On the mechanisms underlying the complexity of networks

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Many natural and artificial systems have been studied in the last decade by means of the networks theory. This theory constitutes a framework for describing the interactions in a complex system from a purely topological point of view, abstracting away the dynamical processes that take such structure as substrate [1]. The empirical analysis of real networks have shown a common, unintuitive and not trivial organization underlying systems of different nature [2]. In particular, complex topologies are characterized by the well known *small world* property [3], associated with low distances between randomly chosen pairs of nodes and a high clustering coefficient. The presence of power-laws in the distributions of some statistical properties of the networks, particularly in the connectivity degrees k of nodes [1, 3] seems to be an ubiquitous trait of the so called complex networks. The degree distribution measures the probability of a node having a given number of links or degree k, and the scaling observed in many real networks displays an asymptotic behavior in the form $P(k) \sim k^{-\gamma}$. This phenomenon denotes a high inhomogeneity in the connectivity degrees, unlike the one observed in classical random graphs, which leads to the term *scale-free* network.

The complexity observed in natural systems can be explained, at least intuitively, as an effect of evolutionary processes. The time and mechanisms associated to these processes would play an important role in the emergence of complexity, however in artificial systems this does not seem so clear. The Internet was one of the first cases of artificial network documented to exhibit similar characteristic complex traits [4]. Nevertheless, such similarities are not so surprising for the Internet case due to its local, uncoordinated and unplanned growth. Recently many artificial systems have shown similar distinctive traits despite their global, coordinated and planned growth, totally different to the evolution of either Internet or natural systems [5, 6, 7, 8, 9]. These results suggest that there may exist universal principles underlying the structure of complex systems irrespective of their origin.

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