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Light Water Reactor Sustainability Program

Seamless Digital Environment – Plan for Data Analytics Use Case Study

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SUMMARY

Multiple research efforts in the U.S Department of Energy Light Water Reactor Sustainability (LWRS) Program studies the need and design of an underlying architecture to support the increased amount and use of data in the nuclear power plant. More specifically the three LWRS research efforts; Digital Architecture for an Automated Plant, Automated Work Packages, and Computer-Based Procedures for Field Workers all have identified the need for a digital architecture and more importantly the need for a Seamless Digital Environment. A SDE provides a mean to access multiple applications, gather the data points needed, conduct the analysis requested, and present the result to the user with minimal or no effort by the user.

During the 2016 annual Nuclear Information Technology Strategic Leadership group meeting the nuclear utilities identified the need for research focused on data analytics. It was suggested that the effort would develop and evaluate use cases for data mining and analytics for employing information from plant sensors and database for use in developing improved business analytics. The research will be conducted in close collaboration with vendors, nuclear utilities, Institute of Nuclear Power Operations (INPO), and Electric Power Research Institute (EPRI).

The goal of the study is to research potential approaches to building an analytics solution for equipment reliability, on a small scale, focusing on either a single piece of equipment or a single system. The analytics solution will likely consist of a data integration layer, predictive and machine learning layer and the user interface layer that will display the output of the analysis in a straight forward, easy to consume manner.

This report describes the project plan for the FY17 research.

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ACRONYMS

CBP	computer-based procedures
EPRI	Electric Power Research Institute
eWP	electronic work package
INL	Idaho National Laboratory
INPO	Institute of Nuclear Power Operations
LWRS	Light Water Reactor Sustainability
NITSL	Nuclear Information Technology Strategic Leadership
PVNGS	Palo Verde Nuclear Generating Station
SDE	seamless digital environment

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1. INTRODUCTION

As technology continues to evolve and become more integrated into a worker's daily routine in the Nuclear Power industry the need for easy access to data becomes a priority. Not only does the need for data increase but the amount of data collected increases. In most cases the data is collected and stored in various software applications, many of which are legacy systems, which do not offer any other option to access the data except through the application's user interface. Furthermore the data gets grouped in "silos" according to work function and not necessarily by subject. Hence, in order to access all the information needed for a particular task or analysis one may have to access multiple applications to gather all the data needed.

The U.S Department of Energy Light Water Reactor Sustainability (LWRS) Program initiated research in to what is needed in order to provide a model for nuclear power plants to reference when building an architecture that can support the growing data supply and demand flowing through their networks. The LWRS Digital Architecture for an Automated Plant effort published the report *Digital Architecture Planning Model* (Oxstrand et. al, 2016), which describes items to consider when designing an architecture intended to support the increasing needs and demands of data throughout the plant.

A well-designed architecture will be able to support the data demands. However, in order to ensure the data is adequately utilized to improve and support the plant operations there also needs to be an easy, quick and reliable method to access the data. A common method is to create a "one stop shop" application that a user can go to get all the data they need. A key to this approach is an approach to integrate the data stored in different applications (e.g., work management system and plant information databases). In other words, there is a need for a Seamless Digital Environment (SDE). Without any effort by the user, the SDE will access all applications, gatherer the data points requested, conduct the analysis requested, and present the result to the user.

Research conducted in both the LWRS Computer-Based Procedures for Field Workers and the LWRS Automated Work Packages efforts indicates an increased interest by the industry to implement electronic work packages (eWPs) and computer-based procedures (CBPs) to improve system efficiency and reliability as well as increase human performance related to activities conducted in the plant. The Nuclear Electronic Work Package – Enterprise Requirements initiative, which was facilitated by Idaho National Laboratory (INL) in 2016, investigated how eWPs will enable immediate paper-related cost savings in work management and provide a path to future labor efficiency gains through enhanced integration and process improvement in support of the Nuclear Promise (Oxstrand and Bly, 2016). The deployment of eWPs and CBPs will create a new source and demand of data that needs to be incorporated in the SDE supported by the plant. The addition of eWPs and CBPs adds more near-real time data which can be used to make important plant decisions.

A study conducted by Oxstrand et al. in 2015 in the LWRS Automated Work Packages effort demonstrated means for automatic and wireless acquisition of plant process and components status information into the work order on a mobile device. To enable this automatic acquisition of data, a prototype platform for data exchange between the field instruments and the mobile devices was designed. The researchers aimed to develop an architecture design that is prompt, robust, and interoperable with any technology.

