Abstract for Dynamics Days Crete 2006
Topic: Complex Networks

Topology governs network evolution

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In recent years, studies of the architecture of large natural and artificial networks have unveiled a common topology, called scale-free, in which the connectivity between elements is power-law distributed $P(k) \sim k^{-\gamma}$ [1]. Given the ubiquity of scale-free topology, we investigate whether this heterogeneous network design confers some kind of evolutionary advantage. We use boolean threshold components to model the dynamics of such networks [2]. Networks with distinct topologies, scale-free or random, evolve towards a pre-established target through a process of random mutations and selection [3, 4]. We find that homogeneous random networks and scale-free networks exhibit drastically different evolutionary paths. Homogeneous random networks evolve by sparse punctuated steps, while scale-free networks evolve faster and continuously. The ability of scale-free networks to evolve is independent of the scale-free parameter γ, whereas homogeneous random networks require a specific tuning of their average connectivity $\langle k \rangle$. These results suggest that the evolutionary paths of complex networks may be determined by the network topology.

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