Next Generation Waste Tracking: Linking Legacy Systems with Modern Networking Technologies

Focus on DOE EM Radioactive Materials Packaging and Transportation

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Executive Summary

This report describes results from a preliminary analysis to satisfy the Department of Energy (DOE) objective to ensure the safe, secure, efficient packaging and transportation of materials both hazardous and non hazardous [1, 2]. The DOE Office of Environmental Management (OEM) through Oak Ridge National Laboratory (ORNL) has embarked on a project to further this objective. OEM and ORNL have agreed to develop, demonstrate and make available modern day cost effective technologies for characterization, identification, tracking, monitoring and disposal of radioactive waste when transported by, or between, motor, air, rail, and water modes.

During the past 8 years ORNL has investigated and deployed Web 2.0 compliant sensors into the transportation segment of the supply chain. ORNL has recently demonstrated operational experience with DOE Oak Ridge Operations Office (ORO) and others in national test beds and applications within this domain of the supply chain. Furthermore, in addition to DOE, these hazardous materials supply chain partners included Federal and State enforcement agencies, international ports, and commercial sector shipping operations in a hazardous/radioactive materials tracking and monitoring program called IntelligentFreight.

IntelligentFreight is an ORNL initiative encompassing 5 years of research effort associated with the supply chain. The ongoing ORNL SmartFreight programs include RadSTraM [3], GRadSTraM , Trusted Corridors, SensorPedia [4], SensorNet, Southeastern Transportation Corridor Pilot (SETCP) and Trade Data Exchange [5]. The integration of multiple technologies aimed at safer more secure conveyance has been investigated with the core research question being focused on testing distinctly different distributed supply chain information sharing systems.

ORNL with support from ORO have demonstrated capabilities when transporting Environmental Management (EM) waste materials for disposal over an onsite haul road. ORNL has unified the operations of existing legacy hazardous, radioactive and related informational databases and systems

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using emerging Web 2.0 technologies. These capabilities were used to interoperate ORNL's waste generating, packaging, transportation and disposal with other DOE ORO waste management contractors. Importantly, the DOE EM objectives were accomplished in a cost effective manner without altering existing information systems. A path forward is to demonstrate and share these technologies with DOE EM, contractors and stakeholders. This approach will not alter existing DOE assets, i.e. Automated Traffic Management Systems (ATMS), Transportation Tracking and Communications System (TRANSCOM), the Argonne National Laboratory (ANL) demonstrated package tracking system, etc.

The ORNL Experience

A number of ongoing ORNL programs demonstrate the variety of different technologies and processes that are relevant to the DOE waste tracking objective (i.e., to ensure the safe, secure, efficient packaging and transportation of materials both hazardous and non hazardous) which include:

- The EPA sponsored Radiological Source Tracking and Monitoring (RadSTraM) [3],
- The EPA, DOE, Department of Commerce (DOC)-European Union (EU) jointly sponsored Lighthouse Project - Global Radiological Source Tracking and Monitoring project (GradSTraM) [6, 7],
- The Southeastern States sponsored Trusted Corridors program[8],
- The ORNL sponsored SensorPedia project [4],
- The Office of Naval Research sponsored SensorNet© Program [9],
- The DHS sponsored Southeastern Transportation Corridor Pilot [8], and
- The ORNL-KC SmartPort jointly sponsored Trade Data Exchange project.

In these programs distinct aspects of multiple technologies, system configurations and integrations (or mash-ups) have been investigated with the core focus on supply chain sensor information sharing over distributed and disparate infrastructures.

