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Computer Applications for Reactor Control and Diagnosis

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As a result of the Three Mile Island (TMI-II) accident, the nuclear industry has emphasized development of methodologies and systems that will enhance the safety of the nuclear power industry. The operator is the focal point of the control of a nuclear power system and, as such, requires the input of reliable and complete information in order to make proper decisions related to plant operation and safety. Extensive effort is being employed throughout the technical community in the area of Man-Machine Interaction (MMI) to assist the operator with this task.

Argonne is actively involved in specific areas of application and development that provide direct support to program goals and objectives defined in the LMFBR Safety Man-Machine Interface Program Plan. The stated objective of that plan is: "Enhancing the operational safety of fast breeder reactors by optimum integration of men and machines and by application of the principles of human-factors engineering to the design of equipments, systems, facilities, operational aids, procedures, and environments."

Argonne's goal is to become a principal participant in the development, integration and demonstration of MMI concepts. Utilizing the unique capabilities of the EBR-II reactor as a test facility, we can offer to the community the opportunity to checkout, test, demonstrate and evaluate their concepts on an operating nuclear power plant. We are presently making the necessary preparations and working with interested members of the technical community to more fully utilize this unique capability.

Development efforts at Argonne are primarily directed to the Man-Machine Control System (MMCS). This system is based on the following concept:

> Mankind develops machine systems to enhance his mental and physical aptitudes. Because machine systems do not exhibit true intelligence, they require some kind of control mechanism. The control mechanism

becomes the control system that provides man with the operational and control interface with the machine and, therefore, the man becomes an integral part of the control system. Control systems should be designed to optimize efficiency, productivity, and safety.

In the man-machine control system, the man and the machine operate both as redundant and unique controllers. As redundant controllers, each has the capacity to perform the same control function. As unique controllers, each can have assigned to it specific and separate control functions. The man-machine control system should be designed to optimize the man and machine interaction and interfaces. This system should allow the man to perform those things a man does best and allow the machine to perform those things the machine does best.

The attached figure is a functional diagram (model) of the EBR-II MMCS.

The "Acquire Data" function is accomplished via the traditional data acquisition type system.

The "Validate Data" function will be accomplished thru application of diagnostic concepts and sensor validation and analytic redundancy techniques. A technique developed by the Charles Stark Draper Laboratory utilizing sensor validation and analytic redundancy for signals where sensors have failed has already been applied successfully to the EBR-II primary flow system.

