A Framework for Evaluating Distributed Control Systems in Nuclear Power Plants
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Introduction:

A framework for evaluating the use of distributed control systems (DCS) in nuclear power plants (NPP) is proposed. The framework consists of advanced communication, control, hardware and software technology. The test-bench provides an interface between any controller and simulator.

Through software monitoring the performance of the DCS can be evaluated. Controller access and response times over a Modbus network are observed and compared with theoretical values.

This framework allows a performance metric to be applied against different industrial controllers in various configurations.

Problem Statement:

Nuclear power plants (NPP) have a wide variety of control needs. They are usually met by products from various control equipment suppliers. These companies currently provide testing and support for state of the art technologies including sensor networks, instrumentation, and distributed control systems (DCS).

To be qualified for NPP, the functionality of commercial DCS should be evaluated.

In order to evaluate DCS systems the construction of a framework and test-bench is required. The initial connections of the testbed are defined above in Figure (4).

The test-bench should be able to monitor both the device and the model, while accurately recording this data for later processing.

Problem Solution:

The problem is broken into five components, each of which is presented in Figure (1).

- Input device characteristics (DCS).
- Input user requirements (BPC Module).
- Input model scenario (NPP Simulator).
- Output device behaviour (Captured by test-bench).
- Output model behaviour (Captured by test-bench).

Analysis of the device and model behaviour can be carried out offline.

Analysis:

The BPC example is used to benchmark the initial test-bench implementation. Figure (5) below shows the results of heating the outflow when feedwater temperature drops drastically. The only user requirement is that by 5 minutes the outflow temperature is restored.

Other factors involved with the DCS system are important. In particular, the communication behaviour is important to determine the number of variables that can be sampled during the control process.

Analysis (Continued)

The following Figure (3) illustrates the behaviour of variable read time versus the number of variables read through the channel. The response time degrades linearly with the number of variables as more time is required for each variable.

Results and Conclusions

The test-bench is successfully developed for the evaluation of DCS in a NPP. A simple boiler example is presented. The test-bench successfully integrates the industrial controller and the model on the NPP simulator. The device behaviour is measured during the testbench experiment.

A framework is designed in which the DCS controllers can be tested with simulated plant models.

Wherever possible, the framework uses the same hardware present in the plant.

Evaluating a particular realization of this controller is the primary interest. Any evaluation through pure simulation may incur uncertainties, since the model may not represent the physical system exactly.

Instead when the implemented controller is evaluated in a native environment, it is possible to better predict the behaviour of the controller and its performance in the NPP.

Future Considerations:

The example presented is only the first of many NPP scenarios that must be evaluated. If the NPP process employs a traditional stand-alone controller, the possibility exists that a further optimal controller may be created with enhanced plant state information delivered over a DCS network. These configurations should be evaluated for their use in NPP!

Thank you very much for taking the time to read through this poster!