

# Hierarchical Organization of Modularity in Complex Networks

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Many real networks in nature and society share two generic properties: they are scale-free and they display a high degree of clustering. We show that the scale-free nature and high clustering of real networks are the consequence of a hierarchical organization, implying that small groups of nodes form increasingly large groups in a hierarchical manner, while maintaining a scale-free topology. In hierarchical networks the clustering coefficient follows a strict scaling law, which can be used to identify the presence of a hierarchical organization in real networks. We find that several real networks, such as the metabolic networks of cells [1], the World Wide Web, actor network, the Internet at the domain level and the semantic web obey this scaling law, indicating that hierarchy is a fundamental characteristic of many complex systems [2].

- [1] E. Ravasz, A. L. Somera, D. A. Mongru, Z. N. Oltvai and A.-L. Barabási, *Science* **297** (2002) 1551
- [2] E. Ravasz and A.-L. Barabási, *Phys. Rev. E* **67** (2003) 026112