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# Fault detection for a class of nonlinear networked control systems with Markov sensors assignment and random transmission delays

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**Abstract**

The paper investigates the fault detection problem for a class of nonlinear networked control systems with both communication constraints and random transmission delays. The access status of the sensors is governed by a stochastic event, which is modeled as a Markov chain taking matrix values in a certain set. The main task of this paper is to design a mode-dependent fault detection filter, such that for Markov sensors assignment, random network-induced delays and the unknown input signal, the error between the fault and the residual signal is minimized. And the resulting fault detection dynamics is formulated as an $H_\infty$ filtering problem of a Markov jump system. The linear matrix inequality-based sufficient conditions for the existence of the fault detection filter are obtained. Finally, two examples are given to show the effectiveness of the developed method.


## 1. Introduction

Networked control systems (NCSs), also named as network-based control systems, integrated control and communication systems, or information-based systems, are spatially distributed systems, wherein the sensors, the controller and the actuators are linked via a shared wired/wireless

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communication channels [1–3]. The last decades have witnessed that NCSs have been widely used in many practical engineering applications, such as automobiles, manufacturing plants, aircrafts and so on for the reason that they offer many advantages, for example, reliability, reduced systems wiring and reconfigurability, and enhanced resource utilization. However, the insertion of the network inevitably induces a series of problems, such as network-induced delays, packet dropouts, quantization problems, schedulings, and fading problems, which are the main sources of poor system performance and instability. Among them, the issues of network-induced delays and packet dropouts are the two most basic problems, therefore, it is not surprising that a lot of outstanding papers have deeply investigated them in the past few years, see references, [4–12].

The majority of the above-mentioned paper have assumed that all the sensors and actuators can be simultaneously accommodated by the communication network. But in fact, this is not always the case, especially for large-scale systems. Therefore, scheduling problems should be thoroughly considered in designing a control or filtering system over networks. Then, a lot of literatures have concerned the problem of scheduling, such as [2,3,13–19]. To mention a few of them, [2] has the first defined the concept of the network scheduling in NCSs, meanwhile, the paper has studied the network scheduling when a set of NCSs are linked to the network and arbitrating for network bandwidth. Ref. [3] has introduced the try-once-discard (TOD) scheduling for multiple-input–multiple-output NCSs and has presented the global exponential stability results for both TOD and statically scheduled methods for the first time. Ref. [13] has discussed the strategy of communication and control co-design problem for systems with the time-delay, wherein a periodic communication sequence has been presented. Both [16,17] have investigated the stability and controller design for linear systems with events assigned sensors and/or actuators, in which events have been molded as Markov chains taking matrix values in certain sets. The main difference between them lies in that the former has concerned the assignment of sensors and actuators and the latter has only considered the assignment of actuators and with the assumption that all the sensors have been active. Then, [19] has dealt with the robust $H_\infty$ control for NCSs with the effect of communication constraints, random transmission delays and uncertainties. The access status of every sensor and actuator is governed by a stochastic variable, which satisfies the binary Bernoulli distribution.

Due to systems increasing demand for high performance, high safety and reliability standards, fault detection and isolation (FDI) has been a hot research field over the past few decades. The recent survey of FDI has been investigated in [20], which has studied all kinds of model-based FDI and reconfiguration methods. Generally speaking, the key point of FDI is to construct a residual signal and compare it with a predefined threshold. If the residual signal exceeds the predefined threshold, an alarm of the fault signal is generated immediately. Nowadays, as far as the extensive usage of NCSs is concerned, a natural and important research problem is to investigate FDI problems for NCSs with the effect of network-induced delays, packet dropouts, quantization problems and so on [21–25]. To mention a few of them, the problem of the robust fault detection for a class of discrete-time NCSs with the unknown input and multiple state delays has been discussed in [23]. A new measurement model has been constructed to represent both random measurement delays and stochastic packet dropouts. Then, [24] has investigated a novel FD strategy for a class of NCSs with the effect of stuck faults and stochastic packet dropouts in the finite-frequency domain. And the resulting system has been modeled as multi-models with a stochastic parameter. In what follows, the problem of event-based fault detection for a class of NCSs in the presence of the network-induced delay and the sector-bounded nonlinearity has been studied in [25]. Then, an event-based fault detection model has been established with the effect of the network-induced delay and the event-triggered scheme.