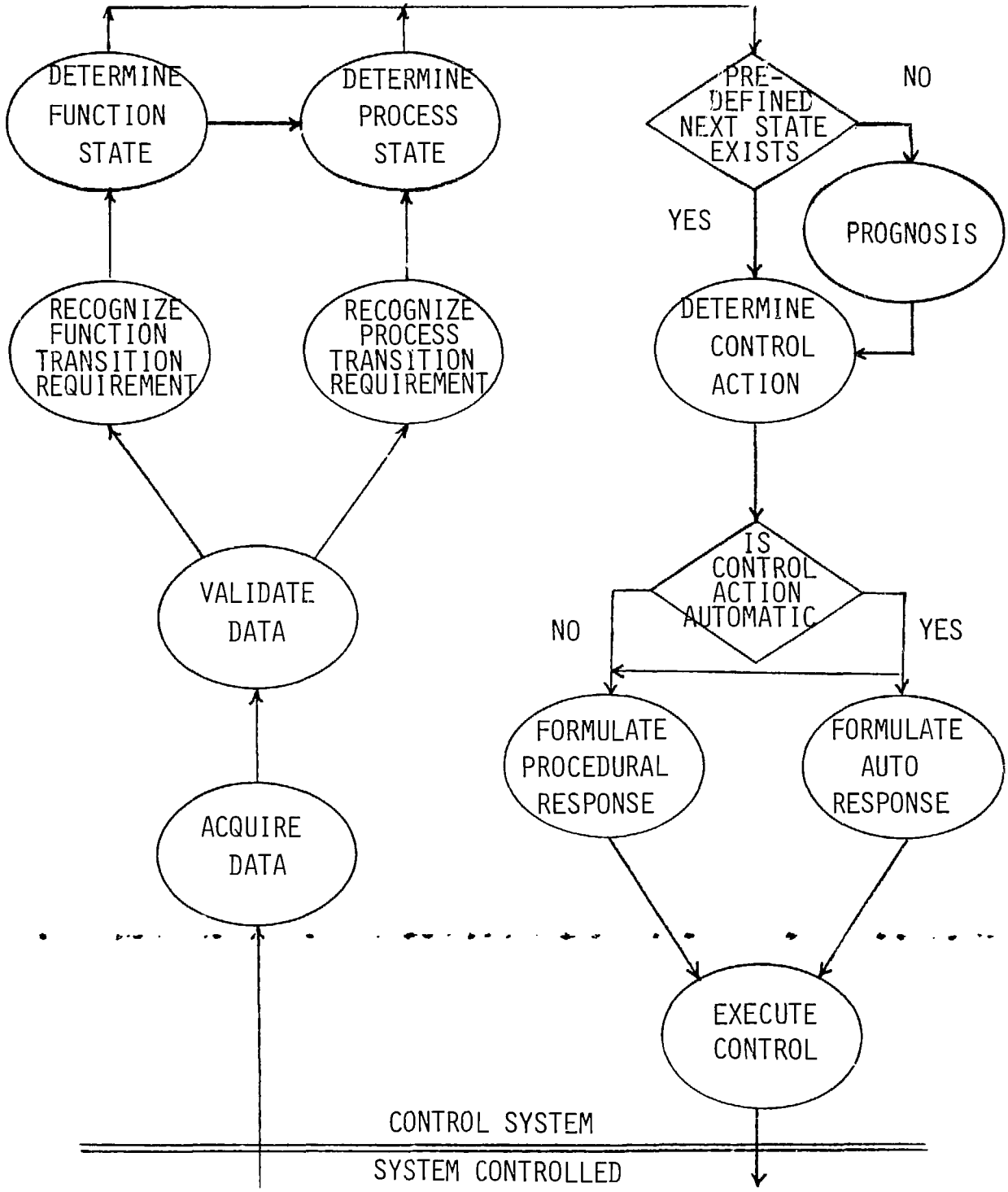
The "Determine States," "Determine Control Action" and "Formulate Response" functions will be accomplished by a system being developed at Argonne called the State Transition Prompting System (STPS). The STPS uses administrative and parametrical data to perform the above functions. Classically, procedures for system control during normal and off-normal states are

developed by system experts answering the "how" and "what if" questions. For large processes such as nuclear power plants, there is not enough time nor resources available to prepare procedures for all possible off-normal situations. Therefore incomplete decision trees are generated. The STPS is a system that effectively resolves these types of problems. This system is predicated on the premise that the plant system can be modeled and that rules can be developed that explicitly define safe states and transition between these states. The STPS will integrate data base file systems with an automated reasoner to satisfy the above premise.

The administrative and parametrical data bases that interface with the STPS are respectively the Component Isolation Control System (CICS) and the Data Acquisition System (DAS). Presently the component isolation process at most nuclear plants is a manual process, maintained by a nonintegrated paper file system. This system has two deficiences; it requires the operator to spend his time searching out the proper diagrams and lists and filling out the appropriate forms and secondly, the final product, the isolation log, does not integrate the lists as a function of system, subsystem and component. The CICS is designed to eliminate the above problems by enabling the operator to automatically obtain drawings and lists, that are maintained accurately by engineering or maintenance groups, from a color graphics CRT screen. The operator will be able to produce the required log and tags via a computer. The system will automatically file and integrate the logs in its data base and will thereby enable the operator to obtain component isolation information from a number of different points of view, e.g., system, subsystem, and componert.

The "Execute Control" function then utilizes the STPS output as an auto-control system to execute the required control activity.

Another complementary development effort being considered by Argonne which builds upon the previous effort deals with the integration of the Plant Protective System functions into the control system. The design philosophy adopted for this effort will be to integrate the safety systems into the digital environment with sufficient isolation features to achieve compliance with safety standards. Benefits to be gained by such a system are simplicity, reduction of maintenance and enhanced operation.



MMCS FUNCTIONAL DIAGRAM