The National PDES Testbed - An Overview

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Abstract

The National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards, has recently established the National PDES Testbed to support industry and government projects in developing and testing the Product Data Exchange Specification (PDES), the next generation of data interchange standards for automated manufacturing. PDES is an ambitious project with the goal of developing a standardized format for representing and exchanging information about almost any manufactured product.

The National PDES Testbed has several functions, including the obvious ones of testing particular implementations for compliance with the emerging PDES standard, and seeking out and diagnosing unsolved problems in the developing specification. Other tasks for the program will include providing a demonstration site for applications of PDES technology, helping to coordinate a national network of other PDES test facilities, and conducting an information and technology transfer program to speed the implementation of PDES standards.

Background

Use of electronic data storage and communication in industry is expanding. Physically distributed, heterogeneous computing environments are being connected into

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complex networks. Many systems that are under development require automated interpretation of product characteristics but currently an extensive amount of human reinterpretation is necessary to augment the digital data before a product can be manufactured. A more robust and complete definition of the physical and functional characteristics of products and their components is needed. The elements, meanings and representations of product data must be managed independently of any particular computing technology.

The Product Data Exchange Specification (PDES) will provide a complete, unambiguous, computer interpretable definition of the physical and functional characteristics of each unit of a product throughout its life cycle. Researchers utilize information modeling techniques to capture the meaning of "product data" (Wilson 1987) (Shaw 1989). PDES is the most complex and multi-faceted data standard ever attempted, but the payoff for success is high. In a development environment where a clear and unambiguous representation for product data exists, duplication and inconsistency are minimized.

The lack of an agreed upon method for transferring information among design, manufacturing, and product support computer systems is one of the biggest roadblocks to the development of efficient, practical computer-integrated design, manufacturing and logistic systems. PDES is designed to support not only the development of product data from within one organization, but the sharing and coordination of product data between cooperating organizations and throughout the entire product life cycle. Management will have the ability to track the development process and engineering will be able to communicate from one functional area to another.

PDES is under development by a diverse group of government agencies, academic researchers and private companies. PDES is a key element in the Computer-aided Acquisition and Logistic Support (CALS) program, which seeks to establish an integrated set of standards and specifications for the creation, management, and exchange of development and logistic data by computer. NIST expects PDES to substantially reduce the cost of procuring and maintaining parts and systems. The goal of the National PDES Testbed is to implement and test PDES as quickly and efficiently as possible.
NIST has made a commitment to become the central focus for PDES standards development and testing. In addition to establishing the National PDES Testbed, NIST continues to lead the voluntary IGES/PDES Organization (Smith 1989) which promotes and facilitates the development of PDES, as well as its precursor—the Initial Graphics Exchange Specification (IGES). The voluntary organization works with other standards making bodies, both foreign and domestic, for the purpose of achieving formal standardization of these specifications (Wilson 1987) (Wilson 1989).

Automated Manufacturing Research Facility

The National Institute of Standards and Technology is in an ideal position to implement the national testbed as it is already addressing the measurement and standards needs for the automation of the small batch, discrete parts manufacturing industries. The Automated Manufacturing Research Facility (AMRF) at NIST has been developed to serve as a testbed and demonstration facility in support of manufacturing research by workers from NIST, industry, academia, and other government agencies.

The AMRF is significantly supported by industry through donations or loans of major components (industrial manufacturing equipment, computer hardware and software) and through cooperative research programs. One goal of the AMRF project has been to identify and exercise potential interface standards between existing and future components of small-batch manufacturing systems. Commercially available products are used in the facility wherever possible, in order to expedite transfer of research results into the private sector.

To provide a real testbed for interface standards, the AMRF is intentionally composed of manufacturing and computing equipment from many vendors, thereby making its construction a major integration effort (Simpson 1982) (Nanzetta 1984). Shop floor equipment includes Computer Numerical Control (CNC) machine tools, a coordinate measuring machine, robots, a vision system, robot carts, automated storage & retrieval systems, cleaning and deburring devices, and part fixturing and robot gripper systems. The configuration is structured
around several self-contained workstations, each capable of executing a well-defined set of manufacturing functions. Each workstation is able to operate either as an independent manufacturing unit under control of a local operator, or as an element of a multi-workstation manufacturing system under control of a higher-level process. A typical machining workstation consists of a CNC machine tool, a robot, a materials transfer station, and local buffer areas for tools and workpieces.

