2012 EL Project Title and Number: Cross-Standards Interoperability for Production Networks

Program Title: Systems Integration for Manufacturing and Construction Applications

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Summary: The Cross-Standards Interoperability for Production Networks project will improve the productivity and agility of production networks by addressing the problem of competing and overlapping standards that impedes the exchange of engineering data. The project will support harmonization of those standards and the integration and testing of the systems that use them. It will work with industry groups to identify key overlapping standards, define a common conceptual model supporting those standards, develop mediation tools based on semantic technology, and use these tools to enable harmonization and testing. This will increase the interoperability of systems within production networks and lead to a simpler and more coherent framework of interface standards supporting them, thus addressing a critical element of the Smart Manufacturing action plan[1].

[1] Implementing 21st Century Smart Manufacturing, Workshop Summary Report, Smart Manufacturing Leadership Coalition (SMLC), June, 2011, p.18

Description:

Objective: The Cross-Standards Interoperability for Production Networks project will improve production network productivity by developing tools to capture mappings that facilitate harmonization between such interfaces and provide for mediation between systems that use them by 2014. The project will also reuse and integrate the architecture and tools developed by the *Engineering Data Quality Measurement Project* in order to evaluate and test these mappings.

Program thrust: Production Network Systems Integration

What is the new technical idea? The Smart Manufacturing Leadership Coalition (SMLC) identifies the following as a priority action item for Smart Manufacturing[2]:

> *An affordable, open, standard platform of software and hardware is needed to integrate small/medium suppliers with Original Equipment Manufacturers (OEMs). This would enable the rapid, effective transfer of data between companies…. Achieving this integration will require common languages and architectures that can be applied across diverse supply chains.*

Further, it identifies a key technical barrier to this goal:

> *Lack of platforms that can accommodate diverse data requirements across industries.*[3]

In complex product manufacturing, these industries can include: bulk materials production for metal, glass and chemicals; electronic subsystem production; electro-mechanical subsystem production; cast and stamped physical component production; and assembly operations. Separate standards for engineering information exchange in these domains have been developed in separate communities centered on product categories. These standards reflect the context in which they have been developed, giving emphasis to what was important to that community, minimum coverage to what was not, and employing the information technologies preferred by that community at the time they were developed. This has resulted in a set of competing standards with some overlap in coverage, and inconsistencies in scope, emphasis, terminology, approach, and technology. This makes integrating the systems involved in a modern production network costly and time consuming, where quick and correct integration is key to competitiveness.

Specifications for manufacturing engineering data have two logical parts: a specification of the things and properties that engineering data will describe (a conceptual model), and a specification of the technical format for structuring and encoding that data (a technical model). This project will enable seamless integration across manufacturing domains involved in production of complex electro-mechanical products (1) by defining shared common conceptual models for the key concepts supporting its production network, and (2) by providing automated tools to translate between different data formats (i.e., technical models) used to convey these concepts. These shared conceptual models are elements of the Common Semantic Library that is called for in the SMLC action plan.[4]

[2] SMLC : "Implementing 21st Century Smart Manufacturing", 2011, p. vi, p.20.
[3] ibid.
[4] ibid.

We will construct a framework of tools that supports the development of common conceptual models and the integration and testing functions enabled by these models. This framework will be extensible and reusable by industry to support other production network integration scenarios. It will enable industry to capture and analyze the mappings between engineering data specifications, to convert data between formats, and to test information exchanges across different industries.

This approach is a significant departure from the conventional approach for mediating between data formats via one-off transformations from one technology-specific form to another. The conventional approach provides little insight into the relationships among the models that facilitates evaluation of the correctness of the mappings, and reuse of them in related standards in the same family. While formal logic models can provide such insights, it is only in recent years that logic languages and the tools supporting them have achieved the expressiveness and functionality needed for mapping the engineering data that is shared in production networks. This project will use and enhance tools developed in other NIST projects, using emerging standard knowledge representation languages to map standards to a common conceptual model of production network information and validate the mappings. It will further develop tools that use those mappings in performing reliable data transformations, thus ensuring successful transformation of the information to a form acceptable to the recipient's software.

The combination of the common conceptual model and the supporting transformation tools provides the platform for seamless exchange of engineering information across diverse industries. According to the SMLC report, such a platform makes the deployment of production networks easier and less costly. The report also identifies other benefits, including: increases speed of information transfer across the production network; enhances global competitiveness of SMEs; improves opportunity for diversification in SME customer bases; enables OEMs to optimize their production networks; and potentially attracts OEMs to manufacture in the U.S.[5]

What is the research plan? The plan of technical work for this project has two main areas of activity that will be executed in parallel.

1. Determination of target overlapping standards, development of common conceptual models, mapping of standards to models, and validation of the mappings
2. Development and integration of logic language based tools for model mapping and cross-model testing

Activity Area 1: In cooperation with the Smart Manufacturing Leadership Coalition (SMLC) and other industry groups, we will identify critical domains of data supported by competing and overlapping standards. Together with industry experts, we will develop a common conceptual model that covers the identified standards. This model will be part of the Common Semantic Library envisioned under Priority Action 8 of the SMLC report. Using the semantic mapping tool from Activity Area 2, we will create a mapping from the concepts in the standards into the common model. This mapping, together with our mediation tools, allows the conversion of information between the differing standard structures. We will develop reference messages and

[5] ibid.

exchange content for each mapped standard, and evaluate the system by comparing the automated translations of those reference information sets with translations made by domain experts. Analysis of the differences between the automated translation and the expert translations will result in improvements to the common model and the mappings. That is, this is a spiral development process that will terminate in a common semantic model that supports reconciliation of the chosen standards, and reliable engineering information exchange via data transformation.

Activity Area 2: We will update the mapping definition tool to enable reconciliation rule creation, to work with the new environment and to be applicable to the chosen target models. The output of this tool is to be used as input by the mediator, which will be updated to be able to make best use of these enhanced inputs. This will enable it to operate on the classes of exchange formats used in the identified target overlapping standards. Furthermore the tools will be extended to capture message metadata, such as source, destination and message identifier for the purpose of storing this metadata in a repository when conducting tests. We will integrate these updated and enhanced tools with the machine reasoning engine being developed by the Engineering Data Quality Measurement (EDQM) project within the SIMCA program. This integrated system then will be used to demonstrate its mediation capability and ultimately be released to external users. We will also integrate the EDQM tool for capturing constraints in Restricted English to enable the inclusion of additional user-defined constraints on exchanged data. We will then release this suite of integrated tools for mediation and testing to external users.

Major Accomplishments:

Recent Results: new project.

Standards and Codes: Standards involvement will be driven by the priorities of industry and anticipated impact as identified through formal interactions with SMLC and other industry groups (through steps described in FY2012 milestones), and the availability of relevant domain expertise or existing mappings. However, it will focus on OAGIS and competing standards supporting manufacture of complex electro-mechanical products and their components.