

DLI-2: Creating the Digital Music Library

Final Report to the National Science Foundation

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Principal Investigator: McRobbie, Michael, A.

Organization: Indiana University

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DLI-2: Creating the Digital Music Library

Senior Personnel

Name: Michael McRobbie

Worked for more than 160 Hours: Yes

Contribution to Project: Principal Investigator and Project Director

Name: Cronin, Blaise

Worked for more than 160 Hours: Yes

Contribution to Project: co-PI

Name: Dillon, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project: co-PI: Usability (Dean, School of Information, University of Texas at Austin)

Name: Thorin, Suzanne

Worked for more than 160 Hours: Yes

Contribution to Project: co-PI and Dean, University Libraries from the beginning of the project to 2005

Name: Crews, Kenneth

Worked for more than 160 Hours: Yes

Contribution to Project: co-PI: Intellectual Property

Name: Fern, James

Worked for more than 160 Hours: Yes

Contribution to Project: co-PI: Music Instruction - Music for the Listener

Name: Isaacson, Eric

Worked for more than 160 Hours: Yes

Contribution to Project: co-PI: Music Theory and Music Instruction

Name: Bernbom, Gerald

Worked for more than 160 Hours: Yes

Contribution to Project: co-PI and Executive Investigator (2000-2003)

Name: Davidson, Mary

Worked for more than 160 Hours: Yes

Contribution to Project: Mary Davidson was the Head of the William & Gayle Cook Music Library until her retirement in 2004. She oversaw metadata research and development activities for the Variations2 project and was also deeply involved in copyright review and collection development activities. Her involvement in the project is an IU contribution; she is not supported with NSF funding.

Name: Brancolini, Kristine

Worked for more than 160 Hours: Yes

Contribution to Project: Kristine Brancolini is Director of the Indiana University Digital Library Program. She is chiefly involved in research and development activities in the area of copyright and intellectual property. Her involvement in the project is an IU contribution; she is not supported with NSF funding.

Name: Dunn, Jon

Worked for more than 160 Hours: Yes

Contribution to Project: Jon Dunn is Associate Director for Technology in the IU Digital Library Program and is chief technical architect for research and development activities on the Digital Music Library project. He also served as project manager and executive investigator from 2003 until the end of the project in 2006. His involvement in the project is an IU contribution, and he is not supported with NSF funding.

Name: Hemmasi, Harriette

Worked for more than 160 Hours: Yes

Contribution to Project:

Harriette Hemmasi was Executive Associate Dean and Director of Technical Services in the IU Libraries until 2005. Her chief involvement in the project was in support of metadata research and development, with a specific focus on music metadata standards. Her involvement in the project is an IU contribution; she is not supported with NSF funding.

Name: Lindsey, Roberta

Worked for more than 160 Hours: Yes

Contribution to Project: Roberta Lindsey is Visiting Assistant Professor of Music at Indiana University. She is chiefly involved in research and development activities in the area of music instruction.

Name: Byrd, Don

Worked for more than 160 Hours: Yes

Contribution to Project: Don Byrd is a senior scholar in the IU School of Music and is a research analyst/programmer on the Digital Music Library project software development team. He also previously worked on Online Music Recognition and Searching (OMRAS) project (<http://www.omras.org/>), funded by NSF and JISC through the International DLI2 program. His work on the IU Digital Music Library project is funded by Indiana University.

Name: Notess, Mark

Worked for more than 160 Hours: Yes

Contribution to Project: Mark Notess is a Usability Specialist working on the Digital Music Library project software development team, with a focus in the areas of user interface design and usability testing, and also served as Software Development Manager for the project from 2004-2006. His work on the project is supported by the NSF DLI-2 award.

Name: Riley, Jennifer

Worked for more than 160 Hours: Yes

Contribution to Project: Jenn Riley is Metadata Librarian in the Digital Library Program at Indiana University and oversaw the metadata research and development activities on the Variations2 project from 2004-2006. Her involvement in the project is an IU contribution, and she is not supported with NSF funding.

