COMPUTERIZED REPRESENTATIONS OF MANUFACTURING RESOURCES: VALIDATION AND STANDARDIZATION EFFORTS

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ABSTRACT

Computer representations for machine tools, cutting tools, and associated hardware are used within a variety of manufacturing software applications. Currently there is no agreed-upon mechanism for representing such *manufacturing resource* data and as a result this information is individually entered and maintained on multiple systems within a single manufacturing facility. NIST has proposed a manufacturing resource representation which could be shared among manufacturing software applications and, thus, would be of great benefit to both the users of the software and the vendors of the software. This proposed solution which supports common milling, drilling, and turning processes will undergo validaton testing through the integration of a shared database with several manufacturing software applications as described in this paper. Efforts to build consensus for such a manufacturing resource representation through standards-making organizations are also discussed.

Keywords: manufacturing resources, database, information modeling, EXPRESS.

BACKGROUND

Manufacturing resources are the equipment which enable industry to turn raw materials into marketable products. Many computer-aided applications (CAx) which support manufacturing require information about manufacturing resources to perform such functions as process planning, cost estimating, and numerical code (NC) programming. Despite the need for this information across many applications, CAx vendors typically maintain this information in different forms which prohibits the exchange of such information between applications. These differences result in redundant data stores within manufacturing facilities, which in turn adversely impact productivity and software configuration/maintenance costs. Members of the Rapid Response Manufacturing (RRM) Consortium, organized through the National Center for Manufacturing Sciences and sponsored by the Department of Commerce Advanced Technology Program, and other manufacturing enterprises seek a common representation of manufacturing resources to facilitate integration of CAx applications and acquisition of resource data from tooling vendors. The NIST RRM Intramural Project, formed to support the technical goals of the RRM Consortium, aims to satisfy this need by developing and proposing a representation of manufacturing resource (MR) data which may be adopted as a common basis for information exchange. To meet this objective, the RRM Intramural Project is executing the following plan:

(1) Determine scope of effort with respect to manufacturing resources and CAx applications;

(2) Gather and analyze MR information from a host of sources, including vendor catalogs, CAx application data structures, industry tooling databases, and manufacturing standards;

(3) Produce a requirements specification for representing manufacturing resource information and seek industry review of the document (Jurrens et al, 1995);

(4) Develop an information model based on the requirements specification using the EXPRESS data modeling language (ISO 10303-11, 1994);

(5) Validate the MR information model by integrating with CAx applications in a shared database environment;

(6) Revise the requirements specification and model based on industry comments and validation results;

(7) Build industry consensus and pursue standardization opportunities.

The first four activities of this plan have been completed. The purpose of this paper is to document current and planned activities relating to validation, industry review and consensus-building, and standardization. Future plans are also discussed.

