Chapter 6

Wireless Sensor Network Based Data Fusion and Control Model for an Oil Production Platform

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ABSTRACT

In this chapter the authors propose methodologies for improving the efficiency of a control system in an industrial environment, specifically an oil production platform. They propose a data fusion model that consists of four steps – preprocessing, classification and association, data association and correlation association, and composite decision. The first two steps are executed at the sensor network level and the last two steps are done at the network manager or controller level. Their second proposal is a distributed hierarchical control system and network management system. Here the central idea is that the network manager and controller coordinate in order to make delays in feedback loops as well as for increasing the lifetime of the sensor network. The authors finally conclude the control system proposal by giving a controlling model using sensor networks to control the flow of hydrocarbons in an oil production platform.

INTRODUCTION

WirelessHART is a standard that has been developed by four major companies in control systems. They mainly deal with field devices and their monitoring and controlling aspects. In this chapter, components are any process devices. Sensor nodes are referred to as nodes or sensor nodes. The sensor nodes can be connected to a component to make it wireless. The sensor nodes are deployed in uniform distribution. Network related decisions that cover a large area are made by the network manager. Localized network decisions are taken by the sensor nodes themselves.
According to (Baillieul & Antsaklis, 2007), research is needed for networked control systems that are distributed, fault tolerant, that gracefully degrade under adverse conditions, and can operate in distributed independence. In this chapter we explore a system that incorporates a sensor network system on an oil field platform. The advantages of using sensor networks are the following. They are cost effective, they can have distributed operations, and their deployment and replacement is very easy in most cases. In this work, we have a case study on aspects of monitoring safety of pipelines. From an oil company’s proprietary data sheet, we see that not only pipeline flow control is required but options for emergency shut down of several pipelines by the use of valves in different locations is also required. We address both these requirements using sensor networks. The scenario is monitoring of pressure with consideration of important factors like flow rate, corrosion amount and flow regime with options of emergency shut down. This scenario is explored by employing sensor network control systems in the feedback loop.

RELATED WORK

There are a few related works in this field from the control system point of view. These works define the sensor network as a component of the system with varying delays. The work in (Eriks-son & Koivo, 2005) gives a model for tuning of a PID controller assuming a Gaussian varying time delays. The work in (Sinopoli, Schenato, Franceschetti, Poolla, & Sastry, 2005) analyzes a control system with time varying delays between sensor and controller and controller and actuator. The work in (Colandairaj, Irwin, Scanlon, & William, 2007) explores a combination of data rate scaling and sample rate adaptation for control systems to handle time varying network conditions. The other works include (Kawka & Alleyne, 2005), (Adam, Brady, & Kosc, 2001), (Peng, Huijin, Lei, Zhi, & Anke, 2006). In (Nikolakopoulos, Panousopoulou, Tzes, & Lygeros, 2005) a LPQ controller is designed whose parameters are changed depending on number of hops taken in network. Having a system based on complete path knowledge from source to destination is expensive and not implementable in sensor networks. Moreover, the Zigbee and 802.15.4 standards are used in sensor networks. According to (Nixon, Deji, Blevins, & Mok, 2008), control loop should execute 4 to 10 times faster than the processing time plus dead time. In addition to delays in the control loop, there is also a presence of jitter (i.e., variation in inputs, outputs, control execution). In terms of communication, the variation in delay to deliver a measurement from source to destination is referred to as jitter. By synchronizing network related processes with control execution, the need for over-sampling and communicating excessive measurements can be minimized. The work in (Dei, Snickars, Landernas, & Isaksson, 2008) proposes a methodology to counteract controller clock drift. It is seen that the performance improves if a Predictive PI (PPI) controller is used. The work also discusses a simulator tool in Simulink called TrueTime. The work in (Lennvall, Svensson, & Hekland, 2008) gives more details of the TrueTime Simulator.

PROPOSED WORK

The organization of this section is as follows. We begin with a discussion of our proposed system model. Next, we discuss the interaction between the controller and network manager and describe the advantages of our proposed system setup over existing work. This is followed by a discussion of our proposed data fusion model. Finally, we conclude by deriving a dynamic state model of a control system with a feedback loop, using sensor network, and propose a methodology for monitoring the health of the wireless sensor network.
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