Graduate Student

Name: Findlay, William

Worked for more than 160 Hours: Yes

Contribution to Project: William Findlay was a graduate research assistant on the Digital Music Library project in 2001, working in the area of music theory instruction. He is pursuing a doctoral degree in Instructional Systems Technology at IU. His stipend and fee remission were funded entirely through this award.

Name: Fuhrman, Michelle

Worked for more than 160 Hours: Yes

Contribution to Project: Michelle Fuhrman was a graduate research assistant on the Digital Music Library project in 2001, working in the area of usability studies. She is completing a master's degree in information science at IU. Her stipend and fee remission are funded entirely through this award.

Name: Yorgason, Brent

Worked for more than 160 Hours: Yes

Contribution to Project: Brent Yorgason was a graduate hourly employee and graduate assistant, providing software development and technical support to the Multimedia Music Theory Teaching (MMTT) development effort of the IU Digital Music Library project. He worked under the direction of project co-PI, Eric Isaacson. His work on the Digital Music Library project is supported by the NSF/DLI2 award.

Name: Swan, Maggie

Worked for more than 160 Hours: Yes

Contribution to Project: Maggie Swan was a graduate research assistant, working in the area of user studies, usability, and user testing. She has worked under the direction of project co-PI, Andrew Dillon, and Mark Notess. Her work on the Digital Music Library project is supported by the NSF/DLI2 award.

Name: Minibayeva, Natalia

Worked for more than 160 Hours: Yes

Contribution to Project: Natalia Minibayeva was a graduate research assistant from June 2001 - September 2002, working in the area of metadata design and development on the Digital Music Library project. She worked under the direction of project senior personnel, Harriette Hemmasi and Mary Davidson. Her work on the Digital Music Library project was supported by the NSF/DLI2 award.

Name: Scull, Erik

Worked for more than 160 Hours: Yes

Contribution to Project:

Erik Scull was a graduate research assistant from August 2001 - July 2003, working in support of the online music instruction activities of the Digital Music Library project. He worked under the direction of project co-PI, Roberta Lindsey. His work on the Digital Music Library project is supported by the NSF/DLI2 award.

Name: Hunter, Caitlin

Worked for more than 160 Hours: Yes

Contribution to Project: Caitlin Hunter is a graduate research assistant in the area of metadata design and development, working under the direction of project senior personnel Harriette Hemmasi, Mary Davidson, and Jenn Riley. Her work on the project is supported by the NSF DLI-2 award.

Name: Lee, Yoon

Worked for more than 160 Hours: Yes

Contribution to Project: Yoon Lee worked as a research assistant and technical programming assistant with the systems development team, under the direction of project senior personnel Jon Dunn and Mark Notess. His work on the project was supported by the NSF DLI-2 award.

Name: Wang, Ding

Worked for more than 160 Hours: Yes

Contribution to Project: Ding Wang worked as a graduate research assistant in the network research area of the project, studying network quality of service (QoS) methodologies, and the network requirements and constraints from January-December 2003, under the supervision of Doug Pearson. His work on the project was supported by the NSF DLI-2 award.

Name: Shaffer, Ann

Worked for more than 160 Hours: Yes

Contribution to Project: Ann Shaffer worked as a student hourly employee and graduate assistant in the metadata research and development area, under the supervision of Harriette Hemmasi, Mary Davidson, and Jenn Riley. Her work on the project was supported by the NSF DLI-2 award.

Name: Cooper, Michelle

Worked for more than 160 Hours: Yes

Contribution to Project: Michelle Cooper worked as a graduate assistant in the areas of project management and usability, under the supervision of project senior personnel Jon Dunn and Mark Notess. Her work on the project was supported by the NSF DLI-2 award.

Name: Shuck, Lorie

Worked for more than 160 Hours: Yes

Contribution to Project: Lorie Shuck was a graduate research assistant, working in support of the online music instruction activities of the Digital Music Library project. She

worked under the direction of project co-PIs Roberta Lindsey and Jay Fern. Her work on the Digital Music Library project is supported by the NSF/DLI2 award.

