A Study for Linkage and Utilization of MMIS Digital Twin and Physical Controller

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1. Introduction

The software V&V (Verification & Validation) for the control logic design change in the current operating nuclear power plant is scheduled to be expanded from safety-grade to non-safety-grade. For performance testing to verify the interconnection operation of the changed part, the test will be conducted directly at the power plant facility because there is no separate testbed. The design change test and application are performed during the power plant preventive maintenance period, which can affect the workload of field maintenance workers and the preventive maintenance period. To solve these problems, it is necessary to develop a separate testbed that can perform performance testing. In this paper, we propose a way to utilize the MMIS digital twin currently under development to connect with the actual control cabinet and use it as a testbed for V&V of control logic design change software.

2. Linkage

A digital equipment performance verification device has been developed to enable IIIL simulation in conjunction with a cabinet. The performance verification device is composed of a function that simulates the dynamic model of power plant equipment and a signal conversion device for linking the computational signals of the simulator to the actual control equipment.
Within the MMIS digital twin, there are virtual controllers, and among them, the connection with the actual target controller is disconnected, and instead, the network of the actual control equipment, the cabinet, is connected to the digital twin network. The binding data connected to the virtual controller is then transmitted from the performance verification equipment to the digital twin. This connection can be made by cabinet unit or rack unit.

3. Utilization

Although the digital twin emulates the physical equipment, it cannot be 100% identical to the actual equipment. Therefore, while software verification is possible with the digital twin, it has limitations in completely mimicking the physical characteristics of the cabinet.

Design changes are subject to unit testing and performance testing before they can be applied on-site. While unit testing can be performed on a separate device capable of card-level testing, such as Hot Panel, performance testing must be performed directly on the operating field equipment at the power plant, as the entire loop must be tested. If any anomalies occur during the performance testing, the cause must be identified and the testing must be redone. Usually, this testing is performed during preventative maintenance. However, as preventative maintenance periods have other schedules, complex changes can take a long time to complete. Nevertheless, utilizing a digital twin is expected to allow for prior inspection of such issues.

4. Second and following pages

When changing the safety-grade control logic software of the power plant, the design change software V&V procedure applies unit testing and performance testing after it is applied to the power plant. For unit testing to verify the changed part, it can typically be conducted at the field's hot panel. However, for performance testing to verify the interconnection operation of the changed part, there is no separate testbed, so the test will be conducted directly at the actual power plant facility. If the interconnection range is broad and the logic is complex, testing with field equipment may lead to situations that were not considered, resulting in an increased testing period and an impact on the power plant preventive maintenance schedule. Furthermore, as regulations are progressing to apply software V&V to non-safety-grade control logic in the future, the need for a testbed that can conduct unit and performance testing is increasing. However, the current hot panel at the field can only conduct card-level testing, and it is impossible to conduct interconnection testing for the entire system. It is difficult to produce a separate verification device that can test the entire interconnected system in APR1400 and OPR1000, considering the cost factor. However, it is expected that the construction of a testbed for unit and performance testing of control logic design change software V&V will be possible by utilizing the MMIS digital twin currently under development. Therefore, this paper proposes a method of using the MMIS digital twin currently under development to connect with the actual control cabinet and use it as a testbed for V&V of control logic design change software.

REFERENCES

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