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ScienceDirect

Procedia Technology 22 (2016) 652 – 656

Procedia Technology

9th International Conference Interdisciplinarity in Engineering, INTER-ENG 2015, 8-9 October 2015, Tirgu-Mures, Romania

Communication Resource Planning for Monitoring and Control Systems based on Distributed Virtual Instrumentation Networks

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Abstract

Distributed monitoring and control systems based on distributed virtual instrumentation networks consist of numerous components, ranging from field sensors to monitoring and control modules, which are potentially spread across a wide geographical area. This configuration requires a communication infrastructure to facilitate both physical and logical connectivity. In this paper, we tackle the challenge of planning communication resources that is in correlation with important topics such as: fast development, dependability and service availability.

Our discussions, conclusions and recommendations are based on an experimental platform developed in LabView. Our investigations pursue designing an optimal communication infrastructure and choosing the right communication bandwidth.

Peer-review under responsibility of the "Petru Maior" University of Tirgu Mures, Faculty of Engineering

Keywords: virtual instrumentation; SCADA; DCS; communication infrastructure; resource planning;

1. Introduction

Many technological processes are controlled by a significant number of functional parameters. Their efficiency is therefore highly reliant on the methodologies used for managing, monitoring, and controlling these parameters. Depending on the nature of the problem to be solved, basic instruments such as the ones provided by application development environments like SCADA (Supervisory Control and Data Acquisition) might suffice. However, real-

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Peer-review under responsibility of the "Petru Maior" University of Tirgu Mures, Faculty of Engineering
doi:10.1016/j.protcy.2016.01.136

time requirements (such as dynamically changing the metric, time frame or display mode) can only be satisfied with a wide range of functionally complex instruments.

In order to accommodate for this complexity, the implementation of such systems must be versatile - basic hardware should support as much functionality as possible. This is the principle behind virtual instrumentation, which leverages commercially available technologies to provide a platform for sophisticated measurement systems. Virtual instrumentation allows multi-level solutions, which provide distributed access to functional parameters and fine-grained control over various layers of abstraction. This is particularly important in technological processes spread across wide geographical areas, where the functional parameters that control the distributed field sensors must be centralized.

One of the main challenges in implementing distributed virtual instrumentation solutions is to connect the physical field devices which collect the data to the virtual instrumentation modules. The performance of the network is highly dependent of the efficiency of the communication between its components. Fast and reliable communication comes at the expense of physical resources, and an optimal trade-off must be determined. Therefore, planning communication resources must be a priority in the design process. The purpose of his paper is to establish a methodology for solving the resource allocation problem in an optimal way.

Previous work employed virtual instrumentation in various applications, such as diagnosis and monitoring of industrial equipment [1], production, transport and distribution of electricity [2, 3, 4], environmental monitoring [5, 6] and industrial quality control [7]. Many of these publications have educational purposes, aiming to study the inner workings of various processes [2, 10, 11] or simply explore virtual instrumentation [8].

Resource planning and network design in the context of virtual instrumentation have been approached from various angles. For instance, Jamont et al. [9] propose a solution based on multi-agent self-organizing processes, which is applicable in the case of wireless or other complex networks. However, their design cannot handle static networks. In contrast, we propose a solution that is applicable for networks that are not dynamically reconfigurable. Beruti et al. [12] provide a performance evaluation of measurement data acquisition systems in a distributed computing environment that makes use of instrumentation. They assess how the response time is impacted by different communication mechanisms and networks under various loads.

Generally, previous work has provided guidelines on how to configure virtual instrument networks, but there is no specific research on how to determine the necessary communication bandwidth.

The remainder of this paper is structured in the following way: the Research Methodology section proposes an experimental platform and describes our investigations. The Discussions and Results section summarizes and interprets our results. Finally, the Conclusions section reiterates our findings

2. Research Methodology

In the context of environmental monitoring and control, one of the most popular graphical system design tools is LabView. Its popularity in the field of virtual instrumentation is the reason why we chose this tool to design our solution.

2.1. The Architecture of the Experimental Platform

Monitoring and control systems consist of numerous components, ranging from field sensors to monitoring and control modules, which are potentially spread across a wide geographical area. This configuration requires a communication infrastructure to facilitate both physical and logical connectivity. Planning communication resources is therefore a crucial part of designing the system. In order to estimate these values, we built an experimental platform, described below.

We developed this experimental platform in LabView 2010 and tested it in a laboratory equipped with communication bandwidth control. Figures 1 and 2 describe the architecture of our solution.