Name: Crenshaw, Qiana

Worked for more than 160 Hours: Yes

Contribution to Project: Qiana Crenshaw was a student employee working in the intellectual property area of this project under the supervision of Kenneth Crews and was funded from this award.

Name: Anema, Deborah

Worked for more than 160 Hours: Yes

Contribution to Project: Deborah Anema was a graduate assistant in the area of software development during the Fall 2005 semester, working under the supervision of Mark Notess. Her work on this project was funded by the NSF DLI-2 award.

Name: Kouper, Inna

Worked for more than 160 Hours: Yes

Contribution to Project: Inna Kouper worked as a graduate assistant in usability, under the supervision of Mark Notess. Her work on the project was supported by the NSF DLI-2 award.

Name: Smith, Dallas

Worked for more than 160 Hours: Yes

Contribution to Project: Dallas Smith worked as a graduate assistant in usability, under the supervision of Mark Notess. Her work on the project was supported by the NSF DLI-2 award.

Name: Li, Yi

Worked for more than 160 Hours: Yes

Contribution to Project: Yi (Richard) Li worked as a Graduate Assistant on the software development team from Fall 2004 - Spring 2005, under the supervision of Mark Notess. His work on the project was supported by the NSF DLI-2 award.

Technician, Programmer

Name: Halliday, James

Worked for more than 160 Hours: Yes

Contribution to Project: James Halliday was a software analyst/programmer on the Digital Music Library project software development team from 2001-2005, working under the supervision of Jon Dunn and Mark Notess. He is also pursuing a doctoral degree in music theory at IU. His work on this project was funded by the NSF DLI-2 award.

Name: Jadud, Matthew

Worked for more than 160 Hours: Yes

Contribution to Project: Matthew Jadud was a software analyst/programmer on the Digital Music Library project software development team from January-November 2001.

Name: Pendleton, Rob

Worked for more than 160 Hours: Yes

Contribution to Project: Rob Pendleton was a senior software/analyst programmer working on the Digital Music Library project software development team from February 2001 - August 2002.

Name: Scherle, Ryan

Worked for more than 160 Hours: Yes

Contribution to Project: Ryan Scherle was a software developer on the software development team, working under the supervision of Mark Notess, and is also a Ph.D. student in the computer science department. His work on this project was funded by the NSF DLI-2 award.

Name: Yang, George (Qiao)

Worked for more than 160 Hours: Yes

Contribution to Project: George Yang was a software developer on the software development team, working under the supervision of Mark Notess. His work on this project is funded by the NSF DLI-2 award.

Name: Pearson, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project: This individual is coordinating participation of satellite sites in US and overseas, and is also overseeing the networking research activities of the project.

Name: Adams, Dawn

Worked for more than 160 Hours: No

Contribution to Project: Dawn Adams is a staff member in the Indiana University Copyright Management Center, who worked in the intellectual property area of this project under the supervision of Kenneth Crews and is partially funded from this award.

Name: Kulchania, Manoj

Worked for more than 160 Hours: Yes

Contribution to Project: Manoj Kulchania worked as a software developer from July 2005 - August 2006, under the supervision of Mark Notess. His work on the project was supported by the NSF DLI-2 award.

Organizational Partners

Waseda University

This organization agreed to participate in the project as a satellite site.
Contact person: Yoichi Muraoka.

Northwestern University

This organization agreed to participate in the project as a satellite site.
Contact person: Peter Webster.

Loughborough University

This organization agreed to participate in the project as a satellite site.
Contact person: Cliff McKnight.

University of Massachusetts Amherst

This organization agreed to participate in the project as a satellite site.
Contact persons: Margo Crist and Roger Rideout.

King's College London

This organization agreed to participate in the project as a satellite site.
Contact person: Barry Ife.

University of Oxford

This organization agreed to participate in the project as a satellite site.
Contact persons: John Wagstaff, Matthew Dovey.