VALIDATION ACTIVITIES

Validation of the MR information model is necessary to ensure its

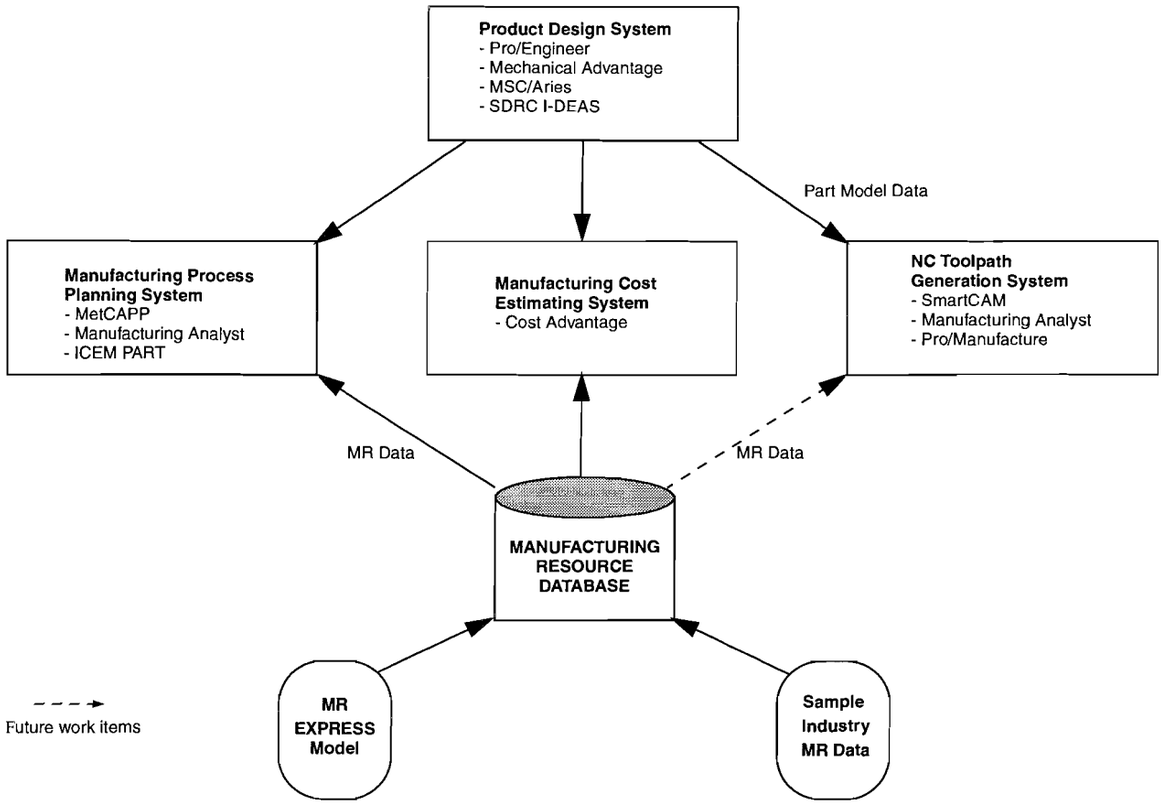

Figure 1 RRM Manufacturing Resource Information Test Environment

usability in "real world" situations. The objective of these efforts is to assess the correctness and completeness of the information contained in the model. Validation results will be used to update the MR requirements specification and information model.

Manufacturing Resource Information Test Environment

Validation activities will be accomplished within the Manufacturing Resource Information Test Environment (Fig. 1). The test environment consists of the MR database, several types of CAx systems, and product design systems. Initial validation efforts will focus on integrating the MR database with a computer-aided process planning (CAPP) system and a manufacturing cost estimating system. The schema for the MR database is created directly from the manufacturing resource EXPRESS model. The database is populated with sample manufacturing data from industry collaborators and tooling vendors.

CAx applications for integration with the MR database were selected based on their "openness" and our ability to redirect internal operations to access the MR database rather than internal application databases. Typically this can be done through an application programming interface (API) and/or external functions.

CAPP Integration

Integration of the resource database with a CAPP system is in its preliminary stages. Figure 2 illustrates the planned mechanisms for achieving this integration. The following system components are used: an EXPRESS compiler to generate C++ classes from the MR EXPRESS model; an object-oriented database whose structure is defined by the C++ classes; and a CAPP system. Integration of the CAPP system with the resource database will be accomplished by extending the system using its API to link with the database through a Standard Data Access Interface (SDAI) (ISO/CD 10303-22, 1994) implementation. This link will pass data for various machine tool and cutting tool attributes as required to create manufacturing process plans. Results of this implementation will provide feedback to update the MR requirements specification and information model.