In order to make plant decisions based on the data it needs to be accurate and relevant. The ability to conduct data analytics becomes an important process needed to be incorporated when designing the SDE.

To facilitate the adoption of the SDE concept research into what data analytics could and should be conducted with the available date is needed. The research should utilize use cases to demonstrate benefits of data analytics as well as to demonstrate how to best present the aggregated or analyzed data to the user. There is also a need to benchmark the use of data analytics both within the nuclear industry and other industries to gather lessons learned. This input will be useful when utilities are moving forward with advanced data analytics. In the nuclear power industry, once a better work practice has been proven, there is a general expectation that the rest of the industry will adopt it. However, the long lead time of information technology infrastructure could prove to be a delaying factor.

In conclusion, the research should aim to provide a platform where the nuclear utilities can share their early experiences and lessons learned for their data analytics and seamless digital environment efforts. The research should also leverage international experience with these technologies and share the insights with the industry.

2. FY16 ACTIVITIES

The goal for FY16 was to complete a feasibility study for data mining and analytics for employing information from computer-based procedures enabled technologies for use in developing improved business analytics. The research team collaborated with multiple organizations to identify use cases or scenarios, which could be beneficial to investigate in a feasibility study.

During FY16 the research team met with an Operations representative from Palo Verde Nuclear Generating Station (PVNGS), several times in order to get a point of view from the industry of an activity that demonstrate advantages of an SDE. It was decided that a demonstration of how data gathered from workers using CBPs flows through the SDE and how it is displayed to upper management in order to make decisions.

It was decided to focus on middleware software to enable the communication and data management between the various data silos to create an SDE. The VP Products & Technology and Co-Founder of NextAxiom Technology Inc. was included in the discussions to help plan how the data could be gathered. NextAxiom is a vendor providing a platform that creates a virtualization layer on top of the various siloed data to present a seamless, location-transparent application.

In addition, the research team and NextAxiom explored a potential for a study with INL's Supply Chain Management group. The topic discussed was to create a status application that would cover the lifecycle of a purchase from the beginning to the time it reaches the user and then until final payment is processed to a vendor. The application would need to access various databases in order to bring the data together and display it in a simple format to an end user. More data could be shown as needed when users drilled down on specific parts of the data they wanted to get more information on.

Many interesting potential use cases were identified throughout the FY16 activity. Unfortunately, due to factors out of the research team's control, none of the studies were initiated this year. However, the insights gained and the relationships built with both PVNGS and NextAxiom will be valuable when moving forward with future research.

During the 2016 annual Nuclear Information Technology Strategic Leadership group meeting the nuclear utilities identified the need for research focused on data analytics. It was suggested that the effort would develop and evaluate use cases for data mining and analytics for employing information from plant sensors and database for use in developing improved business analytics.

3. FUTURE ACTIVITIES

As mentioned above, the outcome of the NITSL meeting was the recommendation to research data mining and analytics. The INL research team will take the lead in the NITSL activity, which will be

conducted in close collaborate with vendors, nuclear utilities, Institute of Nuclear Power Operations (INPO), and Electric Power Research Institute (EPRI).

The goal of the study is to research potential approaches to building an analytics solution for equipment reliability, on a small scale, focusing on either a single piece of equipment or a single system. An equipment or a system with sufficient amount of quality historical data will be selected for best results. The analytics solution will likely consist of a data integration layer, predictive and machine learning layer and the user interface layer that will display the output of the analysis in a straight forward, easy to consume manner. The study should use a middleware vendor's platform for data integration layer between different plant applications, such as the work management system and the plant information database. A statistical programming language such as R or SAS will be evaluated for use in predictive and machine learning layer. Effectiveness of various user interface types will be studied to determine the most appropriate manner in which to present the output to the end user.

The LWRS Digital Architectures for an Automated Plant is a research effort initiated in 2015 with the goal to develop a methodology for mapping power plant operational and support activities into the digital architecture. Due to the close relationship between digital architectures and digital environments it is beneficial to leverage the insights from both research efforts in any future activities. It is strongly recommended that the data analytics use case study be conducted in close collaboration with the Digital Architecture research.

The insights gained from the data analytics use case study should be used to update the digital architecture planning model, which was developed in the spring, 2016 (Oxstrand, et al., 2016). In other words, the data analytics study should be used as a use case in itself to evaluate the planning model. The result from the data analytics use case study should also be used as a bases for further development in the LWRS Automated Work Package research effort.

3.1 FY17 Research Plan

The data analytics use cases study will be conducted between October 1, 2016 and September 30, 2017. The research team will consist of two groups; the NITSL special interest group (SIG) and the project team.

