

Use of MatML with Software Applications for E-learning

Laura M. Bartolo
College of Arts and Sciences
Kent State University
lbartolo@kent.edu

Cathy S. Lowe
College of Arts and Sciences
Kent State University
clowe@kent.edu

Adam C. Powell IV
Materials Science and Engineering
MIT
hazelsct@mit.edu

Donald R. Sadoway
Materials Science and Engineering
MIT
dsadoway@mit.edu

Jorge Vieyra
Materials Science and Engineering
MIT
el_oso@mit.edu

Kyle Stemen
Computer Science
Kent State University
kstemen@cs.kent.edu

ABSTRACT

This pilot project investigates facilitating the development of the Semantic Web for e-learning through a practical example, using Materials Property Data Markup Language (MatML) to provide materials property data to a web-based application program. Property data for 100 materials is marked up with MatML and used as an input format for an application program. Students use the program to generate graphs showing selected properties for different materials. Selected graphs are submitted to the Materials Digital Library (MatDL) so that successive classes may be informed by earlier work to encourage new discoveries.

Categories and Subject Descriptors

D.3.2 [Programming Languages]: Language Classifications – *extensible languages*; H.3.7 [Information Storage and Retrieval]: Digital Libraries – *collection, dissemination, user issues*; J.2 [Physical Sciences and Engineering]: Engineering.

General Terms

Languages, Standardization.

Keywords

Cyberinfrastructure, E-learning and education, Digital Libraries, Materials Science, Materials Markup Language (MatML).

1. INTRODUCTION

Advances toward the Semantic Web and a distributed cyberinfrastructure promise revolutionary changes for the way science and engineering in education, research, and industry will be conducted [2, 4]. The National Science Foundation (NSF) National Science Digital Library (NSDL) Materials Digital Library (MatDL) project investigates research issues associated with the best delivery of materials science information. Some project goals include: building a collection of quality materials science resources, augmenting the educational experience for materials science students, and exploring the role that domain-specific markup languages, such as Materials Property Data Markup Language (MatML), can play in digital libraries.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

JCDL '04, June 7–11, 2004, Tucson, AZ, USA.

Copyright 2004 ACM 1-58113-832-6/04/0006...\$5.00.

This paper discusses a pilot project that provides a practical example of using MatML to supply materials property data to a web-based application program. This pilot is intended to encourage more widespread adoption of MatML by 1) demonstrating the benefits of using MatML to supply materials property data to application programs and 2) providing a specific example of how MatML files may be parsed for use in application programs. This example may serve as a model for future efforts, facilitating development of the Semantic Web for e-learning.

The web-based application program will be used by materials science students enrolled in the *Transport Phenomena in Materials Engineering* course at the Massachusetts Institute of Technology (MIT) to generate graphs comparing selected properties across various materials. The application program will be added to the MatDL collection as a teaching resource. Students will submit selected examples of their results to the collection as well. The addition of this exercise to the existing curriculum is expected to enhance the educational experience by providing access to real data, allowing students to generate the kind of results that professional materials scientists might use to make decisions regarding optimal material selection. By contributing their findings back to MatDL, students are also expected to benefit from the opportunity to see and build upon work submitted by their peers. It is also anticipated that students will gain some familiarity with publishing issues such as supplying metadata for their submissions.

2. MatML

Materials Property Data Markup Language (MatML) is an extensible markup language developed for the management and exchange of materials information [3]. Specifically, MatML addresses interpretation and interoperability problems associated with exchanging materials property data using the World Wide Web. The schema provides self-describing tags and a consistent document structure, which allows for automated data parsing and interpretation for subsequent use in computer applications. An international working group, composed of materials data experts drawn from private industry, government laboratories, universities, standards organizations, and professional societies, has guided the development of MatML in conjunction with international standards bodies.

3. MATERIALS PROPERTY DATA

Materials property data sheets provide critical information to the materials science community. Currently, providers such as ASM

International (<http://www.asm-intl.org/>) offer searchable materials property databases online, which make it faster, easier, and more convenient for materials scientists to locate and access materials with particular properties and to choose the best material for a given purpose. However, unless a common data exchange format, such as MatML, is used, converting materials property information gathered from different information providers into a useable format for application programs can be difficult and time consuming for researchers. The direct exchange of materials information between researchers can also be better supported by a common data exchange format.

