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**Development of Advanced Waste Management Software to Enhance
Operating Efficiency and Reduce Life-Cycle Cost at the
Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA**

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ABSTRACT

The U. S. Department of Energy's Oak Ridge National Laboratory in Oak Ridge, Tennessee has the need to disposition an estimated 500,000 excess chemicals over the next three years as research activities are moved from antiquated facilities into new chemical sciences facilities. In addition, several obsolete facilities will be emptied and prepared for demolition, and the effort will generate excess equipment and high-activity radioactive waste. The cost and schedule impact associated with the disposal of these wastes is significant, and has prompted investing in the development of an advanced waste management software solution to increase the speed of waste disposition and lower the life-cycle waste management costs. The new application will be operated using automated workflows and cover most aspects of waste management. The application will provide "expert system" capability to assist users in complying with regulatory and optimization requirements. ORNL plans to have BroadPointe fully deployed near the end of 2010.

INTRODUCTION

The U. S. Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL) is the largest DOE science and energy laboratory and serves as an international leader in a range of scientific areas. The laboratory hosts a variety of programs for basic and applied research and development in energy, neutron science, high-performance computing, complex biological systems, materials research at the nanoscale, and national security. ORNL's mission also includes isotope production, information management, and technical program management for DOE. ORNL has approximately 4,600 staff (about 1,500 scientists and engineers), hosts 3,000 guest researchers annually, and offers 20 user facilities.

Like many DOE Office of Science sites, ORNL routinely generates a small volume of highly diverse waste. For example, in 2009 ORNL generated approximately 120,000 kilograms of hazardous and mixed waste, and approximately 400 cubic meters of solid radioactive waste. While ORNL's routine waste volume is small, the characterization and packaging is often

expensive and complicated due to the wide spectrum of physical, chemical and radiological aspects of the materials encountered at ORNL. For example, ORNL currently uses tens of thousands of different chemicals and chemical products and is responsible for the experimental development of many new chemicals each year. In addition to chemical research, ORNL has an isotope production reactor and the world's most intense pulsed neutron source. During research activities, materials and chemicals become activated and contaminated by fission and spallation fragments. In 2009, ORNL disposed of radioactive and "mixed" waste with various mixtures of over 225 different isotopes. The waste diversity at ORNL makes it challenging to group items into a limited number of well-defined waste streams.

ORNL relies on a highly experienced staff to prepare the required waste characterization, shipping, and disposal documentation. The process starts with the field deployed staff members collecting process knowledge about the waste items and the type and sources of their likely hazard characteristics. After the process knowledge is collected and documented, waste management staff members meet to discern any data gaps and plan the next steps to obtain additional information. The additional data collection may be associated with intrusive sampling, non-destructive analysis, computer modeling, and literature research. This additional data collection is conducted by specialists and documented in a peer-reviewed calculation or technical paper. After the item or collection of items is adequately characterized, the disposal paperwork is initiated by entering the required administrative and technical data into a database application. A paper version of the database information is the official record since the database application does not accommodate electronic signatures or the addition of item-specific electronic attachments (e.g., photos, spreadsheets, etc.). The waste disposal document set is routed for review by specialists knowledgeable in onsite storage requirements, Department of Transportation (DOT) packaging regulations, and Treatment, Storage, and Disposal Facility (TSDF) acceptance criteria. The reviewers consider the adequacy of characterization and classification for every item within a disposal container. After the waste disposal documentation is approved, the containers are staged until sufficient volume of similar waste is available for an economical shipment to an off-site TSDF. The time required to complete the process for a small collection of waste items can take from weeks to months depending on the required characterization effort, packaging and disposal strategies, and processing time to route the disposal documentation for review, editing, and approval.