The DOE EM National Need

At issue is the balancing of hazardous materials (hazmat) transportation security and safety in a cost effective manner with the ability to continue to move radioactive materials that are critical to public health, commerce, and the DOE EM programs. Many shipping categories must interoperate. The following list exemplify shipment needs/requirements and characteristics are:

- Imported (i.e., brought in from another country in a legitimate fashion)
- Made by all modes of transport
- Made by private, contract, public and for hire carriage
- Special carrier handling and segregation
- Specific physical and chemical characterization
- Specific packaging requirements
- Regulated world-wide by competent authorities
- An emergency response concern
- A security concern

There is a desire to support shipment material real time tracking which would provide obvious advantages to satisfying security and emergency response concerns especially those shipments that are made for hazardous waste and substances. Hazardous shipments also have the property of requiring multiple

shipping documents and substantial data. Several electronic databases applicable to hazardous materials exist and need to be evaluated. In general, shipments are regulated by multiple regulatory agencies (i.e. DOT, NRC, EPA, States, international jurisdictions, etc.). Notwithstanding, there is a strong need to streamline the process of identifying and collating transport lost, astray, damaged and opened shipments (e.g., streamlining insurance claims) and the various contractual legal shipping documents that are required. Indeed, there is a significant gap between what exists in terms of standard operational procedures and what is possible given the array of commercial off the shelf technology (COTS) that exists to address the DOE EM objectives and national needs.

The Challenge

The common challenge of DOE EM, contractors and stakeholders is a coordinated and cost acceptable information infrastructure system (IIS) that is pervasive, secure and safe. Such an IIS is should be naturally distributed, automatically updated, secure and most importantly provide real-time visibility of that sector of the environmental management waste packaging, transportation and disposal chain that is deemed essential. Therefore, the challenge will be to define the operationally contextual parameters in such a way to ensure that the protocols and artifacts that make up the IIS are contextually extensible across all domains of the chain.

The ORNL Demonstrated Web 2.0 Requirements and Capabilities

ORNL has developed and deployed a number of relevant testbeds. DOE EM transportation and packaging objectives can be achieved with emerging Web 2.0 information distribution technologies in an efficient and effective manner with minimal impact on existing legacy shipping systems and proprietary process networks. ORNL believes that through the integration of emerging technologies an IIS can be developed that provides for the following requirements:

- Each DOE shipment of hazardous materials can have an electronic product code assigned, bar code or other tag assigned
- The number assigned is the US and International hazardous material Identification number i.e. UN or NA
- The system will be compatible with current DOE/contractor shipping technologies
- The system can consist of existing technologies from the private sector
- The system will eliminate an existing transportation electronic product identification disconnect with material originators and receivers
- The system will be cost effective
- The system will be regulatory compliant
- The system will meet multi regulatory requirements
- The system will enhance security concerns
- The system will provide for real time tracking
- The system will use existing legacy electronic data bases
- The system can enhance transport, emergency responder and public safety and health
- The system will assist in the emergency response, safety and health areas
- The system can assist the various carriers operations and reduce overall logistics DOE costs
- The system can reduce future DOE EM waste characterization costs
- The system can document waste stream disposal cell coordinates

Tracking 2.0: ORNL's Solution

Most of the information needed to provide for total asset visibility and exceptions-based EM reporting already exists in numerous proprietary, agency-centric, contractor or DOE data systems. A collective technological solution for end-to-end DOE EM, packaging, transportation and disposal, is possible if the "trapped" information in these legacy systems can be joined as part of a common timeline with a common spatial reference. Establishing another defined and bounded information "system of systems" for DOE EM is not a cost effective or realistic solution for EM activities. However, ORNL's approach, which provides a virtual system of systems, preserves the existing legacy applications and links them into a loosely-coupled network of systems based on interfaces associated with the concept referred to as "Web 2.0." Web 2.0 applications include a broad range of social networking sites, content-sharing sites, wikis, blogs, and mash-ups that facilitate interoperability and collaboration on the World Wide Web. These same concepts can be applied to establish near real-time, end-to-end transparency across loosely-coupled EM systems. ORNL's EM solution adapts Web 2.0 information sharing technologies to link incompatible, autonomous, or proprietary systems with minimal impact on existing processes and procedures. ORNL calls this emerging information sharing technology *Tracking 2.0* [5]. There are five basic components of the Tracking 2.0 solution.

