Real Time Prediction of Time Delays in a Networked Control System

Behrooz Rahmani
dept. of Mechanical Engineering
IUST
Tehran, Iran
b_rahmani@iust.ac.ir

Amir H.D. Markazi
dept. of Mechanical Engineering
IUST
Tehran, Iran
markazi@iust.ac.ir

Naser mozayani
dept. of Computer Engineering
IUST
Tehran, Iran
mozayani@iust.ac.ir

Abstract— **In this paper, a novel method for real time prediction of network transmission time delays is introduced. The proposed delay prediction method is based on the Multi-Layer Perceptron (MLP) neural model of the network. Unlike most of the previously existing methods, the proposed approach is both accurate and fast enough for a real time implementation.**

I. INTRODUCTION

A feedback control system in which the control loop is closed through a real-time network is called a networked control system (NCS). In such systems, as depicted in Fig. 1, the control system communicates with sensors and actuators through a suitable network and the system information, e.g., the reference input, the plant measured output and the control input, is transmitted through a network [1], [2].

Compared with the conventional point-to-point interconnected control systems, the primary advantages of an NCS are modular and flexible system design, simple and fast implementation and ease of diagnosis and maintenance.

Despite several advantages of an NCS, some new challenges and complexities arise. A network can be considered as a web of uncertain transmission paths, in which some packets could be lost during the transmission. Another important issue, which is the main objective of this paper, is the network-induced delay occurring in the exchange of data among sensors, actuators and controllers connected through the shared medium. Such delays affect the control loop from two aspects:

1) Performance degradation; i.e. higher overshoot, larger settling time, etc., and 2) the reduced stability or total instability of the closed-loop system [3]. Such delays can be constant or variable depending on the network type.

Unlike a conventional sampled data control system, relatively fast sampling may not guarantee a better performance of the NCS, for it may lead to excessive information traffic. Therefore, the selection of a suitable sampling rate for guaranteeing the performance may not be an easy task.

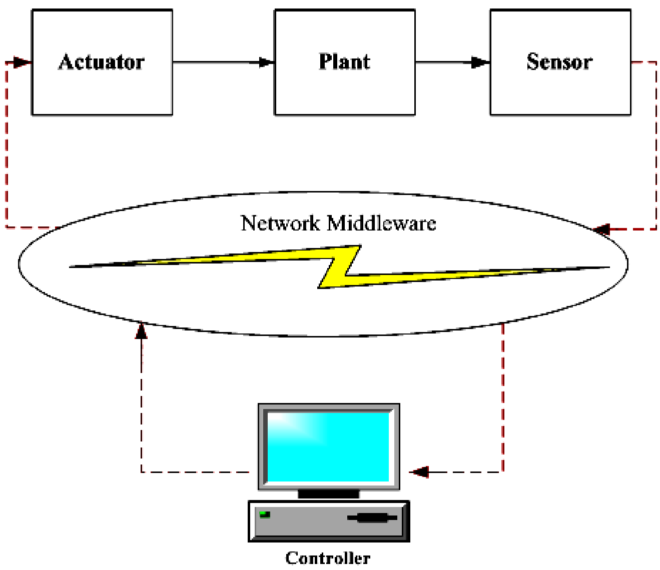

Fig. 1. NCS Setup and its Components

Some previous researchers studied the effects of fixed sampling periods on the stability of an NCS, and found bounds on the transmission delay, in terms of system parameters and selected sampling time, which guarantee the closed loop stability of the system. Zhang et al. [2] used the stability region plot of an NCS with respect to the sampling rate and network delay to determine the maximum allowable time delays. Ma et al. [4] proposed a new method to obtain a maximum allowable delay bound guaranteeing the stability of NCS with multi step delay by linear matrix inequalities (LMI), considering a fixed selected sampling time. Kim et al. [5] obtained such a bound for the stability of an NCS using the LMI formulation, and used it as the basic factor in the time scheduling. Walsh et al. [6] considered a continuous plant and controller assuming they are connected to

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