The NITSL SIG will focus on broader questions related to data analytics and how/when it should be used to support the Nuclear Promise. The purpose of the SIG is for members to share insights and lessons learned from related activities in their organization and learn from others' experiences. The SIG will provide feedback on the Use Cases Study and feed the results from the study back to their organizations.

It is expected that the SIG have monthly telephone conferences and that minutes will be shared with all members. The SIG will have one main workshop at the next annual NITSL conference, July 2017, to discuss the progress and initial results from the study. There might be one or two additional workshops during the year if needed.

As of now, Arizona Public Service, Southern Nuclear Company, INPO, and INL are represented in the SIG. The project team is also a part of the SIG. The amount of members of the SIG is expected to increase as the effort kicks off in October, 2016. Any organization and system matter experts in the areas related to data analytics and SDE are welcome to participate in the SIG.

The project team is responsible for planning and executing the data analytic use cases study. The team is also responsible for communicating progress, potential issues, and insights with the SIG.

The project team will consist of information management and information technology experts at PVNGS, identified end-users at PVNGS, information integration experts from NextAxiom, and digital architecture and human factors researchers from INL. The project team will have more frequently recurring telephone conferences than the SIG. It is expected that the project team meet face-to-face at least a couple of times throughout the project to ensure a successful study.

Table 1 below shows the research plan for the FY17 data analytic use cases study. The plan consists of six main activities; identify use cases, develop technology, conduct the study, analyze the results, conduct the NITSL workshop, and compose a report.

Table 1. Data analytics use cases project plan for FY17.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Identify use cases												
Develop technology												
Conduct study												
Analyze results												
NITSL workshop												
Compose report												

The project needs to identify the use cases to be studied before moving to technology development. A part of this activity is to identify the systems which are affected in the use case and the potential users. The project team should investigate and document how the specific use cases are carried out with the current work processes. This will serve as the baseline in the data analytics use cases study. This activity is planned to take three months. However, the project will be mindful of the PVNGS outage, holiday, and vacation schedule. This activity will overlap with the technology development activity to allow minor revisions of the use cases based on insights potentially gained early in the technology development.

Three initial project team meetings have already been conducted in September. Two were conducted over the telephone and resulted in a scope description (incorporated in this report), identification of organizations to invite to the SIG, and initial discussions of use cases. The third meeting was conducted on site at PVNGS, September 14, 2016. During this meeting potential use cases were further discussed.

When the use cases are identified and the baseline documented, the team will start the technology development. During this activity the prototype needed to support the data analytics use cases study should be developed. It is expected that the main part of the development is conducted in collaboration between NextAxiom and PVNGS. The INL will provide usability and user interface design recommendations.

The technology development is assumed to be an iterative process where feedback from users (and team members) is requested and incorporated at least twice throughout the development to ensure the prototype meets the needs of both the study and the users. The development activity is scheduled for a total of four months.

The data analytics use cases study will be hosted by PVNGS in the spring of 2017. It is important that the project is mindful of PVNGS outage schedule when planning and conducting the study. The study should gather both quantitative data, e.g., time spent on task and amount of data points analyzed/presented to the user, and qualitative information, such as feedback on the user experience.

The quantitative and qualitative data will be analyzed and compared to the baseline information collected in the first activity. In July, 2017, the SIG workshop will be conducted at the NITSL conference. The purpose of the workshop is to discuss the study and its initial results. The feedback gathered during the workshop will be factored into the analysis.

The methodology, execution, and the results will be described in a report to be distribute to all NITSL members by the end of September. Any sensitive information will not be included in the report. The report will be reviewed by the SIG and other industry peers before finalized and made available to the public. If requested, a PVNGS specific report can be composed, which will be under limited distribution.

4. REFERENCES

Oxstrand, J., & Bly, A. (2016). *Computer-Based Procedures for Field Workers - FY16 Research Activities.* Idaho Falls: Idaho National Laboratory (INL/EXT-16-39984).

Oxstrand, J., Al Rashdan, A., Bly, A., Rice, B., Fitzgerald, K., & Wilson, K. (2016). *Digital Architecture Planning Model.* Idaho Falls: Idaho National Laboratory (INL/EXT-16-38200).

Oxstrand, J., Al Rashdan, A., Le Blanc, K., Bly, A., & Agarwal, V. (2015). *Light Water Reactor Sustainability Program Automated Work Package Prototype: Initial Design, Development, and Evaluation.* Idaho Falls: Idaho National Laboratory (INL/EXT-15-35825).