

ROBUST STABILITY OF NETWORKED CONTROL SYSTEMS BASED ON LYAPUNOV-RAZUMIKHIN THEORY

Vojislav Filipovic

Abstract: A model of the networked control systems (NCS) is considered in the presence of network-induced delay, the data packet dropout in the transmission and unmodeled dynamics. The model is equivalent to a linear system with a bounded time-varying delay. For such system the state feedback controller is proposed. Using Lyapunov-Razumikhin theory stability of system is considered. In the form of theorem the improved delay-dependent stability criteria are formulated.

Key words: Networked control systems, Razumikhin theorem, Stability

1. Introduction

Many modern control systems have some control loops that are closed via a serial communication channel that transmits signals from many sensors and actuators in the system. The examples are well known high-speed LAN such as Ethernet (standard IEEE 802.3) and Token Ring (standard IEEE 802.5)[1]. Networked control systems (NCS) are currently receiving considerable attention in the literature [2]-[4]. The basic problems in NCS are: network induced delay, single-packet or multiple packet transmission of plant inputs and outputs and dropping of network packets [5]. Also, the serial communication channel has many nodes (sensors and actuators) where only one node can report its value at the time so that scheduling of NCS is a very important task [6].

A basic problem in an NCS is the stability of the system. Different approaches exist for such kind of problems. When only messages from a sensor are transmitted through a network the NCS can be approximated by a continuous time model, a perturbation method of stability analysis of NCS is considered in [7]. A model based stability of NCS is considered in [8]. Stability problem of NCS, based in hybrid system technique, has been investigated in [5]. Hybrid control systems recently is considered in series of author's papers [9]-[13]. In all of the above works one first designs the controller without taking into account the network and then, in the second step, one determines a design parameter, known as a maximum allowable transfer interval, so that the closed loop remains stable.

The controller design for the NCS, for stochastic control systems, have been proposed in [14] and [15]. The NCS, in the frame of constrained control and estimation, is considered in [16]. Stability and robustness of high-speed networks, using randomized algorithms, is considered in [17]. In [18] the model of the NCSs is provided under consideration of both the network-induced delay and the data packet dropout in the

transmission. The controller design method is based on a delay-dependent approach.

Nonlinear NCS have received less attention. Such problems are considered in [19] and [20]. In the reference [20] the result on input-output L_p stability of NCS are presented for a large class of network scheduling protocols. In this paper we will consider the controller design for the NCS in the presence of model uncertainty. The uncertainty is described by an affine family of matrices. Also, the model includes network-induced delay and data packet dropout in the transmission. As in [18] it is supposed that the sensor is clock driven, the controller and actuator are event driven, and the data are transmitted in the form of a single packet. In this paper we will improve results from [21].

2. Problem formulation

The continuous system with unmodeled dynamic is given as

$$\dot{x}(t) = A(q)x(t) + Bu(t) \quad (1)$$

$$A(q) = A + \sum_{i=1}^e q_i A_i, \quad q \in Q \quad (2)$$

where $x(t) \in R^n$ and $u(t) \in R^m$ are the state vector and control input respectively. The $A(q)$ is an affine family of matrices by which the uncertainty is described. It is supposed that the sensor is clock-driven, the controller and actuator are event driven and the data is transmitted as a single packet.

The control input is realised as a zeroth-order hold. That means that the input is piecewise constant function. The system (1), if we take into account network-induced delay and network packet dropout, will take the form [5], [18]

$$\dot{x}(t) = A(q)x(t) + Bu(t), \quad t \in [i_k h + \tau_k, i_{k+1} h + \tau_{k+1}) \quad (3)$$

