Exponentially Synchronization of Stochastic Complex Networks with Time-varying Delays and Switching Topology via Pinning Control

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***Abstract*—In this paper, the exponentially synchronization is investigated for stochastic complex networks with both switching topology and time-varying delays via pinning control. The model of complex network is quite general since many factors such as noise perturbations, switching topology and internal and outer time-varying delays are considered. By employing the Lyapunov-Krasovskii functional, the Itö formula, stochastic analysis theory as well as linear matrix inequality (LMI), the sufficient conditions are derived to guarantee the exponentially synchronization. The numerical examples are provided to show the effectiveness of the theoretical results.**

***Keywords*-Stochastic Complex Networks; Switching; Exponentially Synchronization; Time-varying Delays; Pinning Control**

I. INTRODUCTION

Complex networks are becoming increasingly important in modern society. A complex network is a large set of nodes (or vertices) connected by a set of links (or edges), such as coupled biological and chemical system, neural networks, social interacting species, the Internet, the World Wide Web, etc [1]. The synchronization in complex networks is an important phenomenon in both mathematical and physical sciences because of its numerous applications to diverse problems such as population dynamic, power system, chemical process simulation, automatic control as well as many others.

Synchronization is the process in which two (or more) dynamical systems seek to adjust a certain prescribed property of their motion to a common behavior in the limit as time tends to infinity either by virtue of coupling or by forcing [2]. Since Pecora and Carroll found the chaos synchronization in 1990, synchronization has been widely studied because of its potential application in many different areas. In the process of studying synchronization of complex networks, time delays and stochastic perturbations should be considered in order to simulate realistic networks. Time delays are ubiquitous in the real world. In complex dynamical networks, the internal delay time cause chaos, such as delayed neural networks and delayed Chua's circuit system, etc; the outer coupling delay time cannot be ignored, such as in communication and traffic congestion, etc. In [3][4][5], authors investigated synchronization of complex networks with coupling delays. Furthermore, uncertainties commonly exist in the real world, such as stochastic forces on the physical systems and noisy measurements caused by environmental uncertainties, so a stochastic behavior should be produced instead of a deterministic one [6]. In fact, signals transmitted between nodes of complex networks are unavoidably subject to stochastic perturbations from environment, which may cause information contained in these signals to be lost [7]. Additionally, synchronization of networks with switching topology has attracted researchers interest [8][9]. Switching topology often due to link failures or new creation is general in real-world networks [9].

As we all know, the real-world networks normally have a large number of nodes, and it is usually impractical to control a complex network by adding the controllers to all nodes. Pinning control, in which controllers are only applied to a small fraction of nodes, is an effective way to reduce the number of controlled nodes. Chen T. *et. al.* [10] proved that the complex networks with symmetric or asymmetric coupling matrix achieved synchronization by a single pinning controller. Zhao J. *et. al.* [11] showed that a pinning scheme was proposed to globally exponentially stabilize a network onto a homogeneous state and how to select an optimal combination between the number of pinned nodes and the feedback control gain . Lu J. *et. al.* [12][13] found the relationship between coupling strength and the number of pinning node of a network with a fix network structure.

Based on the above analysis, we study the exponential synchronization of stochastic time-varying delay complex networks with switching topology by pinning control in this paper. We formulate a new stochastic complex network with internal time-varying delayed nondelayed and time-varying delayed couplings, switching topology, and Wiener processes. By using the Lyapunov-Krasovskii functional method, the stochastic stability analysis theory, and linear matrix inequality technique (LMI), some novel sufficient conditions are derived to guarantee exponential synchronization of the complex networks.

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