1. The assignment of a permanent and unique web address or Uniform Resource Locator (URL) to track a unique EM element.
2. A secure portal with "social networking" capabilities to connect the various EM stakeholders *and their applications* with each other.
3. The ability to associate searchable user-defined tags to the EM element's URL. These tags are assigned to the URL by the various systems that monitor the linked element at different times and provide the means to "find" the element through independent searches on *any* of the tags. The tags for each element creates a "tagsonomy" or "folksonomy" which permits a single element to be located by searches for any of the tags that are unique to each of the different systems that tracks it (i.e., where relationships or associations exist).
4. The use of geotags to enable all elements a way to be geo-referenced and combined to present a spatial "mashup" of its locations over time (i.e., where and how was the element transported).
5. The use of Web 2.0 publish and subscribe standards (e.g., Really Simple Syndication - RSS [10] and The Atom Syndication Format [11]) to link data feeds to social networks.

The ORNL Technical Approach

ORNL chose the linkage of five separate internal systems with which to demonstrate Tracking 2.0. Often DOE-ORO needs to inquire into exposure levels of former employees to radioactive and/or hazardous substances. To respond to such inquiries, the systems managers must access information from a number of independent, internal systems. The system managers felt that an application, built upon these principles of Tracking 2.0 would be optimal in supporting their responses to such inquiries –this led to the development of the ORNL SmartTrack system. Not only would SmartTrack link exposure to radioactive and hazardous materials, but it would also provide visibility into the tracking of materials from "cradle to grave" or procurement to disposal. Therefore, to accomplish this particular task, SmartTrack had to "Mashup" or aggregate information from five different and independent ORNL systems: the Radioactive Materials Information System (RMIS), the Hazardous Materials Management Information System (HMMIS), the Environmental Management Waste System (emWaste or BROADpointe), the Bechtel Jacobs RFID System (EMWMF), and the Bechtel Jacobs Waste Transportation Management System (WTMS) [12]. The high-level Tracking 2.0 SmartTrack Concept is shown in Figure 1.

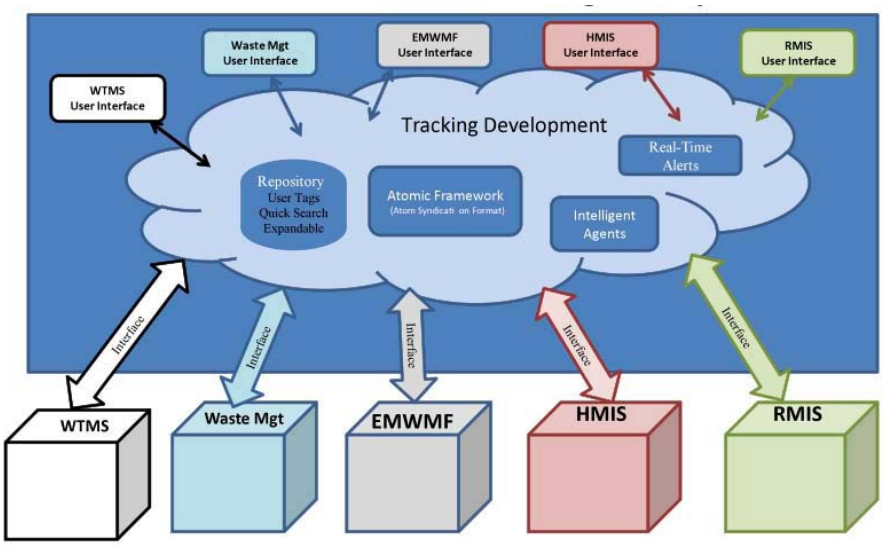

Figure 1. SmartTrack concept showing the bridging and aggregating elements necessary to combine all relevant functionalities.

In this concept, the SmartTrack system links the data from all five of the systems to display the mashup of either the EMWMF and WTMS systems or the RMIS, HMMIS, and emWaste systems.