The current ORNL waste disposal process is primarily "expert-based" and relies on many levels of internal review to assure quality. The current process does not take advantage of the information efficiency possible with a robust electronic database system. The inefficiency of the current process is particularly problematic due to the anticipated surge in waste generation expected at ORNL over the next few years as the laboratory continues with modernize efforts. ORNL anticipates the need to disposition up to 500,000 excess chemicals over the next three years as chemical research is moved to new chemical sciences facilities. ORNL also expects to generate a considerable amount of excess equipment and high-activity radioactive waste from the decommissioning and demolition of older hot-cell facilities. Budgetary planning efforts have identified significant cost and schedule impacts associated with the disposal of the anticipated waste volumes and ORNL has decided to invest in the development of a new advanced waste management software database application to increase the speed of waste disposition and lower life-cycle waste management costs.

ORNL has defined five key design features to guide the development of an efficient waste management software application for ORNL waste. The key features are:

1. Item-level information management to facilitate accelerated review of characterization, onsite movement and consolidation of items in a central packaging facility. This information will also be utilized in an item-based generator charge-back cost model to encourage waste minimization and to ensure waste generators fund appropriate waste disposition costs,
2. Web-based central database application and field-deployed laptop and barcode reader applications to feed information into the central application,
3. Paperless workflow automation to route requests, monitor timely resolution, and track performance,
4. Dynamic User Interface (UI) to customize screens for minimizing key strokes and detailed screen sequencing using a “tax software” style UI to lead the users through the more involved aspects of characterization and calculations, and
5. Expert-system capability to capture and utilize the extensive waste management expertise at ORNL.

In fiscal year 2009, ORNL developed small prototype software applications for testing important aspects of the key design features. The tests included an item-level workflow, low-level radioactive waste classification, and characterization of chemical waste using manufacturer’s product code as a key identifier. The tests were successful and ORNL began to build the basic infrastructure and design the normalized relational database structure. A name, “BroadPointe”, was selected for the future application. This paper presents the current state of BroadPointe development with an emphasis on the major workflows and expert-system goals.

WORKFLOWS

A workflow is a sequence of connected steps that provide an abstraction of and control platform for real work. BroadPointe employs automated workflows to electronically process requests associated with waste, infrastructure, and data access. Some workflows contain only a few steps while others contain more than a dozen steps. Workflows are managed by moving individual requests through various “states” that are set by the responsible individuals who hold the appropriate role. When the request is processed, the “when, who and why” of the processing becomes part of a permanent electronic history file. The history files are accessible for quality assurance and process improvement purposes.

The workflow process is supported by application-generated notifications to assure timely processing of requests. The notifications are sent to responsible individuals who hold a role associated with the processing of requests. The notifications are triggered by an excessive time lapse of a request in one state, an excessive quantity of requests in one state, and/or a specific action taken by a reviewer of a request. In general, an acceptable time for an item to reside in one state is a few days; however, that time is readily adjustable if needed. The number of requests that are acceptable in one state is variable depending on the type of workflow but the

intent is to avoid a “log jam” and assure that enough staff is put into the processing of workflow requests. The typical specific actions that would generate a notification would be a rejection or an approval of a request.

The workflows in BroadPointe can be grouped into five categories:

- Item Acceptance
- Movement, Packaging and Shipment Planning
- Inventory, Equipment and Facility Management
- Waste Profiling
- Data Administration

Each of these workflow categories has unique aspects and a reliance on the information generated by the appropriate use of the other related workflows.

Item Acceptance

The key BroadPointe workflow process is the management of a waste “item”. From an information management perspective, BroadPointe considers an item to be an “indivisible waste unit” that may undergo physical management operations such as movement and packaging but retains the initial characteristics. For example, a plastic bag of radioactively contaminated paper and an excess unused chemical vial of solvent would qualify as valid “items” if the material characteristics and information were not altered after acceptance. An alteration to the item would include the removal or addition of materials, further characterization leading to a change in classification, and change in characteristics by processing. The typical item workflow in BroadPointe starts with the creation of the data record containing the administrative and characteristic information for the item, submittal of the information for internal review and approval, and marking of the approved item as available for final disposition. The end of the item workflow results in a data record in an “approved” state that corresponds to a physical item that is available for further management such as onsite movement, packaging, or shipment.

