# The evolution of communication ties

Giovanna Miritello[1,2], Rubén Lara[2], and Esteban Moro[1,3,4]
[1] *Departamento de Matemáticas & GISC, Universidad Carlos III de Madrid, 28911 Leganés, Spain*
[2] *Telefónica Research, Madrid, Spain*
[3] *Instituto de Ciencias Matemáticas CSIC-UAM-UCM-UC3M*
[4] *Instituto de Ingeniería del Conocimiento, Universidad Autónoma de Madrid, 28049 Madrid, Spain*

The dynamics of social networks is highly articulated and evolves as a result of the joining and leaving of nodes and the creating, reinforcing, weakening and dissolution of ties[1–4]. Understanding the evolution of social ties is not only useful to characterize human behavior, but also to understand and model its impact on dynamical processes such as diffusion of information, passage of opinions, community formation. In recent years, there has been a large interest in characterizing the structure and dynamical triggers of link formation and decay. However, little is known about how to model the dynamical process of tie evolution. In most studies it is assumed that a tie forms at the moment the communication is observed[5]. However, the dynamics of ties formation/decay is entangled with the very dynamics of communication, which is characterized by bursts of events and heavy-tailed distributed inter-event times[6]. If many efforts have been spent to characterize the burstiness of communication events and understand the underlying mechanism leading to such a human activity pattern, much less is known about the dynamics of ties formation/decay. The main reason for this lack of understanding is based on the believe that tie formation/decay is a much slower process than tie interactions and that available data is restricted to small networks or short periods of time.

Here we address the problem of how ties form/decay by studying the mobile phone communication network of about 20 million people over a long period of 19 months. This long database allows us to consider three time windows, focus on the links evolution in the window in the middle and use the right and left intervals to assess whether a tie exists before and after the observation window. By doing this we are able to disentangle the links formation/decay from the burstiness of communication thus analyze the temporal evolution of social ties with high precision. Our results show that most people form/remove communication ties almost constantly in time with a given rate $\alpha_i$. More interestingly, we find that users tend to balance the formation/deletion of edges which yields to a steady number of open relationships maintained by people over time. This suggest that people have finite social capacity $\kappa_i$ and that the number of interactions (the connectivity $k_i$) observed in a time window is a function of both the social capacity $\kappa_i$ and the rate of formation of edges. Finally, we find that the evolution of communication ties affects information diffusion. In particular the turnover of the social network over time due to the evolution of ties hinders the propagation.

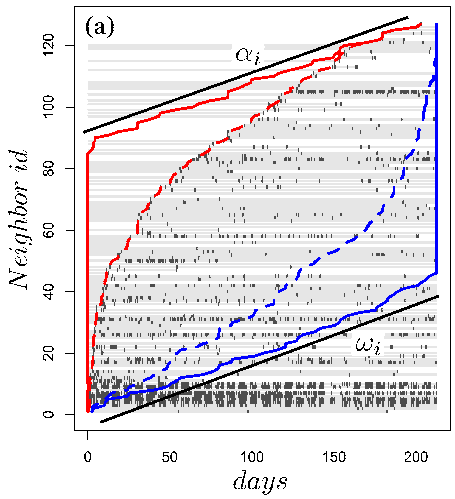


FIG. 1. Schematic view of the dynamics of tie formation/decay and the interplay between tie communication patterns and tie dynamics for a single user and a given observation time window $T = 7$ months. Each black vertical line is a communication event. Solid red/blue curves are the aggregated open/closed links at a given time (including those open/close outside the time window), while dashed lines are the observed open/closed links only within the time window.

[1] Grindrod, P. & Higham, D.J., 2011. Models for evolving networks: with applications in telecommunication and online activities. IMA Journal of Management Mathematics, 23(1), pp.1-15.
[2] Holme, P., 2003. Network dynamics of ongoing social relationships. Europhys. Lett., 64(cond-mat/0308544. NORDITA-2004-28), pp.427-433.
[3] Modeling the evolution of continuously-observed networks: Communication in a Facebook-like community, T. Opsahl, B. Hogan, arXiv:1010.2141v2 (2011).
[4] J. Leskovec, *et al.*, *Microscopic evolution of social networks.* In KDD '08: Proceeding of the 14th ACM SIGKDD international conference on Knowledge discovery and data mining. (2008).
[5] M. Karsai *et al.* Correlated dynamics in egocentric communication networks arXiv:1202.3062v1 (2012).
[6] G. Miritello, E. Moro, and R. Lara, Dynamical strength of social ties in information spreading. Phys. Rev. E (2011) vol. 83 (4) pp. 045102.