

## Detecting the overlapping and hierarchical community structure of complex networks.

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Many networks in nature, society and technology are characterized by a mesoscopic level of organization, with groups of nodes forming tightly connected units, called communities or modules, that are only weakly linked to each other. Uncovering this community structure is one of the most important problems in the field of complex networks and has countless applications in different disciplines like biology, computer and social sciences. The solution is hampered by the fact that the organization of networks at the “mesoscopic”, modular level is usually highly non-trivial, for at least two reasons. First, there is often a whole hierarchy of modules, with communities embedded within other communities. Second, nodes often belong to more than one module, resulting in overlapping communities. Here we present the first algorithm that finds both overlapping communities and the hierarchical structure. The method performs a local exploration of the network, searching for the natural community of each node. During the procedure, nodes can be visited more times, no matter whether they have been assigned to a community or not. In this way, overlapping communities are naturally recovered. The variation of a resolution parameter, determining the average size of the communities of a modular structure, allows to explore all hierarchical levels of the network. The method is very fast and makes possible the analysis of systems with millions of nodes. Tests on real and artificial networks give excellent results. The method is also capable to reveal the absence, not only the presence, of community structure, as shown by applications on random graphs.

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