Movement, Packaging and Shipment Planning

In the majority of cases, an approved BroadPointe item is moved to a central on-site storage facility, but is not packaged to comply with Department of Transportation packaging regulations or off-site Treatment, Storage, and Disposal Facility (TSDF) acceptance criteria. Prior to performing any packaging, the ultimate disposition plan for an item needs to be determined and the plan needs to incorporate the expertise of several individuals. In BroadPointe, the planning workflows engage the appropriate decision makers in a sequential fashion and provide “what if” scenarios to aid the decision process. The planning workflows project a future condition, test the compliance and desirability of the future condition, and if found to be acceptable, moves the request to the next person for approval. After the proposed action is approved, BroadPointe generates a “work order” in the form of an electronic plan that is loaded into a laptop or barcode reader for field use. The electronic plan ensures field operations stay strictly within the approved parameters. The goal of the planning process is to assure that, prior to any actual physical work, all aspects of the field operation are considered for safety, compliance, and efficiency.

All planning workflows in BroadPointe follow the same general sequence:

- The requestor selects one or more objects and proposes an action to take with the objects,
- The requestor submits the request for approval,
- The approver(s) review the requests and generate an electronic “work order”, and
- The field staff performs the requested actions and updates the main database with the changed condition.

One example of a planning workflow is for a chemical labpack (49 CFR 173.12) . A labpack plan would only include specific barcoded items that were acceptable for labpacking and compatible with each other. Once the plan was loaded into the barcode reader, the field operations staff would execute the plan. During field activities, if an item that was not included in the labpack plan was scanned, the barcode reader would reject the item for labpacking and the item would not be placed into the labpack. Once the labpack was completed, the barcode reader information collected in the field such as date and time of execution, container identification code, etc. would be uploaded to the main application for permanent item history recording and to change the state of the items to “packaged”.

Inventory, Equipment and Facility Management

Once an item has been accepted by the ORNL waste management organization as appropriately characterized and a viable item for disposition, the item can be packaged with other compatible items in the field location or moved “unpacked” to a central location for future packaging. In either case, the item has entered into the waste management inventory and must be tracked. The inventory, equipment and facility management workflows are associated with “maintaining” the state of the inventory and associated infrastructure. This workflow set differs from the planning workflows since the planning workflows are designed to handle the requests for “changing” the state of the inventory. For example, the movement planning workflow includes obtaining approvals to move a set of containers into a waste management facility prior to authorizing the movement. In contrast, the management workflows include requests for performing a facility inventory, performing routine preventative maintenance, and procurement of equipment and supplies.

Waste Profiling

Before a waste item can be submitted for disposal, BroadPointe will require that a general disposition “waste profile” has been established that categorically (chemically, physically, and radiologically) encompasses the item. In addition, BroadPointe will require that each item is directly tied to an onsite waste stream. The waste stream is more specific in the type of information and one waste profile may be associated with several waste streams. The rigor and complexity of establishing the waste stream varies greatly depending on the type and extent of regulated characteristics but, in general, is proportional to the level of hazard represented by the characteristic.

The general workflow for establishing a waste stream involves the following:

- Defining the waste stream scope (e.g., RCRA regulated waste from laboratory operations in Building X),
- Documenting process knowledge that supports characterization assertions and entering the information into BroadPointe as a workflow request to establish a waste stream,
- An adequacy review of the request by the responsible ORNL subject matter experts and, if necessary, the development of a plan to obtain more information, and
- Completion of the waste stream data package including any calculations and user tools.

The waste profiling effort includes the application of very specific and detail expertise. BroadPointe will include several expert system features to assist the waste profiling process. A limited discussion of these features is presented later in this document.

Data Administration

BroadPointe relies on a number of underlying reference data tables to function. These tables include administrative information such as personnel, facilities, training, cost charge accounts, and technical information such as regulatory threshold values, correlation factors, unit conversion factors, and much more. The process of modifying the dataset by adding, modifying or deleting information is controlled through the data management workflows. All information has a responsible owner who must agree to any changes prior to the proposed changes being implemented. Any application user can request specific information be added and updated to better reflect the current need.

Depending on the nature of the information, the request may be quickly approved or it may take careful consideration. For example, if the request is to add a new facility room number to the picklist for location, the request would be quickly agreed to. However, if the request is to change the threshold value for facility characterization or modify the DOT hazard class of a chemical, a review by organizations other than just the waste management organization would be required and the workflow will manage the routing.