The intelligence structure of each workstation includes the Robot control system, the Machine Tool control system, sophisticated sensor systems and a Workstation control system to coordinate the activities. A Cell controller coordinates the batch manufacturing processes. All of these control and sensory processes are software systems, which reside on interconnected computer systems, making the AMRF a distributed computing network (McLean 1986) (Rybczynski 1988). Many different computer languages and types of computer systems make up the computing environment of the AMRF. A distributed heterogeneous data system that provides data services to support the design, planning, manufacturing, and inspection of parts in the AMRF is an integral part of the "data driven" AMRF (Furlani 1988) (Krishnamurthy 1987) (Su 1986).

In addition to the shop floor activities, manufacturing data preparation activities, including part design, geometry modeling, process planning, and offline control programming, are performed on "engineering" computer systems linked into the factory floor network. The manufacturing data preparation effort within the AMRF has long used a product part model consistent with the developing PDES standard (Tu 1987) (Hopp 1987) (Ressler 1987) (Lee 1988). Thus the AMRF can demonstrate how PDES can be used effectively to manage and exchange product data between components of a computer-integrated manufacturing facility (Kramer 1988).

The Testbed

Product data exchange specifications are large and complex (Smith 1988). Undoubtedly, the first implementations of PDES will uncover problems and inconsistencies in the various definitions. If vendors implement PDES in ways which are inconsistent (due to
their interpretations of ambiguous statements) the standard will fail. A strong testing and implementation program can, among other things, identify potential problems and serve as an arbitration mechanism to decide what is the "correct" interpretation of the standard.

Thus the National PDES Testbed will be used to examine implementations of PDES in order to better understand how to augment the standard. Experienced researchers working in a testbed environment such as the AMRF can identify potential problems and suggest clarifications and interpretations of the standard. Testbed researchers will actively seek out and diagnose problems in the developing specification and provide information about these problems to the voluntary standards development community.

In addition to testing the validity of PDES' manufacturing data the National PDES Testbed will demonstrate the practicality of the data in an operational environment. In the process, software tools will be developed to aid industry in testing PDES implementations in industry production environments.

The first client of the testbed is PDES, Inc., the industry cooperative that was specifically established to accelerate the implementation of PDES'. Initially, the PDES, Inc. program focuses on validation and implementation of the subset of PDES necessary for manufacturing mechanical parts and rigid assemblies. In the future, the scope will broaden to include electronic components and assemblies.

Government support of this industrial activity is through the establishment of the National PDES Testbed. NIST researchers work closely with the technical team members of the cooperative in identifying the subset of PDES that will be tested for their particular manufacturing applications. In addition, NIST provides a neutral laboratory, with the necessary computer resources, for industrial organizations and NIST researchers to develop the necessary software tools and implementations.

For more information about PDES, Inc. contact Robert G. Kiggans at (803) 760-2700.
In addition to testing particular implementations for compliance with PDES when it becomes a standard, the Testbed will integrate a national network of testbeds. The scope of PDES is, as some have said, unbounded. Several testbeds, each involved with a limited area of the manufacturing spectrum, will be required in order to test and demonstrate all aspects of PDES. The activities of these testbeds will be coordinated by establishing a computer communications network to provide convenient access. Multi-testbed demonstrations will allow each testbed to contribute its own expertise and physical capabilities to develop a complete PDES test.

The National PDES Testbed will establish a clearinghouse that will be a central source for the documents and information models of PDES, as well as information about PDES and PDES testing activities. Archival storage and configuration control of the information models used in PDES is critical to maintaining quality control of the models. Tandem Computers' has loaned a large mainframe to the National PDES Testbed for this activity under the NIST Industrial Research Associate Program (NBS 1986). Tandem and NIST researchers are working closely together to provide nationwide access to this data repository.

In addition, Hypertext technology will be used to create a PDES "Hyperstandard" to address the problems of organizing and disseminating information about PDES (Ressler 1988). CD-ROMs will be produced containing the official standard, related research documents, implementation guidelines, etc. Researchers at the National PDES Testbed will establish a mechanism for evolving this new form of documentation to reflect input from all PDES-related sources.

\^ Certain commercial products are identified in this paper in order to adequately describe the National PDES Testbed. Such identification does not imply recommendation or endorsement by NIST.
References


"Cooperative Research Opportunities at NBS", NBS Special Publication 723, NIST, Gaithersburg, MD, December 1986.