The EMWMF and WTMS systems are associated with data from the Decontamination and Demolition (D&D) activities on the ORNL reservation [12]. Specifically, the EMWMF system provides information on the trucks carrying material from demolished builds at the K-25 and ORNL sites to the EMWMF waste facility on the Oak Ridge reservation. The EMWMF system uses RFID tags attached to dump trucks to track their location. The WTMS processes information related to the waste characterization of the load being carried by the truck along with the truck weight and transportation parameters such as transit times to and from the waste facility. These transportation parameters are utilized by the waste facility operators to optimize productivity of the waste shipments and waste facility utilization. The WTMS system provides the electronic shipping papers required for each shipment of waste from the demolition site to the waste facility.

Figure 2. Dump Truck Bound for EMWMF on Scales Adjacent to RFID Reader.

Figure 2 shows a dump truck on its way to the EMWMF waste facility currently passing over the weigh scales which are located adjacent to the yellow RFID reader/writer. A portable Weigh-In-Motion system also could illustrate the scenario [13]. The basic waste characterization data was written onto the RFID tag, the black rectangle on the truck's hood just above the tie-down strap, before the truck left the demolition site. The truck then passes over the scales where it is weighed and the weight information is process via the electronics in the yellow tower to the WTMS. The truck then travels to the EMWMF waste site where the debris is unloaded and placed into the waste facility. The dump location is then written to the RFID tag and the truck returns for another waste load. RIFD reader/writers at or close to

the demolition site and the waste facility provide truck location and transit times to the system. Once the truck is weighed, the waste characterization data and truck information, including weight, is transmitted to the WTMS system where the electronic shipping papers for that shipment are produced.

The SmartTrack system aggregates the data from the EMWMF RFID system and WTMS system into a display which allows oversight into the waste shipment process. The EMWMF shipment display of the SmartTrack system is shown in Figure 3 which depicts how a rapid overview assessment of the status of the shipments on the Oak Ridge Reservation. The colored icons enumerate the number of shipments in route from that location to the next. These icons are "hotlinks" which, when clicked, display additional logistics information such as transit and residence times for the shipments in a "bubble" so that work flow can be maintained and monitored. Within this bubble, there is an additional "hotlink" for each shipment which, when clicked, displays pertinent shipment information in the three boxes at the bottom of the screen. There are additional hotlinks within these shipment information boxes which allow the user to seamlessly merge the data from the EMWMF RFID system with the electronic shipment papers created by the WTMS system. Additionally, there is a link for first responder use, which presents the applicable portions of the Emergency Response Guide for the materials contained within the selected shipment.

