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A network with tunable clustering, degree correlation and degree distribution, and an epidemic thereon

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Abstract

A random network model which allows for tunable, quite general forms of clustering, degree correlation and degree distribution is defined. The model is an extension of the configuration model, in which stubs (half-edges) are paired to form a network. Clustering is obtained by forming small completely connected subgroups, and positive (negative) degree correlation is obtained by connecting a fraction of the stubs with stubs of similar (dissimilar) degree. An SIR (Susceptible $\rightarrow$ Infective $\rightarrow$ Recovered) epidemic model is defined on this network. Asymptotic properties of both the network and the epidemic, as the population size tends to infinity, are derived: the degree distribution, degree correlation and clustering coefficient, as well as a reproduction number R_*, the probability of a major outbreak and the relative size of such an outbreak. The theory is illustrated by Monte Carlo simulations and numerical examples. The main findings are that clustering tends to decrease the spread of disease, the effect of degree correlation is appreciably greater when the disease is close to threshold than when it is well above threshold and disease spread broadly increases with degree correlation ρ when R_* is just above its threshold value of one and decreases with ρ when R_* is well above one.