NSF Engineering Research Center
for Reconfigurable Manufacturing Systems
Professor Dawn Tilbury (tilbury@umich.edu)
Dr. James Moyne (moyne@umich.edu)

Dedicated vs. Shared Networks for Safety and Control Systems

Kyle Schroeder and Aditya Thomas
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Introduction

Safety networks and associated programmable safety systems have been emerging in recent years in many manufacturing arenas. A consensus has not been reached on the most effective ways to make use of this new technology. A fundamental issue that has not been adequately explored is whether safety networking should be combined with existing controls networks on a shared wire as opposed to dedicated safety and controls networks. Resolving this issue is fundmental to plant floor network architectures and delivery of high Return-On-Investment. Results of applying a weighted cost function approach to the decision process show that either solution could be determined to be optimal, depending on the weights applied to specific cost factors as a result of the application environment.

Background

The purpose of a safety system is to reduce the risk of injury, environmental damage, or financial loss. A safety function is an action performed by a safety system which achieves or maintains a safe state for the equipment under control (EUC) [1]. In manufacturing, hardwired electrical circuits are still the primary mechanism used to perform safety functions. For example, the system installed on the Reconfigurable Factory Testbed (RFT) the cells are surrounded by a fence to prevent students and visitors from being hurt by the robots and CNC machines. When maintenance is performed on the equipment, the gate is opened. If no action is taken, the machinery would have the potential of injuring the student. To maintain the safe state, opening the gate breaks an electrical contact.

Cost Calculator

In a very general sense, each network configuration has advantages and disadvantages. A dedicated network configuration will be easier to set up, configure, and maintain than a shared network due to the interactions of two sets of performance requirements. System complexity impacts the performance, engineering, and maintenance costs of a system is a significant issue. A benefit of shared networks is that they often have a lower hardware (fixed) costs, while individual networks in some instances can have lower performance (recurring) costs.

In order to generalize this cost a two tiered cost calculator was developed to include relevant costs that should be included when network cost is to be calculated. Each of the top tier terms, described to the right can be further broken down to include second tier costs that will allow for an incremental cost calculator that terms can be added to as the body of research that describes the costs grows.

1. Hardware and installation ($Cost_H$)
2. Engineering and maintenance ($Cost_E$)
3. Performance ($Cost_P$).

This equation represents the first tier of the two tier cost calculator being proposed. Each of the three categories is made up of sub-categories such as number of nodes, network capacity, and ratio of shared to control nodes among other parameters. Additionally, the different weights (W_H, W_E, W_P) represent the terms assigned to Hardware, Engineering, and Performance costs to conduct an analysis of network cost with a common unit of measurement and, more importantly, to account for the different levels of importance assigned to each category.

Future Work

The major focus of this work is to develop the terms in the cost calculator. While the hardware and engineering costs of a network have been defined in terms of monetary measurements that can be easily defined and measured, the methods required to find the cost of poor network performance are not straight-forward and will require a significant effort to define. This research is moving forward with test protocols being planned and constructed that will allow for the gathering of safety network performance data that be used to develop the terms and weights of the cost calculator.

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References

[1] IEC 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems, 2001.

[2] Moyne, James, Bradley Triden, Aditya Thomas, Kyle Shroeder, and Dawn Tilbury. "Cost function and tradeoff analysis of dedicated vs. shared networks for safety and control systems." Automated Technology in Practice 2(2006): 22-31.