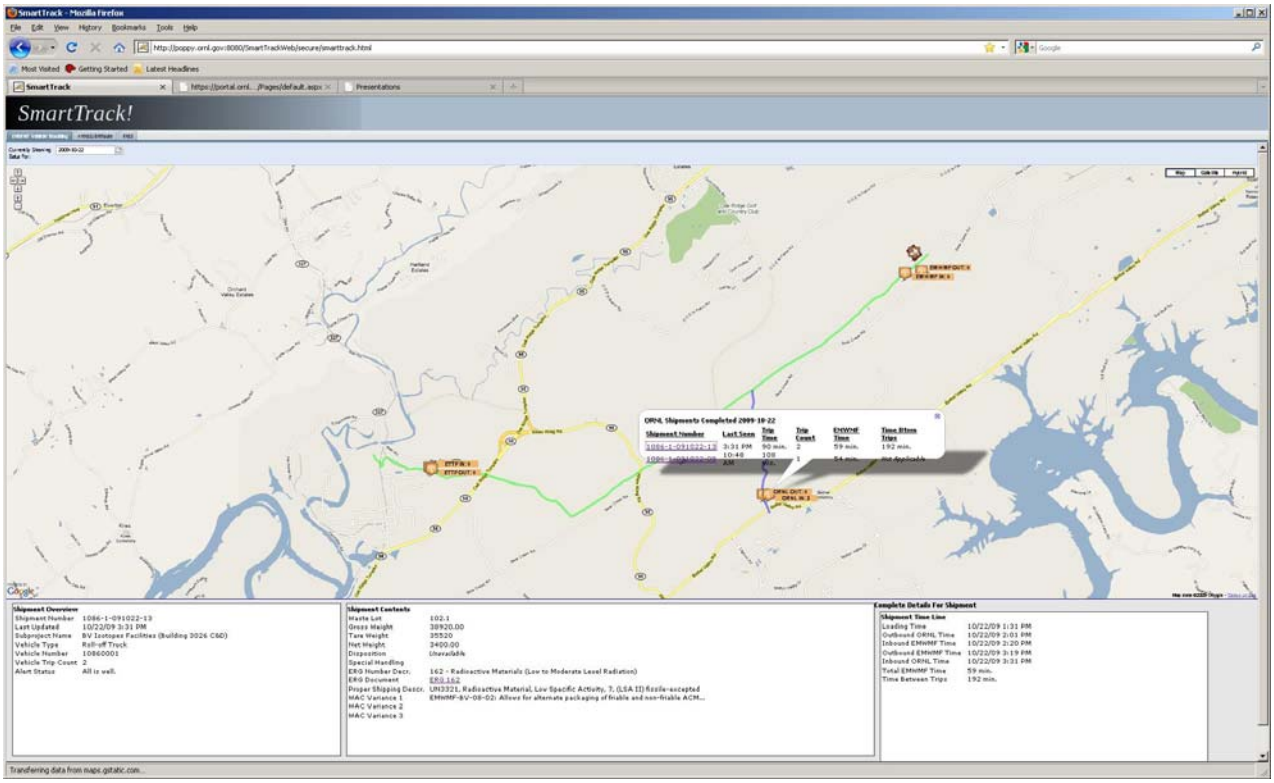

Figure 3: SmartTrack EMWMF Display Screen

The Path Forward

An integrated technological solution requires universal digitization of DOE EM information via the emerging social media and collective intelligence technologies of the Semantic Web. The path forward proposal starts with a DOE real world offsite demonstration project for the tracking of RAM in the waste packaging, transportation and disposal chain that establishes the following capabilities toward the next generation waste management tracking system:

- Create a “secure honest broker” data clearinghouse prototype
- Develop a Tracking 2.0 universal shipment tagging prototype
- Baseline the inherited information databases available
- Track the shipments using remote tracking technology(s)
- Distribute and receive tagged data using a Tracking 2.0 engine prototype
- Develop a secure social networking engine based on electronic shipping data tagging
- Develop automated exceptions reporting distribution prototype
- Develop a query-enabled and knowledge-sharing search engine prototype

The aforementioned technology attributes are readily available and applied in the current Tracking 2.0 information management environment. Search engines like Yahoo® and Google™ are practically household words. Web 2.0 social networks such as Wikipedia, Facebook© and Twitter© are changing the way knowledge is shared. Secure data clearinghouses using the EDI model already exist in the supply chain. Shipment tagging and digitalization information already exists in large Commercial Sector Enterprise Resource Planning systems such as SAP® and Oracle®. These deployed “COTS” applications were used as a basis to define operationally contextual parameters for searching, linking, sharing and managing information (i.e., enabling knowledge discovery and intelligent use of information resources). In this way, we have envisioned achieving the DOE EM objective to ensure the safe, secure, efficient packaging and transportation of both hazardous and non hazardous materials.

Therefore, an enhanced DOE EM waste transportation and disposal demonstration is being planned currently. After the demonstration an ORNL DOE EM workshop will be conducted to share experiences and chart a path to share technology with contractors, stakeholders and regulatory agencies.

Conclusion

As an alternative to waiting for reactive solutions, the ORNL and DOE EM initiative is proposing a low cost, fast to market solution, driven by demonstrated experiences. Such a solution is scalable and will have minimal impact on existing legacy systems and databases.

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