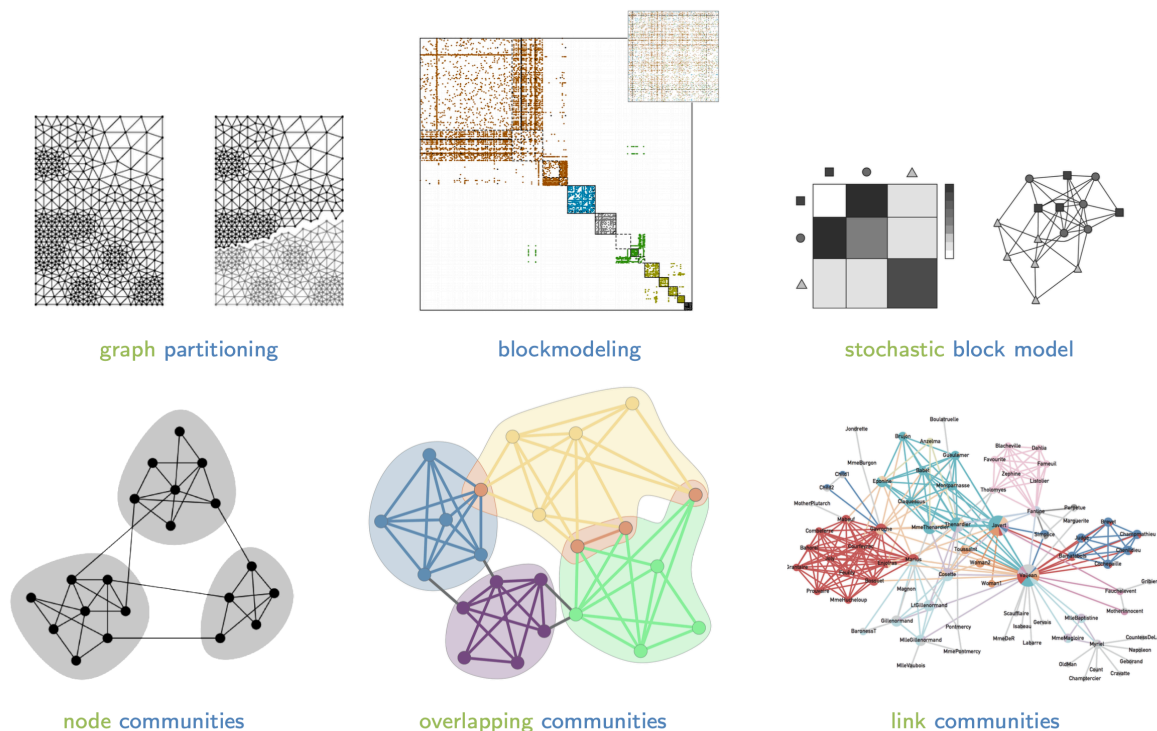


Node clustering by community detection

Node clustering methods aim to assign each node i to a "meaningful" group, block, or cluster c_i within the network. Recall that even simple graph bisection is a classical NP-hard problem, while the number of possible partitions in general node clustering grows super-exponentially with the number of nodes (i.e., as the Bell number). Therefore, heuristic approaches are typically used in practice. *Descriptive* approaches try to identify clusters directly from the observed graph structure, whereas *inferential* approaches infer clusters by fitting a generative model to the network ([Peixoto, 2023](#)).

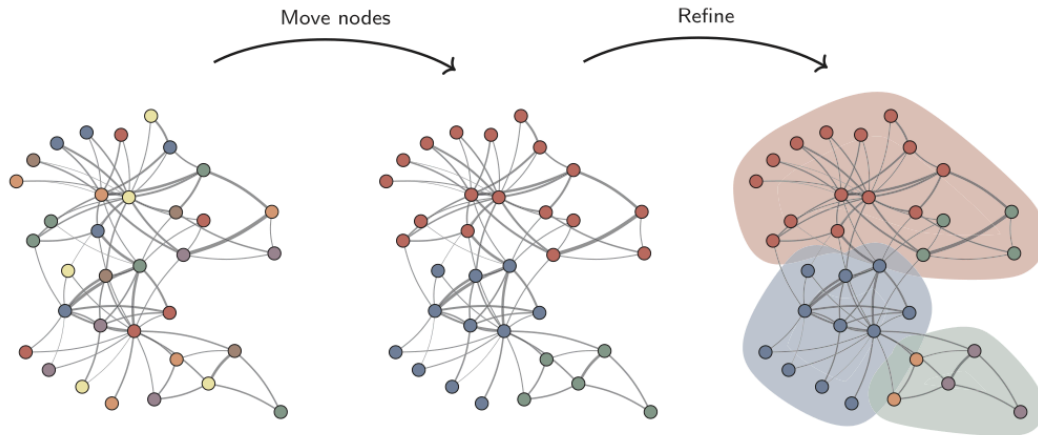


Modularity optimization

Modularity optimization techniques for community detection aim to maximize the quality function known as modularity Q ([Girvan & Newman, 2002](#)), which is defined relative to a chosen random graph model (e.g., configuration model).