4. TRANSPORT PHENOMENA IN MATERIALS ENGINEERING

The *Transport Phenomena in Materials Engineering* course (MIT) combines a rigorous introduction to fluid dynamics (including Navier-Stokes, the Bernoulli equation turbulence and boundary layer theory) with heat and mass transfer (including radiation, convection, estimation of heat and mass transfer coefficients). In addition, it introduces students to numerous examples of materials processing and performance, from vacuum arc remelting of titanium and nickel superalloys, to polymer extrusion, to thin film deposition, to mixed-limitation transport through encapsulated liposomes for long-term drug delivery. Students also review material from differential equations and are exposed for the first time to methodologies for solving partial differential equations.

4.1 Thermal Properties and Optimal Materials Selection

The pilot expands on a current homework assignment used to illustrate thermal properties and optimal materials selection. At present, students are given a short list of materials along with values for three properties and are asked to select the best material for six different functions. The number of example materials used in the current assignment is constrained by the time and effort associated with performing calculations manually. The pilot application software will allow far more materials with additional materials properties to be considered and will generate graphical results. Viewing graphical output should highlight and reinforce property differences among materials as well as enable students to see emerging patterns. The application will also help to teach students how to intelligently make trade-offs between various properties of competing materials, and rank the candidates according to programmable criteria. Students will describe and upload selected results to MatDL so that successive classes may be informed by earlier work to encourage new discoveries.

Exposing students to MatML, an application program with graphical output, and a digital library support ABET Criterion 3 part k which requires that graduates of an engineering program have "an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice" [1].

5. IMPLEMENTATION

A database containing materials property information for 100 materials was supplied by ASM and subsequently converted to MatML format. Existing XML parsing libraries were identified and adapted for the purposes of this project. Currently, a relational database is being used as an intermediary between

MatML and the application program, which is written in two parts: 1) a Perl script extracts the data from the XML files and parses the properties for insertion into a database and 2) the front end, written in PHP server-side web scripting language, creates scatter plots, which are displayed in the user's web browser. Two other strategies for making data formatted in MatML available to an application program are under consideration: 1) using MatML directly as a data format and 2) using a native XML database.

6. DISCUSSION

By fall 2004, the application program will be expanded to utilize the chemical composition information provided for each material so that a second class at MIT, *Introduction to Solid State Chemistry*, can be offered relevant data encoded in MatML to complete a class assignment.

This pilot is expected to further the development of the Semantic Web and cyberinfrastructure for e-learning by 1) demonstrating the benefits of using MatML to supply materials property data, including thermal properties and chemical composition information, to an application program used by students in two different materials science education courses and 2) providing a model of how MatML files may be parsed for use in application programs.

7. ACKNOWLEDGMENTS

MatDL is part of the National Science Digital Library project and is supported by NSF grant DUE-0333520 and National Institute of Standards and Technology grant 70NANB3H1079. The authors thank ASM for providing materials property data.

8. REFERENCES

- [1] ABET. Evaluation criteria for accrediting engineering programs. *Accreditation Board for Engineering and Technology, Inc.* 2003. <http://www.abet.org/images/Criteria/E1%2003-04%20EAC%20Criteria%2011-15-02.pdf>
- [2] Atkins, D., Droegemeier, K., Feldman, S., et al. Revolutionizing science and engineering through cyberinfrastructure: Report of the National Science Foundation blue-ribbon advisory panel on cyberinfrastructure. (The National Science Foundation, 2003, p. ES 2). <http://www.cise.nsf.gov/sci/reports/toc.cfm>
- [3] Begley, E. MatML version 3.0 schema. (National Institute of Standards and Technology, NISTIR 6939, 2003). <http://www.matml.org/downloads/MatMLv30.pdf>
- [4] Berners-Lee, T., Hendler, J. and Lassila, O. The semantic web. *Scientific American.com*, May (2001). <http://www.sciam.com/article.cfm?colID=1&articleID=00048144-10D2-1C70-84A9809EC588EF21>