Challenges to a Man-Machine Interface System in Nuclear Power Plants

Yeonsub Jung
Nuclear Engineering and Technology Institute, KHNP, 25-1 JangDong Yuseong, Daejeon, Korea
**Corresponding author: ysjung@khnp.co.kr*

1. Introduction

When the APR1400 project started nearly 20 years ago, advanced features such as intelligent alarms, computer-based procedures, and soft control technology were introduced. Although some of these technologies had been utilized in fossil plants, APR1400 opened a new horizon in MMIS for nuclear power plants.

Currently, however, it appears that further challenges do not exist in the MMIS area. Engineers are simply busy in designing and constructing the next nuclear plant without exploiting the new features of MMIS. This paper explains newly emerging and feasible technology and suggests new ideas for MMIS compared with other industries.

2. Challenges

The current architecture of I&C has evolved over time, and additional features of MMIS are not supposed to change the architecture. Fig. 1 shows a graph that integrates all of the challenges explained in this paper. The simulator is one node of the graph, which is different from the current I&C architecture.

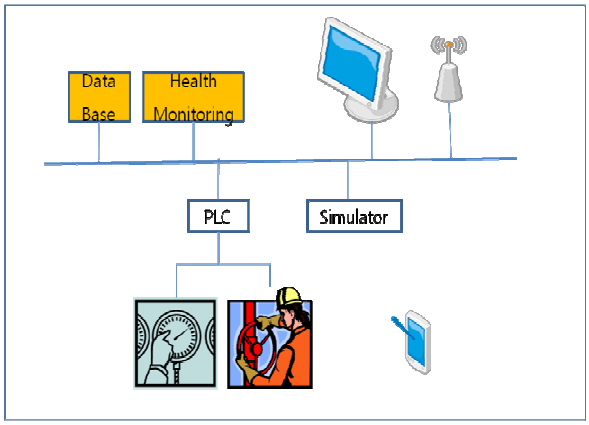

Fig 1. Advanced MMIS Architecture

2.1 Unified Soft Control [1]

As the equipment of nuclear power plants is categorized according to its safety level, the quality of the equipment can also be graded. The concept of classification proves useful and cost-effective during the design and construction of nuclear power plants. However, when this principle is applied to soft control, it is no longer a useful operating concept. It is inconvenient for operators to distinguish safety components from non-safety components for control. If soft control is developed as a safety grade, it can be applied to both safety and non-safety components.

2.2 User-Friendly Computer-Based Procedure [2]

Filling in a registration form on a website is sometimes a tedious task as carrying out a procedure in a nuclear power plant. In particular, the address field is one of such tedious item. Fortunately, the address can be linked and automatically filled in with the Korean postcode dialog.

Procedures require a considerable amount of information and control dialog, such as soft control, recording, and checking dialog. The various dialogs are difficult to implement and rarely supported by computer-based procedures.

Computer-based procedures have been used in nuclear power plants in western countries; however, there remains room for improvement in terms of the presentation, evaluation logic, and continuously applied steps used in those plants.

2.3 Integrated User Interface based on either P&ID or Systematic Drawings [1]

Most services of portal sites are integrated with maps because maps are intuitive. Furthermore, the maps are often overlaid with satellite images. Before MCR in chemical plants was introduced, control of the components took place in the local area where the component was installed. Due to I&C technology, controls from the MCR become the dominant design concept. At the same time, human engineers have struggled to find the best solution to arrange the indicators and switches so that they mesh with human cognition. The time to harness intuitive drawings such as P&ID or 3D schematic system drawings for user interfaces such as portal maps is the present.

2.4 Plug and Play

Most PC devices are plugged in and used immediately on account of predefined protocols. These tools have dramatically reduced the burden of maintenance and configuration. Software drives for specific devices no longer exist. On the other hand, the instruments of nuclear power plants are too specific for vendors. Once a device is obsolete, it is difficult to replace. Recently, most PLC and DCS possess similar functionalities; accordingly, it is likely possible to standardize the interface protocols. One example of this technology is OLE for process control as proposed by Microsoft [3].

2.5 System Health Monitoring [4]

Traditional I&C methodology focuses on the monitoring and control of important components owing

to a limited budget. Periodic health monitoring of the system is typically performed manually. At present, the cost of a sensor is a major concern. Actually, system health monitoring is closely related to control and monitoring. For instance, when an alarm occurs in a component, component health monitoring can give the cause of the alarm.

2.6 Synchronized Simulation

Simulators have been effective training tools, especially for operational training. The functions of simulators need to be expanded to support maintenance works. In addition, simulators should be synchronized with actual plants, as explanatory Korean Baduk boards for audiences are synchronized with a real Baduk match. This type of simulator is useful when operators predict the effects of a specific task. An operator can run the simulator prior to the actual operation.

2.7 Use of Mobile over Wireless Communication

Mobile technology has changed the pattern of ordinary life. Its applications, however, are limited to logging tools in nuclear power plants. Work in the local field demands a considerable amount of information, including a work plan, control logics, procedures, experiences, information on the status of nearby devices, and the voices of the MCR crew. These resources can be made available through mobile technology. Both EMI and the inconvenience of user interfaces have prevented nuclear personnel from using mobile devices. The MIT media lab is one of the frontiers in the development of ideas regarding mobile technology [5].

2.8 Object-Oriented Standard and Guidelines for a Man-Machine Interface

Human factor guidelines are published by many organizations, such as the NRC, IEEE, and IEC. Whenever these documents are applied to an indicator, which usually has many attributes (i.e., color, scale, characters and needle), it is not easy to find all of the guidelines in a single section. The requirements are scattered all over the document. Object-oriented design and documentation characterized by inheritance are useful for these tasks [6].

2.9 Modern Control [7]

It appears odd but true that all systems in nuclear power plants are controlled in a classical PID. The feedwater control system (FWCS) is not an exception. The FWCS is regarded as difficult to control due to its non-minimum phase behavior. Engineers have attempted to control the feedwater system in vain using systems other than a PID. Modern control pursues the achievement of control objectives without compromising its constraints. A modern controller can calculate the control output of a complex equation one per second.

2.10 Embedded and Linked Objects

Object linking and embedding has been a fascinating concept as implemented in Microsoft Office. An object such as a table, a figure or a drawing can be reused in other applications and documents after simply copying and pasting. The documents in the nuclear power plants are not dead but living things. They are continuously updated in accordance with design changes and organizational changes. However, a revision of a document demands much time and effort, and sometimes the approval of a regulatory body. If all the living objects are stored and maintained in a central server, the documents referring to the object can be automatically updated without further effort.

2.11 Work Order Management

How many hours do crew members spend to operate actual components? How does this apply to work order management? If the daily tasks of operators are analyzed, tasks other than operation take a larger portion. Presently, work order management is supported by other systems which are not integrated with the data from the actual plants. Work order management includes tagging, flagging, entrance permission, and beginning and ending notices for each subtask.

3. Conclusions

Control and monitoring in the analog age were regarded different from information technology. With the advance of digital technology, the boundary between MMIS and IT has gradually disappeared. The popularity of both PLC and DCS in plants results from the data management system in some aspects, which is invisible to MMIS engineers.

The features of I&C technologies have scarcely improved since APR1400 introduced a dramatic computer-based procedure. This paper has attempted to explain and suggest new design features of MMIS with consideration of state-of-the-art technology and its demands.

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