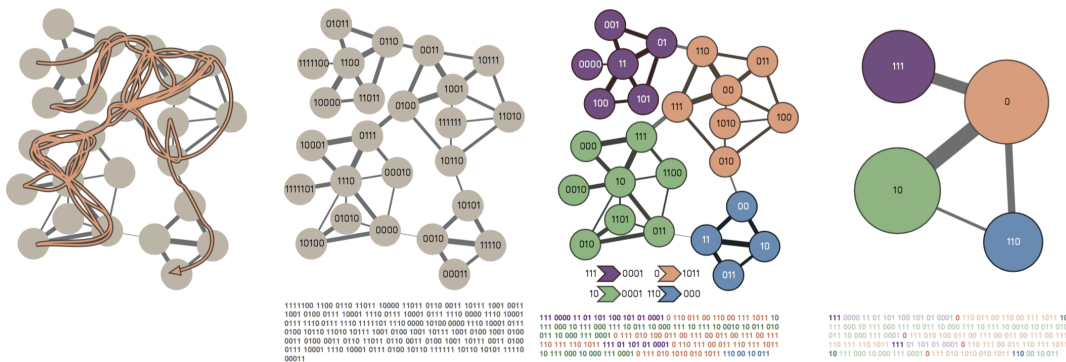
$$Q = \frac{1}{2m} \sum_{ij} \left(A_{ij} - \frac{k_i k_j}{2m} \right) \delta_{c_i c_j}$$

Among the most well-known approaches are the Louvain algorithm ([Blondel et al., 2008](#)) and its improved variant the Leiden algorithm ([Traag et al., 2019](#)).



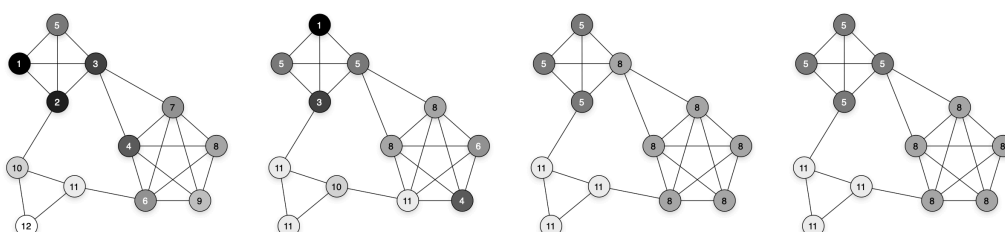
Map equation compression

The Infomap algorithm ([Rosvall & Bergstrom, 2008](#)) detects communities by finding a network partition that minimizes the *map equation*, which measures the expected description length of a random walk on the network.



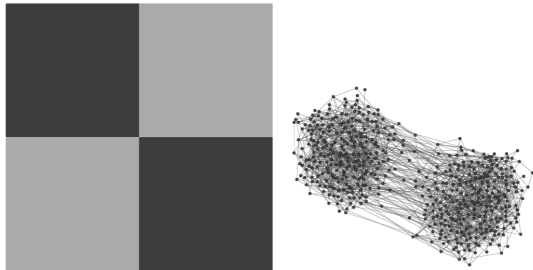
Label propagation

Label propagation is a fast heuristic method for community detection, in which each node is iteratively assigned the most frequent label among its neighbors ([Traag & Šubelj, 2023](#)).

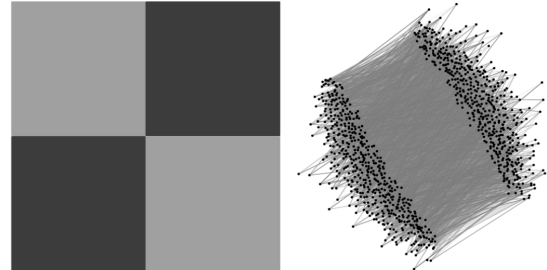


Stochastic block model

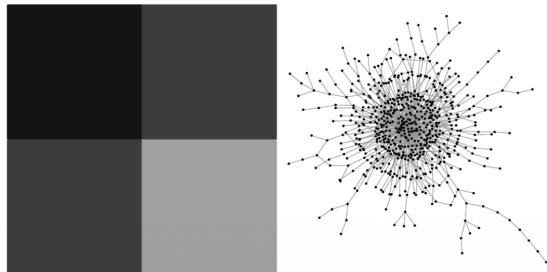
The *stochastic block model* (*SBM*) is a generative random graph model with planted structure such as communities, bipartite patterns, or core–periphery organization. Clusters in the network can be inferred nonparametrically by statistical methods that minimize the description length ([Peixoto, 2019](#)).



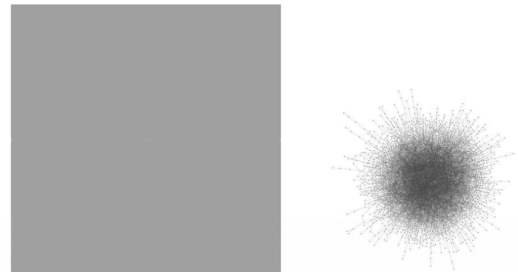
community block model



disassortative (bipartite) block model



core-periphery block model



random block model