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Nonlinear dynamic evolution and control in CCFN with mixed attachment mechanisms[☆]

Jianrong Wang[a], Jianping Wang[a,*], Dun Han[b]

[a] School of Computer and Communication Engineering, University of Science and Technology Beijing, Beijing, 100083, PR China

[b] College of Science, Jiangsu University, Zhenjiang, Jiangsu, 212013, PR China

HIGHLIGHTS

- A fitness model of evolution network based on complex networks with mixed attachment mechanisms is researched to solve an actual network — CCFN (cooperative communication fitness network).
- The evolution of CCFN is given by four steps with different probabilities, and the rate equations of nodes degree are presented.
- The degree distribution is analyzed by calculating the rate equation and numerical simulation with the examples of four fitness distributions such as power law, uniform fitness distribution, exponential fitness distribution and rayleigh fitness distribution.
- The robustness of CCFN is studied by numerical simulation with four fitness distributions under random attack and intentional attack to analyze the effects of degree distribution, average path length and average degree.
- The results of paper are more significant for building CCFN to programme the resource of communication.

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ABSTRACT

In recent years, wireless communication plays an important role in our lives. Cooperative communication, is used by a mobile station with single antenna to share with each other forming a virtual MIMO antenna system, will become a development with a diversity gain for wireless communication in tendency future. In this paper, a fitness model of evolution network based on complex networks with mixed attachment mechanisms is devised in order to study an actual network—CCFN (cooperative communication fitness network). Firstly, the evolution of CCFN is given by four cases with different probabilities, and the rate equations of nodes degree are presented to analyze the evolution of CCFN. Secondly, the degree distribution is analyzed by calculating the rate equation and numerical simulation with the examples of four fitness distributions such as power law, uniform fitness distribution, exponential fitness distribution and Rayleigh fitness distribution. Finally, the robustness of CCFN is studied by numerical simulation with four fitness distributions under random attack and intentional attack to analyze the effects of degree distribution, average path length and average degree. The results of this paper offers insights for building CCFN systems in order to program communication resources.

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* Corresponding author.
E-mail address: jpwang@ustb.edu.cn (J. Wang).

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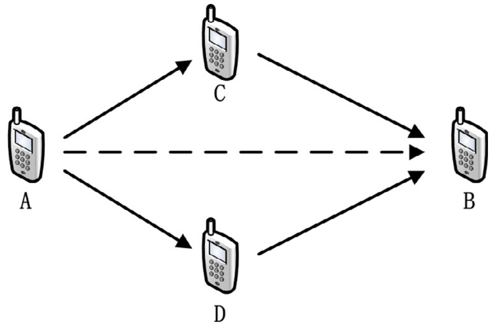

Fig. 1. While the communication is established between user A and user B, the relay node C or D can be requested for assistance to forward information because of the user A with limited power.

1. Introduction

With the development of wireless communication technology, the requirements of data rate and quality of service constantly increase for wireless transmission, but also technology standard of communication system are required higher and higher. Compared with cable channel, it is more severe and complex for wireless channel environment to propagate the radio wave. There are a large number of direct wave, reflected wave and diffracted wave, which produce multipath effect, and lead to receiving unstable signal of wireless communication.

Because the wireless spectrum resources are very scarce, the important problems of wireless communication for achieving a balance between validity and reliability are researched to resist multipath fading and to greatly improve the spectrum utilization. Therefore, MIMO (Multi Input Multi Output) antenna system has been used for increasing system bandwidth, antenna transmission power and capacity of communication system [1,2].

The terminal equipments are restricted by volume, hardware complexity and power consumption, confine the use of MIMO antenna system. Hence, in Refs. [3–6] cooperative communication has been presented as a new space diversity technology. The basic idea of cooperative communication is: in a multi-user communication environment, a virtual antenna array is formed by the cooperative nodes of single antenna terminals. The principle of cooperative communication through relay nodes to forward information is shown in Fig. 1. With the continuous requirements for wireless communication, cooperative communication will become a development in tendency future [7]. In recent years, a large number of achievements have been created for cooperative communication such as coding theory [8,9], power allocation [10,11], relay selection [12,13], information security [14–16] and so on.

Complex networks play important roles in researching the functional properties of complex systems and focus on the topology structure of complex system for interaction among the individuals. Complex networks have been permeated into many academic disciplines, such as sociology, biology, epidemiology, ecology, communication system and many other fields. Watts and Strogatz presented the Small-World Model (WS Model) [17] and described the differences and conversions between completely regular network and completely random network. Barabasi and Albert presented the Scale-Free Model (BA Model) [18] containing both growth and preferential attachment widely existing in real networks. In Refs. [19–21], the properties of evolving network had been studied by some extended models of scale-free for more realistic description of the local processes, incorporating the addition of new nodes, new links, and the rewiring of links.

The in-degree and out-degree distributions of a growing network model have been introduced in Ref. [22]. When the node and link creation rates were linear functions of node degree, these distributions exhibited distinct power-law forms. Ref. [23] investigated the scaling properties of a class of models which assign weights to the links as the network evolves. Ref. [24] focused on the study of degree correlations of the group preferential model, in which a link has been established with a pre-existing vertex according to an attachment probability which is depended on the degree of the m targeted vertices of the new vertex. Ref. [25] studied ad hoc networks, where one also had to contend with rapid and random deletions of existing nodes. Dynamics only based on the well-known preferential attachments of new nodes did not lead to a sufficiently heavy-tailed degree distribution in ad hoc networks.

In Refs. [26–31], based on spatial predator–prey theory, the global stability of ecological system is analyzed on herbivore outbreak. And some other studies are considered with time delay or nonlinear to analyze the influence of epidemic models [32–34].

In Ref. [35], Liu et al. considered that the attachment rules of some networks were neither completely random attachment, nor completely preferential attachment in reality. A general class of growing networks was constructed with both preferential and random attachments, which included random and scale-free networks as limiting cases when a physical parameter was tuned.

In scale-free model, the oldest nodes will have the highest number of links, since they had the longest time frame to acquire them. However, numerous examples convincingly indicate that in real systems connectivity and growth rate of one node do not depend on its age alone. For example, in social networks some individuals acquire more social links than others, or on the WWW some web pages attract considerably more links than others. Therefore, the rate at which nodes in a network