Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Physica A 350 (2005) 643–656
PHYSICA A
www.elsevier.com/locate/physa

Weighted networks of scientific communication: the measurement and topological role of weight

Menghui Li[a], Ying Fan[a], Jiawei Chen[a],
Liang Gao[a], Zengru Di[a], Jinshan Wu[a,b,*]

[a]Department of Systems Science, School of Management, Beijing Normal University, Beijing 100875, PR China
[b]Department of Physics and Astronomy, University of British Columbia, Vancouver, B.C. Canada V6T 1Z1

Received 22 September 2004; received in revised form 13 November 2004
Available online 18 December 2004

Abstract

In order to take the weight of connection into consideration and to find a natural measurement of weight, we have collected papers in Econophysics and constructed a network of scientific communication to integrate idea transportation among econophysicists by collaboration, citation and personal discussion. Some basic statistics such as weight per degree are discussed in Fan et al. J. Mod. Phys. B (17–19) (2004) 2505. In this paper, by including the papers published recently, further statistical results for the network are reported. Clustering coefficient of weighted networks is introduced and empirically studied in this network. We also compare the typical statistics on this network under different weight assignments, including random and inverse weight. The conclusion from weight-redistributed network is helpful to the investigation of the topological role of weight.

PACS: 89.75.Hc; 89.65.−s; 89.70.+c; 01.30.−y

Keywords: Weighted networks; Networks of scientists; Clustering coefficient; Random weight

*Corresponding author. Tel.: +604 322 4099.
E-mail address: jinshanw@physics.ubc.ca (J. Wu).

0378-4371/$ - see front matter
doi:10.1016/j.physa.2004.11.039

1. Introduction

Recently, many researchers in different fields use the topological properties and evolutionary processes of complex networks to describe the relationships and collective behaviors in their own fields [1,2]. This methodology, which is so-called network analysis, often leads to discoveries. Also new analysis methods and new topology properties are proposed by this approach. A network is a set of vertices and a set of edges which represent the relationship between any two vertices. Just because of its simplicity of this description, network can be used in so many different subjects (see Ref. [1] and its references), including linguistics, collaboration of movie actors and scientists, human sexual contacts, disease propagation and controls, community structures, information networks, and food webs.

However, a single line representing the existence of the relation will be a limitation when it is used to describe relations having more than one level. For instance, in the network of scientists, both collaboration and citation are the ways of idea transportation but with different contributions. When we analyze this transportation as a whole, we have to use different weights to measure these different contributions. Also, even for the same level interaction, such as collaboration, not only the existence of connection but the times of collaboration is valuable information. So to fully characterize the interactions in real networks, weight of links should be taken into account. In fact, there are already many works on weighted networks, including empirical studies and evolutionary models [3–6].

The way to measure the weight for weighted networks has been introduced differently in several types by some authors. First type, converting some quantities in non-weighted network into the weight of edge. In Ref. [7], the weight of an edge is measured by the point degrees k_i and k_j (e.g. $w_{ij} = k_i k_j$) of its two ends. Second type, in some networks, typically natural measurement of weight is already given by the phenomena and event investigated by the network. In the scientific collaboration network, the times of co-authorship are registered as the weight of link [8]. In Ref. [9], in the case of the WAN the weight w_{ij} of an edge linking airports i and j represents the number of available seats in flights between these two airports. In Ref. [10], the weight w_{ij} stands for the the total number of flights per week from airport i to airport j. The third type is in the works about modelling weighted networks. Some prior weights are introduced in [4]. In Ref. [11], the weight w_{ij} of a link l_{ij} connecting a pair of nodes (i and j) is defined as $w_{ij} = (w_i + w_j)/2$, where w_i is defined as i node's assigned number (from 1 to N) divided by N. In Refs. [12,13], the weight w is assigned to the link when it is created, which is drawn from a certain distribution $\rho(w)$. In fact, the first type of weight description should be regarded as an approach of non-weighted networks. It is helpful to discuss new properties of the non-weighted networks but without taking any more information than the non-weighted networks about the real interactions. In the second type, which is a very large class of the weighted networks, typical measurement of weight is already given by the phenomena. The investigation of such network focuses mainly on how to define and discover the topological character of the networks. In the last type, from the viewpoint of empirical study, we never know whether or not such models already