

Robust Control of Systems over Communication Network

Vojislav Z Filipović, PhD (Eng)¹⁾

In this paper the problem of robust control of constrained linear dynamic systems, in the presence of communication networks with queues, is considered. The communication network is between the process and the controller. We assume that the queue is in the sensor. The closed-loop system may face the problem of induced random delays caused by the communication network and that delay would deteriorate the system performance as well as its stability. Digital control systems with random but bounded delay in the feedback loop can be modeled as finite dimensional discrete-time jump linear systems with transition jumps being modeled as finite state Markov chains. The queue is modeled as a nonlinear systems to which feedback linearisation methodology is applied. Then the complete system (process, communication network, queue) can be presented as a discrete-time jump system. For such a system, without unmodeled dynamics, the constrained quadratic control is proposed. The analysis of the system is then performed in the presence of unmodeled dynamics. This kind of systems has wide applications in military systems and process control systems.

Key words: communication system, communication network, network control, robust control, dynamic system, linear system, random delay.

Introduction

IN many industrial systems, especially those with remote sensors, actuators and controllers, a communication network is used to gather sensor data and send control signals. A communication network is a cost-effective and reliable way to coordinate different modules of control systems. Utilization of a multi-user network with random demands, affecting the network traffic, could result in random delays in the feedback-loop. These delays will deteriorate the system performance as well as stability. The problem becomes more complicated when, queue formation is also, considered for closed-loop data transmission.

Time-delays are important components of many dynamical systems that describe interconnection between dynamics, propagation or transport phenomena and heredity and competition in population dynamics. In monograph [14] the stability and stabilization of such systems are considered using a unified eigenvalue-based approach. Application of methodology is demonstrated on the congestion analysis in a high performance communication network.

The paper considers a situation when a communication network is incorporated between the process and the controllers (up link case). The control systems, involve a queue as well. Such kind of systems is considered in [3]. In this paper the queue has a FIFO (first-in, first-out) structure. With the known maximum buffer size and the upper bound of random delay in the communication link, the recursive relation for controller input is described in the above paper. The static controller is then considered for jump systems.

In [17] the problem of control systems with random communication delays is considered. It is shown that the control systems with random and bounded delays in the feedback loop can be modeled as finite dimensional

discrete-time jump linear systems with the transition jumps being modeled as finite-state Markov chains. The important conclusion of this the paper is that control of the augmented state-space model is an output feedback problem even if a state feedback law is intended for the original system.

Many physical systems are subject to frequent unpredictable structure changes (random failures, sudden environment disturbances, abrupt variation of operating points). Such systems can be described with Markovian jump systems. The system is a hybrid system with the state vector which has two components x_k and $r(k)$. The first one is generally referred to as the state, and the second one is regarded as the mode. Stability of stochastic systems with Markovian switching is considered in [1], [13] and [20]. Stochastic nonlinear hybrid systems are considered in [7].

In this paper we will consider the robust control of systems over a communication network and a queue. The results in this paper differ in the following from the known results in the literature

- (i) For a network buffer (queue) in this paper we use a nonlinear mathematical model. The feedback linearization is applied to that model.
- (ii) The process model has unmodeled dynamics
- (iii) The controller is robust and designed in the presence of a set of constraints
- (iv) The transition probability of Markov chains is not exactly known but belongs to the convex hull.
- (v) Using the LMI tool, the robust stability, in the sense of mean square stability, is proved.

The problem under consideration belongs to the field of discrete-time Markovian jump linear systems. That kind of systems is considered in [5].

¹⁾ Regional Center for Talents, PO Box 126, 15300 Loznica, SERBIA

