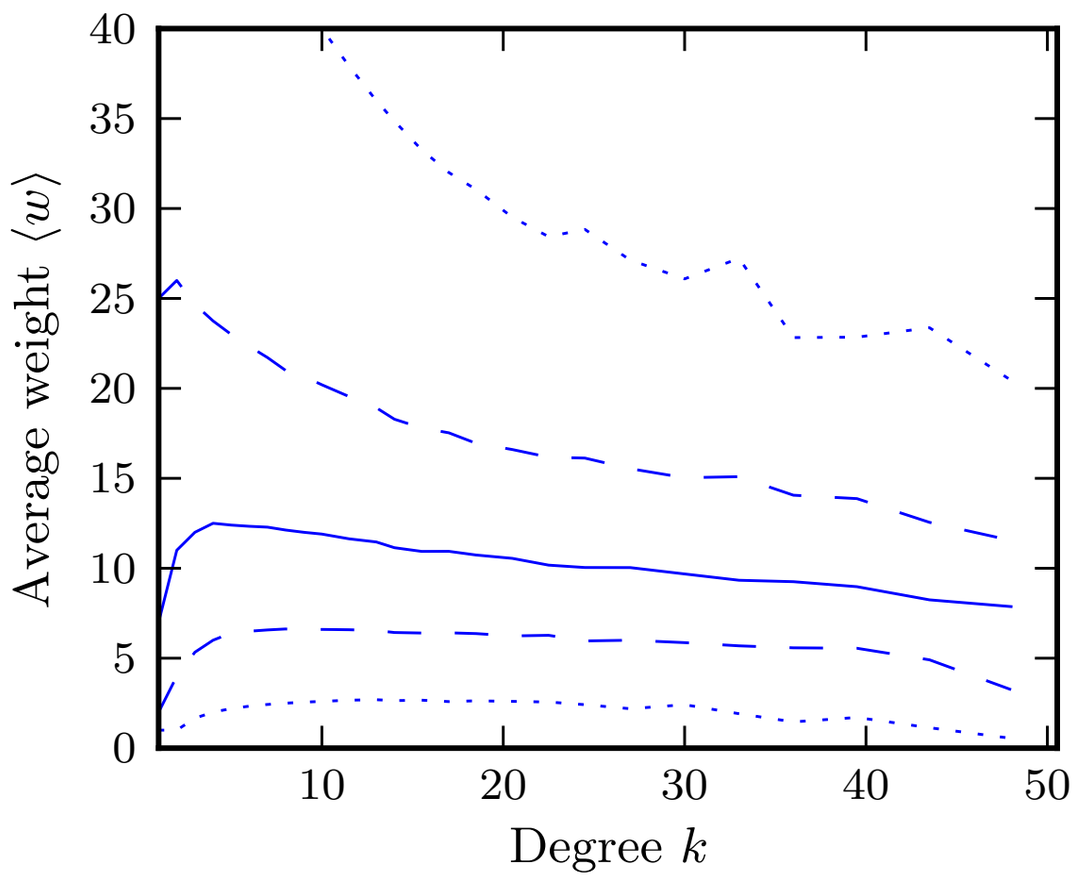
The party who has more acquaintances tends to initiate communication

Tie strengths vs number of acquaintances

prepaid



postpaid



Q2:
Are social ties balanced in terms of communication?

No, one calls more often than the other. The one who calls more often has in general more acquaintances.

Conclusion

- Investigating the dynamics of individual "social atoms", in this case calls and text messages, is a promising direction
- Our first results: i) clear evidence of communication triggering communication, ii) "biassed" relationships
- Topics to be studied:
  - Patterns involving several participants; effect on information transmission
  - From temporal patterns of "atoms" to network level
  - "Roles" of individuals: "group leader", "connector", etc