Cost Estimating Integration

The MR information model will also be evaluated from a

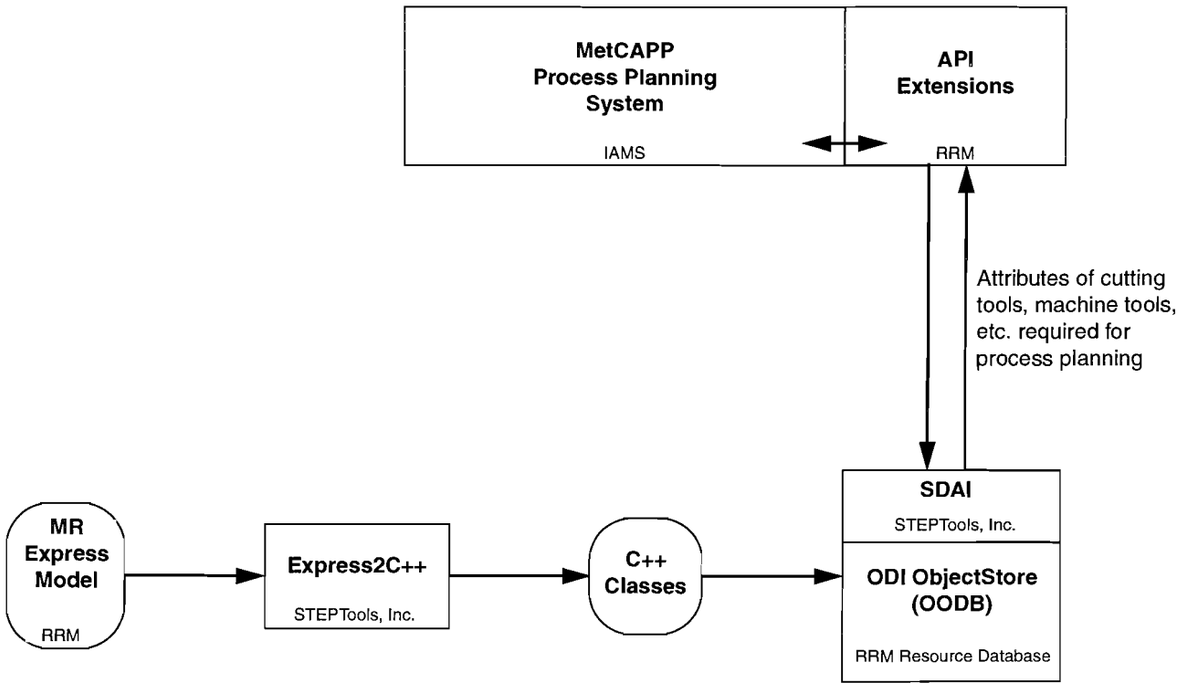

Figure 2 CAPP-MR Database Integration

manufacturing cost estimating perspective using industry-developed cost models for machining operations. This validation will share the same MR database as with the CAPP integration; however, the interface between the database and the cost estimating application will differ. Details of this interface are currently under development, but will include function calls within the cost model to access external data elements. Costing sessions will be performed using sample industry parts. As with the CAPP integration, results of this validation activity will provide feedback to update the MR requirements specification and information model.

CONSENSUS-BUILDING AND STANDARDIZATION ACTIVITIES

Building consensus for a common representation of manufacturing resources among manufacturing companies, manufacturing resource vendors, and manufacturing software vendors is necessary to accomplish the goals of increased productivity and reduced software configuration/management costs. Industry review, technical workshops, prototype vendor implementations, and standards development are established mechanisms for stimulating discussion and building consensus. The RRM Intramural Project plans to pursue all of these activities. Efforts within several national and international standards bodies could impact or be impacted by the development of a common representation of manufacturing resources. One effort of particular interest is the recently-formed working group for "computerized machining data exchange" (WG34) within the International Organization for Standardization (ISO) Technical Committee (TC) 29 for cutting tools. Their objective is to define an electronic representation of machining data in accordance with the ISO 13584 "Parts Library" standard. Similar efforts for representing and standardizing manufacturing resource information have been initiated worldwide.

FUTURE PLANS

Future plans for the RRM Intramural Project include: additional validation of the MR model from other perspectives (e.g., NC programming); refinement of the requirements specification and information model based on industry review and validation efforts; industry consensus-building activities in support of a standardized MR representation; interaction with standards bodies to initiate and facilitate standardization; and extension of the MR model beyond its current scope of milling, drilling, and turning resources.

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