CHAPTER 1

INTRODUCTION

Over the past decades, the Networked Control Systems (NCS) has given rise to a new paradigm in control systems analysis and design in order to achieve real time requirements.

1.1 BACKGROUND AND MOTIVATION

A networked control system is a closed loop control system operated over a data communication network. The various components of NCS exchange information via a shared medium, a data network. The main motivation for using networks for data transmissions in control systems are high control utilization, reduce system wiring, simple and easy installation, greatly flexible, ease of system diagnosis (as all information is available everywhere in the system), cost has reduced after breakthrough of internet and presently reliable network technologies are available. Due to these reasons, networks will be more popular in real-time control data transferring.

When NCS is growing on one side and on the other side, wireless networks have been extensively researched at the same time because of providing possibilities for distributed, ubiquitous sensing applications and flexible and where also each node in the network performs sensing, processing of data and communication functions.

The high distributed nature of wireless network makes them adaptive to dynamically changing environment and fault tolerance. Even if
one node in the network experience problems, the network, sensing and data processing algorithms could adapt to the changing situation. Hence when packets would not be delivered through the faulty node, routes would be re-established and data processing would adapt to a missing source of measurements. So in wireless network automatic route establishment and other self healing properties are required in order to execute control tasks. But often in industrial applications pose stringent timing and reliability requirement and with wireless solution these are more difficult to meet with wired network.

The shared communication medium of NCS may be reserved at the time of sampling or there might be collisions of packets. Therefore the nodes might have to wait indefinitely before transmission or sometimes hard to share common timing information due to their distributed nature. NCS faces major challenges as networked-induced delays and packet losses/ dropouts which in turn degrades and destabilizes the closed loop control system performances.

During recent years the research of NCS has been rapidly increasing and various solutions to cope with varying time delays and loss of data have been proposed and developed. But currently only few main streams or methodologies are under specific investigation. A NCS can be modeled as a linear discrete time state space system with varying time delays in the control and output signals. The lyapunov like stability criteria are applied and the conditions for the corresponding Linear Matrix Inequalities (LMI) problem are presented as control laws and developed. Using efficient numerical solver the LMI is solved. On the other hand quite common way is to develop observers that act on the intermitted and delayed measurements and to apply Linear Quadratic Gaussian (LQG) design on them.
In these approaches the practical applicability is difficult and questionable, because their calculations are computationally demanding. An industrial control engineer might feel difficult or discomfort in using these mathematical challenging solutions in practice. More over even in wireless control systems computational issues plays a major role. Hence this motivates in developing computationless controllers for NCS and also for analyzing how the network deficiencies could be overcome by the right choice of controller structure and timing parameters.

This research discusses the control design aspects of NCS and focuses on the various types of controllers for networked DC motor control. Initially the traditional PID controllers which have been widely used in the industries is discussed and then moved towards the recent research area of Intelligent and Optimization technologies.

In order to study and synthesize the challenges in NCS, the networked DC motor control is chosen, due to the vast usage of DC motors in industries. The simple structured and robust PID controller is used initially inspite of their optimal tuning gain values which is often a burden with network induced time delay and nonlinearities.

For these reasons, the artificial intelligent techniques as Fuzzy Modulated PID, Neural Networks, Fuzzy Logic and Neuro-Fuzzy have been employed to improve the performance than PID controller and finally the performance of the networked DC motor is also carried out using PID-Particle Swarm Optimization (PSO) technique. Thus this thesis discusses and compares the performance of all the controllers such as PID, Fuzzy Modulated PID (FMPID), Artificial Neural Networks (ANN), Fuzzy Logic
Controllers (FLC), Neuro-Fuzzy Controllers (NFC) and PID-PSO for networked DC motor control and the results are verified.

1.2 OBJECTIVES

The objective of the research is to develop a controller such that it should maintain and track the desired output with minimum distortion for the networked DC motor system even though the measurements would be affected by the challenges faced by the networked control system. The sub-objectives of the research are as follows:

- Focusing on the behavior of the Ziegler Nichols tuned PID controller for networked DC motor control.

- Removing the hindrances of PID controller performance on networked DC motor control by using intelligent controllers.

- Developing a fuzzy compensator to modulate the PID controller for improving the performance of the system.

- Proposing and simulating the Fuzzy Logic Controller and Neural Network (NN) for further improving the performance of the system with network challenges.

- Using Neuro-Fuzzy controller (Adaptive Neuro-Fuzzy Inference System - ANFIS) by combining the Neural Network and Fuzzy Logic Controller in order to still reduce the distortion in the system.

- Synthesizing the system performance by using PID-PSO technique for improving the output of the system.
Thus the objective here is to examine and develop a computationally light controller algorithm which would have remarkable benefits over the traditional control methods. Hence the aim is to justify the choice of the intelligent controllers for NCS by comparing the performance from the reference tracking, robustness to delays, robustness to disturbance and noise perspectives.

1.3 CONTRIBUTIONS

The contributions towards this research are

1. Reviewed the challenges in networked control systems and available compensation techniques.

2. Proposed various controllers to compensate the challenges for networked DC motor control.

3. Developed a model for simulation on the DC motor set-up with proposed controllers for compensating the challenges such as induced delay, losses of signals and disturbances in the network path.

4. Compared the performance of the controllers from the simulation results obtained.

1.4 ORGANIZATION OF THE THESIS

The Thesis is organized as follows:

Chapter 2 presents the details regarding the overview of networked control systems and the challenges faced by the networks. The different approaches in networked control system, stability problem in NCS and
modeling of DC motor have been discussed. A detailed survey on networked control systems with several methods suggested by various authors taken from well-known literature are studied.

Chapter 3 discusses the basic conventional PID controller for controlling the networked DC motor. The tuning Zeigler Nichols method for PID gain parameters is presented. The PID algorithm is evaluated using simulation for various ranges of network-induced delays and losses and the results are analyzed.

Chapter 4 illustrates the use of Fuzzy Logic with PID controller as Fuzzy Modulated PID controller (FMPID) to remove the hindrances of PID controller. A Fuzzy Logic Controller (FLC) is proposed for the improvement in the performance of networked DC motor control system. The simulation is carried out for various ranges of network-induced delays and losses to study the performance of the networked dc motor control.

Chapter 5 describes the use of proposed Neural Network and Neuro-Fuzzy Controller for DC motor regulation in network environment. The simulation results are obtained for networked dc motor control system with network challenges and compared with other controllers.

Chapter 6 discusses the Particle Swarm Optimization for tuning the parameters of PID which is used for controlling the networked DC motor. The simulation results for various ranges of network-induced delays and losses are carried out and studied.

Chapter 7 summarizes the conclusion of the research and provides the future work.
1.5 SUMMARY

In this chapter the motivation, objective and the contribution towards the study and analysis of the challenges faced in the networked control systems are discussed.