International Journal of Innovative Computing, Information and Control
Volume **7**, Number **6**, June **2011**

ICIC International ©2011 ISSN 1349-4198
pp. 3533–3543

ROBUST GUARANTEED COST CONTROLLER DESIGN FOR NETWORKED CONTROL SYSTEMS: DISCRETIZED APPROACH

Thuan Nguyen Quang, Ivan Holič and Vojtech Veselý

Institute of Control and Industrial Informatics
Faculty of Electrical Engineering and Information Technology
Slovak University of Technology
Ilkovičova 3, 812 19 Bratislava, Slovak Republic
{ thuan.quang; ivan.holic; vojtech.vesely }@stuba.sk

Received May 2010; revised September 2010

Abstract. *The paper addresses the problem of static output feedback guaranteed cost controller design for Networked Control Systems (NCSs) with time-varying delay and polytopic uncertainties. Based on partitioning scheme of time-varying delay and using integral quadratic constraint (IQC), a new discretized Lyapunov-Krasovskii functional method is obtained to design a PI controller achieving a guaranteed cost such that the NCSs can be stabilized for all admissible uncertainties and time-varying delays. Finally, some numerical examples are given to illustrate the effectiveness of the proposed method.*
Keywords: Lyapunov-Krasovskii functional (LKF), Networked control systems (NCSs), Polytopic system, Time-varying delay, Integral quadratic constraint (IQC)

1. **Introduction.** Feedback control systems wherein the loops are closed through real-time networks are called Networked Control Systems (NCSs) (Ray and Halevi [1]; Nilson [6]; Walsh et al. [5]; Zhang et al. [16]). Advantages of using NCSs in the control area include simplicity, cost-effectiveness, ease of system diagnosis and maintenance, increased system agility and testability. However, the integration of communication real-time networks into feedback control loops inevitable leads to some problems. As a result, it leads to a network-induced delay in networked control closed-loop system. The existence of such kind of delay in a network-based control loop can induce instability or poor performance of control systems (Jiang and Han [17]).

There are two approaches for controller design and study of closed-loop system stability in the time domain: Razumikhin theorem and Lyapunov-Krasovskii functional (LKF) approach. It is well known that the LKF approach often provides less conservative results than Razumikhin theorem (Friedman and Niculescu [3]; Richard [7]; Kharitonov and Melchor-Aguilar [13]). The challenge of all approaches using simple LKF is the conservatism of the respective algorithms. The delay-independent stability condition is very conservative if the delay is known. Although the simple delay-dependent condition using model transformation is intended to improve the situation, it is not necessary less conservative in all situations. Furthermore, the method using implicit model transformation is less conservative than two previous ones; however, it still includes certain conservatism and requires the system to be stable if the delay is set to zero (Gu and Niculescu [8]). To reduce the conservatism efficiently, two techniques have been developed. The first one is partitioning the delay to N_d parts and using the discretized scheme of the Lyapunov-Krasovskii matrices for these parts. It has been shown that if $N_d \to \infty$, the sufficient stability conditions for time delay systems approach to necessary ones (Gu et al. [9]). The price of an increasing N_d is the increased number of variables to be optimized. Another