

## Directed Scale-Free Transport Networks Induced by a Rank-Based Routing Strategy

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We present a transport network model based on complex networks. In this model, the transport vector from one node to its nearest neighbor explicitly relies on the rank of the target's nearest neighbor according to the node potential measure, and the probability to link the target node is its ranking power-law function with exponent  $\alpha$ . We find that the transport networks based on scale-free networks are scale-free and the power-law exponent  $\gamma$  is independent of  $\alpha$ , and the same holds for the substrate network. The transport network based on a random network also has a scale-free degree distribution, but the power-law exponent  $\gamma$  depends on the exponent  $\alpha$ . By the curve fitting method, the relation between  $\gamma$  and  $\alpha$  is obtained.

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### I. INTRODUCTION

Complex networks as an indispensable tool for the description of different complex systems have recently attracted enormous attention [1–3], natural and social systems as well as technological webs have been successfully described through scale-free networks [4–6], which are characterized by a degree distribution with a broad tail  $p(k) \sim k^{-\gamma}$  for large values of the degree. The growth and preferential attachment have inspired the introduction of the Barabasi-Albert (BA) model [4], which led for the first time to a scale-free network with a power-law degree distribution with the exponent  $\gamma = 3$ . Krapivsky *et al.* [7] have demonstrated that the scale-free nature of the network is destroyed for nonlinear preferential attachment, the only case in which the topology of the network is scale-free is the one where the preferential attachment is asymptotically linear. Later, there were a number of models which introduced the generation for the scale-free networks, such as the copying models [8], fitness-based models [9], optimization models [10], etc.

Often the transport process is caused by the local gradient of some transport entities, such as a chemical potential, temperature, force, material good, power, etc. To be able to consider the transport process in the network, it is reasonable to hypothesize the existence of a gradient field that governs the information flow. Based on this idea, Toroczkai and Bassler [11, 12] have put forward the complex gradient network, which introduces a different mechanism generating power-law degree distributed networks. They have found that the