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COMPONENT CONFIGURATION CONTROL SYSTEM DEVELOPMENT AT EBR-II

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SUMMARY

COMPONENT CONFIGURATION CONTROL SYSTEM DEVELOPMENT AT EBR-II

One of the major programs being pursued by the EBR-II Divsion of Argonne National Laboratory is to improve the reliability of plant control and protection systems. This effort involves looking closely at the present state of the art and needs associated with plant diagnostic, control and protection systems. Our review indicates that much can be done to substantially improve performance in all three of these areas. Our experience, as well as that of others, indicates that faulty or improper maintenance activities are the underlying cause of the majority of operational problems. Recent advances in computer capability and applications have provided opportunities for great improvement in better accomplishing maintenance activities via component configuration control.

One of the areas of development at EBR-II involves a component configuration control system (CCCS). This system is a computerized control and planning aid for the nuclear power operator. Certain operation and maintenance activities in the plant require that the operator place and maintain specified plant elements in specific states. Plant elements are components (equipment, instruments, and valves), subsystems and systems that are a physical part of the plant and provide defined functions. State defines the condition of existence of an element, e.g., on, off, standby, failed, and maintenance.(1) For these plant activities, the operator must determine which elements will be placed in

specified states. He must then determine the functional impact of the defined element state transitions. And lastly, he must validate the element states subsequent to the placing of the elements in the desired state. Presently, the nuclear plant operator uses plant drawings (electrical schematics and piping and instrument diagrams), engineering and physics principles, training and plant specific knowledge to perform the above functions. The CCCS via classical computer programming and artificial intelligence aids in these functions, i.e., element and state determination, functional impact analysis, and element state validation.

The nuclear plant operator examines the operation or maintenance activity under consideration to determine the potential set of plant elements to be effected by the activity. The element set must also be considered from the points of view of personnel and equipment safety, purpose of the activity, and element functions required to maintain the plant objective. Knowing the above, the operator selects specific elements using plant electrical schematics and piping and instrument diagrams (P&ID's). He then logs this information, performs functional input analysis, and fills out component status tags.

The CCCS reduces the administrative burden required by this element identification function.(2,3) Using color graphics and an interactive screen, the operator interfaces with electrical schematics and P&ID's of his choice to identify and select components required for configuration control. This information is automatically logged in the configuration control data base (log) and status tags are output on demand. This information is maintained as a potential or candidate configuration until approved for plant execution. Approval is contingent on the results of the element function impact analysis. The configuration information is stored in the computerized data base for operator query, modification, and processing. The processed data can be output as integrated reports, information sheets, and status tags.

A major concern to the operator is the impact on the plant as a result of the candidate configurations. The operator must know and understand the functions lost because of the candidate configuration and its relation to the functions required as a result of the maintenance and plant objective. That is, the plant may require that two of three pumping functions be operable (one operating and another in standby) in order that the plant be allowed to operate above 10% power. Therefore, if the candidate configuration reduces one of the three pumping functions, flexibility is lost but functional capability still exists for operating above 10% power. However, if the candidate configuration reduces two of the three pumping functions then the plant capability is reduced to hot standby.

Impact analysis determines the functional impact on the plant state as a result of the desired configuration. Impact analysis is performed using the knowledge of the present element states, the candidate element states, and a functional model of the system and integrated systems in question. This part of the CCCS involves artificial intelligence (AI) and utilizes the AI language Prolog.[4] Impact analysis utilizes Prolog to encapsulate the system functional model, rules, and knowledge base in order to reason about the functional aspects of the candidate configuration.[1,5]

After a configuration requirement has been implemented on the plant, the new element state status must be verified. Classically, verification is performed by having an independent party visually verify the new states implemented by the executing party. Validation can also be performed by using plant parameters and knowing their association to element states. That is, if a valve is in the shut (off) state, then flow downstream of the valve should be zero. The CCCS validation function determines the realtime state of the plant elements via plant parametrical data, simulation models, valve positions, and control signals. The plant information required for validation is extracted from the realtime plant Data Acquisition System and the Dynamic Simulation Nuclear Plant (DSNP) simulation model. This function of the CCCS therefore utilizes artificial intelligence (AI) as well as physics validation models. However, the aspect of AI used here for knowledge representation and heuristics is an expert system approach.[6,7]

The initial application of this development work will involve the EBR-II Argon Cooling System (ACS) which is used in fuel handling operations. This system contains all the features needed for a test bed.

- Provides sufficient components, complexity, and redundancy to allow meaningful tests.
- Highly instrumented.

- High safety significance.
- Available for testing except when required for fuel handling operations.
- Well understood by operating personnel.

Once the system has been demonstrated, efforts will be made to apply it to larger systems and then to the total plant.

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