The dynamical strength of social ties in information spreading

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Quantitative understanding of human communication patterns is of paramount importance to explain the dynamics of many social, technological and economic phenomena. Most studies have focused on the complex *topological patterns* of the underlying contact network and its influence in the properties of spreading phenomena in social networks such diffusion of information, innovations, computer viruses, opinions, etc. In these studies the real temporal activity is aggregated over time giving a static snapshot of the social interaction where ties are described by static strengths which do not include information about the *temporal patterns* of human interaction. In this framework, the dynamics of interaction between individuals is described by a homogeneous Poisson process in which the communication events are uncorrelated events with the same probability to happen.

However, recent studies of human behavior show that humans act in bursts or cascades of events[1], most ties are not persistent[2] and communications happen in the form of group conversations[3]. Thus, since human communication and information transmission are concurrent, the temporal structure of communication must influence the properties of information spreading[4].

In a recent study[5] we investigate the influence of the temporal patterns of human communication in the spreading of information by analyzing the mobile communication of 20 million people during one year. According to previous results[1,3], we observe that human communication is bursty and happens in group conversations. To investigate the influence of these temporal aspects on the spreading of information, we simulate the epidemic SIR model in which an infected node can infect a susceptible node with probability λ. We compare the results with the real time sequence of communication events with the ones when the real time-stamps of the communication events are shuffled (that simulates a homogeneous Poisson process). A significant difference is observed between the real and the shuffled-time data for different regimes of λ: when λ is small, the total reach is bigger for the real data, while the opposite behavior is observed for large λ.

By mapping the dynamical SIR model to a static percolation model where each tie is described by the transmissibility $\mathcal{T}_{ij}$[6], e.g. the probability that the information is transmitted from i to j, we are able to explain the observed behavior.
In particular we show that both the bursty nature of human communications and the existence of group conversations are the two main dynamical ingredients to understand the spreading of information in social networks. These two effects compete in the spreading, favoring (small λ) and hindering (large λ) the information reach when compared with the homogeneous case (Fig.1).

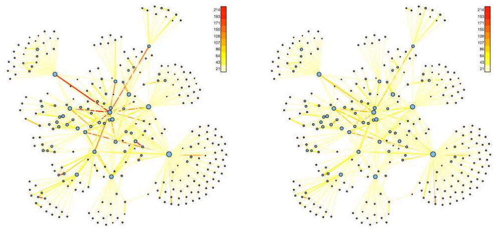

Figura 1. The structure of the mobile call network around a randomly chosen individual. Each link represents at least one call between the two users. The weight of the links assigned on the basis of their transmissibility $\mathcal{T}_{ij}$ for a large value of λ for the shuffled-time (left) and the real (right) case.

Our results indicate that a an effective way to incorporate temporal patterns of communication in the description and modeling of human interaction is through the transmissibility, that represents the *dynamical strength* of the ties.

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