Comparative analysis of transport communication networks and q-type statistics

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We perform a comparative analysis of spatial networks to reveal the dependence of the network topology from the connections character. In case of spatial networks, the communication spatial embedding influences network topology in different ways [1]. There is strong restriction for the network nodes degree for the road network. It is induced by the spatial restriction on the physical location of connections. However, in the case of the airline network this restriction is rather weak. We have studied various transport communication networks amongst inhabited localities of the Moscow region and the Russian Federation. In the first network, railway stations of the Moscow region were considered as vertices and railways as edges. The second network shows inhabited localities of the Moscow region as vertices and highways as edges. In the third case the network shows inhabited localities connected by both highways and railways. The fourth network is the RF airline network. In the latter, cities with airports are nodes, and edges show direct flights between the relevant airports. We have analyzed the data for the corresponding networks and constructed degree distributions. We have elaborated the dependences of the vertex nearest neighbours average degree on its degree to reveal the presence and type of correlations in the networks. The data analysis results show that the degree distributions for the spatial networks under study are subject to continuous deformation from Gaussian distribution for the railway network up to the power law distribution for the airline network. We obtain degree distributions of the q-type applying the maximum entropy principle, the generalized Tsallis entropy and the corresponding restrictions. With the entropy index tending to unity, this distribution amounts to the Gaussian one; with large values of the vertex degree it is of the power law type. Thus, we describe the degree distributions obtained from the data analysis with the q-type distribution. We have performed fitting with the maximum likelihood method. The comparison allowed us to define the q entropy index that characterizes the fractal dimension of the constructed networks. The fitting outcome makes it possible to conclude that the network topology tends to become scale-free with the decrease of the restrictions to the physical arrangement of connections. We have also analyzed small-world properties of the studied networks and the community structure in them. We have studied the connections length distributions as well. We have generated statistically equivalent networks and studied processes of epidemic spreading in them in the frameworks of the SIS and SIR models, as well as rumor spreading processes.

[1] S. Boccaletti, V. Latora, Y. Moreno, M. Chavez and D. U. Hwang, Phys. Rep. **424**, 175 (2006).