Strict management of the underlying data table information is a principle tenant of agreements between the ORNL waste management organization and other ORNL divisions who have responsibility for health and safety, regulatory compliance, transportation oversight, emergency response and radiation protection. Any data change requests that involve critical information are routed through a workflow that includes review and approval by responsible members of other organizations.

EXPERT SYSTEM FEATURES

BroadPointe is designed to integrate automated features in the workflow UIs to assist the users to navigate through the more complicated processes. The features are intended to improve the extent, accuracy, and availability of information, and facilitate the intuitive use of BroadPointe. In addition to conventional data entry features such as smart picklists, client- and server-side error checking, and content-sensitive dynamic UIs, BroadPointe will include several features

specific to waste management. The features are comprised of custom reference information and code developed by waste management experts.

Chemical Waste

At ORNL, chemicals are classed by the waste generator, reviewed by the waste management organization, and reviewed again by the transportation department prior to shipment. The classification is based primarily on the associated Material Safety Data Sheet (MSDS). The independent and redundant effort to determine the correct MSDS is time consuming and subject to error even with easy access to the ORNL online MSDS database. To better manage this process, BroadPointe will include an ever-growing database of pre-determined chemical characterization, packaging, and shipping information linked to the manufacturer's product code. This database information will be leveraged for the disposition of future chemical items. In the case of unused excess chemicals, the associated information is very specific to that product or chemical. The dataset will serve as a "template" for all future similar items which saves a considerable amount of data entry and, if unaltered, allows all downstream reviewers a high level of confidence in the data and shortens their review.

BroadPointe will include an "auto labpack" feature to assist personnel responsible for labpacking operations. The feature automates compliance with the labpacking criteria in 40 CFR 268.42(c) and 49 CFR 173.12(b) and verifies compatibility using the method presented in the EPA Chemical Compatibility Chart. The user of the auto labpack feature first defines the candidate population of items by selecting one or more of the filter categories such as the location, DOT class, origin date, and/or generator division. The auto labpack feature builds a table of the candidate items meeting the filter criteria and then executes an iterative algorithm to try various packaging arrangements to find the most efficient arrangement. The efficiency of the plan is measured by how many labpack containers are required to accommodate all the of the candidate items. The plan with the least number of containers is the proposed plan. The labpack plan includes proposing the type and size of the outer container and the type of sorbant to use. The feature also allows the users to define additional parameters beyond the regulatory criteria when selecting and assigning items to a labpack to meet the most cost-effective packaging arrangement criteria as defined by the intended TSDF.

Radioactive Waste

BroadPointe will incorporate an automated feature to assist with waste stream profiling. The feature is based on a "tax software" style interview process to assist the user through with waste stream definition and characterization process. The feature will provide numerical analysis support for establishing the nominal waste stream radionuclide distribution and the associated high-low range, hierarchical logic to help determine parent isotopes from progeny, comparison of data validation flags such as gross beta/gamma values to gamma spectrometry results, and statistical comparison of the new waste stream to existing similar waste streams. Once the waste stream isotopic distribution is established, BroadPointe will automatically develop a standard quantification tool set for each waste stream item. The basic tool set will be based on "dose-to-curie" correlation factors for volumetrically contaminated items and surface contamination scaling factors for equipment and other surface contaminated items.

COMPUTER TECHNOLOGY

BroadPointe users will interact with the software solution through three different applications;

- an internally hosted ASP.NET Web application,
- a Windows client application, and
- a hand-help device application for use with barcode scanners.

The core of the system is the ASP.NET based application deployed on ORNL's intranet. The ASP.NET application serves up a standards-based Web interface that is intended to perform integration, workflow, and reporting tasks. The Windows client application is the primary data collection tool. The application is optimized for collecting large amounts of data in the field quickly and accurately. It operates independently in a disconnected fashion and is synchronized with the ASP.NET Web application regularly. The hand-held devices provide conventional inventory management functionality for item and container management.