INTEGRATED CONTROL AND DIAGNOSTIC SYSTEM ARCHITECTURES FOR FUTURE NUCLEAR PLANTS

Richard T. Wood
José March-Leuba
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6010

Nuclear plants of the 21st century will employ higher levels of automation and fault tolerance to increase availability, reduce accident risk, and lower operating costs. Key developments in control algorithms, fault diagnostics, fault tolerance, and communication in a distributed system are needed to implement the fully automated plant. Equally challenging will be integrating developments in separate information and control fields into a cohesive system, which collectively achieves the overall goals of improved performance, safety, reliability, maintainability, and cost-effectiveness. Under the Nuclear Energy Research Initiative, the U. S. Department of Energy is sponsoring a project to address some of the technical issues involved in meeting the long-range goal of 21st century reactor control systems. This project, "A New Paradigm For Automated Development Of Highly Reliable Control Architectures For Future Nuclear Plants," involves researchers from Oak Ridge National Laboratory, the University of Tennessee, and North Carolina State University. The research tasks under this project focus on some of the first level breakthroughs in control design, diagnostic techniques, and information system design that will provide a path to enable the design process to be automated in the future. This paper describes the conceptual development of a proposed framework for an integrated nuclear control and information system (or Plant-Window System) architecture incorporating control and diagnostic capabilities.

The Plant-Window System (PWS) architecture can establish the integration platform for functional capabilities and the distributed communications framework to support operations, maintenance, and engineering personnel at the 21st century nuclear power plant. The network conveys information from the data acquisition sources to the users and applications that process the information. The issues of architecture for the nuclear power plant are:

1. Provide a common, consistent interface to I&C systems;
2. Enable uniform, transparent access to distributed data sources;
3. Establish a computing environment that facilitates the integration of information and applications (e.g., diagnostics and control);
4. Define a system architecture that permits flexibility in implementation and expandability of functional capabilities; and
5. Define an approach to application support that lays the foundation for standardizing functions and interface conventions for the nuclear power industry.

Simply establishing network links among the various systems and installing workstations as network nodes addresses only part of the desired support for plant personnel at the of 21st century

plant. An integrated platform is needed to providing common functionality throughout the control and information system architecture.

The first objective for the PWS architecture is to establish user interface conventions and symbology based on human factors guidelines for consistent, easy-to-remember interactive features. Consistency in the interface style simplifies user training, allows users to accomplish tasks more efficiently, and reduces user errors.

The PWS architecture requires coordinated information about the data available and its location. In addition, a common mechanism is needed for access to and interaction with distributed data sources of diverse types. Transparency implies plant-wide data access without requiring the user to become involved in the details of locating and connecting to data sources on the network, interacting with different data sources through diverse transaction mechanisms, and converting data from different sources to a common representation. By providing distributed data management capabilities with uniform data interaction services and a consistent data representation, information gathering through the system architecture can be automated and the user can focus on the task at hand rather than the computer interface.

An open architecture for software services ensures compatibility of software from different vendors and suppliers of software. Wrapper software, called "application programming interfaces," handles environment dependent operations. The integration of plant tasks through the information system architecture establishes standard system services, programming and communications. The application programming interfaces provide connections between applications and the functional capabilities of the system. Providing functional requirements for interaction among network hardware and software components ensures a level of software development uniformity and abstraction that allows high-level software development techniques such as automated code validation and computer-aided design of nuclear systems to be possible in the future.

The PWS concept is based on a layered approach with the capabilities and services of the application environment supporting the functionality of applications (e.g., diagnostics or controls). Figure 1illustrates the proposed integrated platform architecture. Prototypes of the specific software elements needed to realize this architectural concept are currently under development for an intended project demonstration. The PWS architecture can provide the framework for the integration and use of plant controls, operator advisors, and diagnostic aids. The results of this approach for the 21st century plant lead to improved performance, safety, reliability, maintainability, and cost-effectiveness.

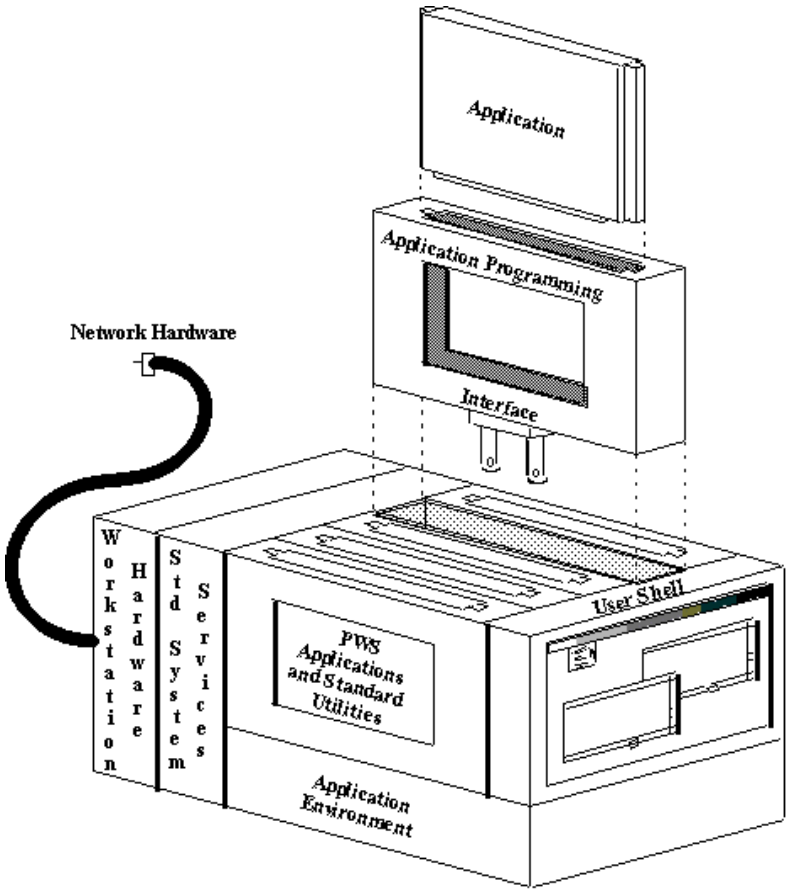

Figure 1. Illustration of Plant-Windows System Application Environment and Application Programming Interfaces