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Big Data For Operation and Maintenance Cost Reduction

PI: C. Smidts, The Ohio State University

Collaborators: M. Khafizov, The Ohio State University; H. Abdel-Khalik, Purdue University; V. Yadav, Idaho National Laboratories; A. Brock and E. Helm, Framatome; A. Zelaski and J. Greenwood, First Energy

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ABSTRACT:
This research will develop a first-of-a-kind framework for integrating Big Data capability into the daily activities of our current fleet of nuclear power plants. Big Data is traditionally defined as data sets with high volume, velocity, and heterogeneity. In the nuclear industry, while the volume and velocity of data may present computational challenges for existing analytics capabilities, data heterogeneity are seen to present the major challenge. This proposal will mainly focus on incorporating the wide range of data heterogeneities in nuclear power plants into an integrated Big Data Analytics capability. The primary end-product of this project will be a Big Data framework that is capable of dealing with the large volume and heterogeneity of the data found in nuclear power plants to extract timely and valuable information on equipment performance and to enable optimization of plant operation and maintenance based on the extracted information. The framework will be used as a support tool in daily activities of plant operation and maintenance and will reduce current costs while maintaining or improving safety levels. Overall, the project will not only benefit existing reactors, however it will open new frontiers to realize the long overdue value of Big Data Analytics in the nuclear sphere.

The major tasks include: Task 1. Defining the Knowledge Extraction Component of the Big Data Framework includes Identifying Available Data, Determining which information to Extract, Extracting the Knowledge; Task 2. Generate Insights and Plans includes Building and Reasoning with the Domain Knowledge, and Developing the Plans; Task 3. Develop interfaces that will allow plant managers to review the plans generated and make adequate decisions; Task 4. Tool Development consists in implementing the necessary algorithms; Task 5. Case Study consists in developing metrics for assessing the effectiveness and efficiency of the Big Data framework and applying it to a case study.

The methods include structured surveys and questionnaires, means-ends analysis, information reduction approaches such as Singular Value Decomposition, development of physics based signatures, machine learning approaches based on hierarchical combinations of neural networks (multi-layer perceptrons, Convolutional Neural Networks, Recurrent Neural Networks) and natural language processing for treating heterogeneous data, automated reasoning with domain knowledge, automated planning based on Markov Decision Processes and human computer interface design based on traceability, and explainability principles including the use of probes into neural networks, finally the use of measurement science to define sound measures for measuring the effectiveness and efficiency of the framework.

The Big Data framework will allow plant management to leverage the rich data available in nuclear power plants to monitor plant state in a timely manner and optimize plant management while maintaining the risk at an acceptable level and reducing operation and maintenance cost significantly.