City University

Principals involved: Geraint Wiggins, Head of Department, Department of Computing, School of Informatics, and Director, Center for Computational Creativity (CCC); Tim Crawford, faculty researcher within CCC, Intelligent Sound and Music Systems Group.

City University sees prospects to collaborate with IU project team on development of additional tools for Variations2, e.g., pattern discovery and retrieval; music structure analysis; courseware development tools.

City University-London in the UK was a new addition in 2002 to the Variations2 satellite site institutions. Note that in 2004 the principals at City University moved to the Department of Computing at Goldsmiths College, University of London.

University of Illinois at Urbana-Champaign

This organization agreed to participate in the project as a satellite site.
Contact person: Richard Griscom. In 2003, this included work on cooperative cataloging using the music metadata model and system developed as part of this project.

Illinois State University

This organization agreed to participate in the project as a satellite site.
Contact person: David Williams
Illinois State was a new satellite site for 2003.

Goldsmiths College University of London

Principals involved: Geraint Wiggins, Professor of Computational Creativity, Department of Computing, and Tim Crawford, faculty researcher.

Goldsmiths sees prospects to collaborate with IU project team on development of additional tools for Variations2, e.g., pattern discovery and retrieval; music structure analysis; courseware development tools.

Goldsmiths College, University of London, in the UK was a new addition in 2004 to the Variations2 satellite site institutions.

Other Collaborators or Contacts

The project has had a standing committee that serves as a project advisory board. Some of these individuals consult with members of the project team on an individual basis, and a two-day meeting of the advisory board was held in November 2002 as a midterm review of the project. Members of the advisory board are:

Grace Agnew
Associate University Librarian for Digital Library Systems
Rutgers, the State University of New Jersey

Georgia Harper
Office of General Counsel
University of Texas System

Dr. John B Howard
Associate Director for Technology Development and Services
Countway Medical Library, Harvard Medical School

Dr. Sherry L. Vellucci
Director, Division of Library & Information Science
St. John's University

Donald J. Waters
Program Officer for Scholarly Communications
Andrew W. Mellon Foundation

Dr. David B. Williams
Associate Vice President for Technology
Professor of Music and Arts Technology
Illinois State University

Activities and Findings

Digital Library System Research and Development

Indiana University's Variations2 Digital Music Library project focused on three chief areas of research and development: system architecture, including content representation and metadata standards; component-based application architecture; and network services. We tested and evaluated commercial technologies, primarily for multimedia and storage management; developed custom software solutions for the needs of the music library community; integrated commercial and custom software products; and tested and evaluated prototype systems for music instruction and library services, locally at Indiana University, and at a number of satellite sites, in the U.S. and overseas.

System Development, System Architecture, Application Architecture

Over the course of the project, three major releases of the Variations2 software system have been completed. Version 1, completed in 2002, focused on basic infrastructure components (data and metadata repositories, authentication, logging), a search user interface based on the new data model developed for Variations2, presentation and navigation of music audio and scanned musical scores, and a cataloging/administrative interface for creation and editing of descriptive, technical, and structural metadata. Version 2, completed in 2003, added support for printing of musical scores, the 'Opus Window' for synchronized playback of audio and display of scanned scores, and the 'Timeliner' tool for creating and saving visualizations of musical form using audio recordings from the digital library. Version 3, completed in 2004, added support for audio playlists, score image annotation, encoded scores, and access control. Version 4 was completed in 2005, with a focus on turning Variations2 from a research system into a true 'production-ready' system, adding integration of Variations2's access control and authorization capabilities with IU's Student Information System for as well as features for generating self-quizzes from playlists. Version 4 is currently deployed at IU and is used daily by hundreds of music students and faculty to access and interact with recordings and scores for their courses.

The following technical environment supports Variations2.

