IPD network creation Games

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ABSTRACT

Motivated by the possible application to technical communication networks, we study a game-theoretical approach to network structure creation. By allowing nodes to change their neighborhood to maximize their payoff according to the rules of the iterated prisoner's dilemma (IPD) the network structure is coupled to game dynamics. The local changes of the network topology lead to various different self-organizing network structures, depending on the payoff matrix. These emerging networks are benchmarked with respect to objective functions inspired by performance measures for communication networks.

The prisoner's dilemma (PD) is a game where each player has two strategies cooperate (C) and defect (D) to choose from. The payoffs of the PD are temptation to defect (T), reward (R), punishment (P), and sucker's payoff (S). These payoffs obey the relation $T > R > P > S$ and can be written as a 2×2 payoff matrix $\pi = \begin{pmatrix} R & S \\ T & P \end{pmatrix}$.

When the PD is played repeatedly with a memory of the last $m \geq 1$ moves of the opponent it is called the iterated prisoner's dilemma (IPD). We choose $m = 1$ which yields 8 possible strategies, therefore the IPD can be regarded as an 8×8 matrix game. Apart from adapting their strategy the players are also allowed to change their neighborhood to maximize their payoff.

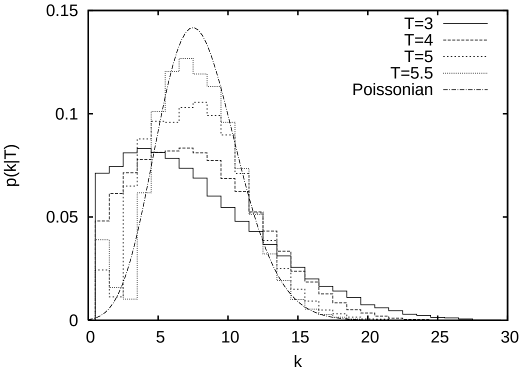

Figure 1: Degree distribution $p(k|T)$ emerging from node encounter dynamics

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As shown by the degree distributions $p(k|T)$ presented in Figure 1 these local changes to the network topology lead to different emerging network structures which differ depending on the varied parameter T of the PD payoff matrix.

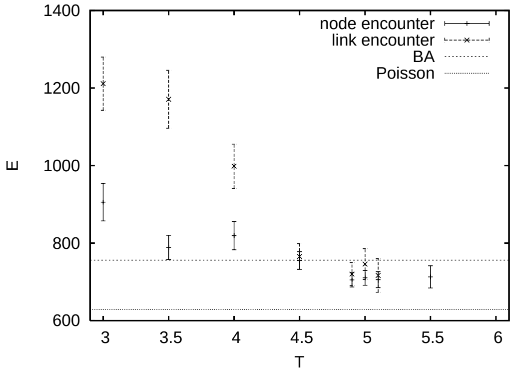

Figure 2: Benchmarking the networks emerging from node encounter and link encounter with the objective function Equation (1).

The performance of the emerging networks is benchmarked by objective functions proposed by Holme and Ghoshal [2] and Krause, Scholz and Greiner [3]. The benchmark function shown in Figure 2 is

$$E = \frac{1}{N(N-1)} \sum_{i=1}^{N} \frac{c_i}{k_i} \tag{1}$$

where $c_i = \sum_{j=1(j\neq i)}^{N} d_{ij}^{-1}$ is the closeness centrality of node i. The comparison of the value of E for the reference topologies of poissonian random graphs and networks of the BA-model with a scale-free degree distribution shows a significant increase of the performance of the networks for $T \leq 4$. The increase of performance is especially pronounced for the kind of topology exploration we call *link encounter* where the players try to improve their payoff via attachment to pairs of nodes whereas *node encounter* allows only for testing of links to single nodes.

Keywords

complex networks, network structure, evolutionary dynamics, game theory

1. REFERENCES

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