- Client and server developed in Java,
- Java RMI used for client-server communication
- Windows and Mac OS X client platforms, AIX and Linux servers
- Database: IBM DB2, DB2 Net Search Extender
- Audio streaming: Apple Quicktime for Java, Apple Darwin Streaming Server
- Audio compression: MPEG-1 layer 3 (MP3) and MPEG-4 AAC
- Image compression: DjVu from AT&T Labs and Lizardtech

Metadata

The major accomplishment in the area of Metadata has been the design and development of the data model that provides the underlying structure for the Variations2 system. This new data model is a major improvement upon existing metadata systems for music. The model contains five major entities: Work, Contributor, Instantiation, Container, Media Object. The model specifies descriptive, structural, and administrative metadata elements associated with these entities, and defines the functional relationships among the entities. The metadata model has been presented to a number of professional associations and organizations: International Association of Music Libraries, ACM/IEEE Joint Conference on Digital Libraries, and International Conference on Music Information Retrieval. These are cited in the Outreach Activities section of this report.

In 2003, we continued to test the data model by creating entries for many diverse forms of classical music as well as jazz, popular, and ethnic music, a total as of mid-December 2003 of approximately 1730 Work records, 1303 Contributor records, and 245 Container records. We also tested whether or not the model can be exported to one satellite site (University of Illinois at Urbana-Champaign), and interns trained to produce all forms of records accurately and in a timely fashion. A questionnaire was designed with the help of the Usability team, and distributed to the participants. The intention was to discover their reaction to specific portions of the exercise, and the efficacy of the working model from a cataloger's point of view.

In 2004, work continued creating descriptive and structural metadata for sound recordings and scores in the Variations2 system. While much work remains before we can determine the long-term sustainability of the Variations2 data model, bibliographic models based on entity-relationship analysis, like Variations2, are emerging at an increasing rate. In 2004, we learned of two other entity-relationship data models in the field of music, from the Citas de la musique in Paris and the British Library Sound Archive. The International Federation of Library Associations and Institutions (IFLA) 1997 Functional Requirements for Bibliographic Records (FRBR) report has been a leader in this shift of thinking about bibliographic data. Although none of these three music data models are identical, we believe this movement towards entity-relationship bibliographic models will continue and expect that the Variations2 data model will remain a major player in this environment.

One of the major benefits of the Variations2 data model to users of the catalog is greatly improved discovery over traditional MARC catalogs. Much of this improvement comes from the work-based nature of the model. However, in 2004 we developed two vocabularies for use within Variations2 metadata records to further assist users in finding relevant music within the Variations system. First is an instrumentation list (including terms for voices) in both alphabetical and hierarchical forms. The instrumentation list was created based on a survey of LCSH instrumentation headings by metadata team graduate assistants, on Harriette Hemmasi's earlier work with LCSH instrumentation headings for the Music Library Association Music Thesaurus Project, and was influenced by local project needs. The second vocabulary developed in 2004 is a preliminary draft of

a form/genre/style vocabulary for music materials. Again, this vocabulary was created by metadata team graduate assistants from a number of sources, including LCSH, Amazon.com, and the work of the Music Thesaurus Project. Adding terms from this draft vocabulary to Variations2 records will serve as a first step towards learning more about how users format music queries with form, genre, or style terms. This research should benefit the larger cataloging community, beyond Variations2, and users searching for musical materials.

Structural metadata in the Variations2 system is key in allowing some of the advanced functionality of the system, including navigation within a digital object and synchronization of audio files and scores of the same work. Creating this structural metadata, however, has proved very slow to date. We continue to investigate means of further streamlining this process. For creating container structures, which allow location of a given work within a digital object, we are investigating moving this from the cataloging workflow into the digitization workflow. For binding sound files to scores at the measure level, which allows them to be synchronized together on playback, we have begun investigation of programmatic means of creating this data and allowing it to be created by persons outside of the metadata team.

The metadata team's work in the final stages of the Variations2 project focused heavily on improving the rate at which metadata records can be created. One strategy we employed was to develop a list of 'basic works,' musical compositions likely to appear in a large number of recordings and score editions and be heavily studied in academic schools of music. By creating Variations2 Work and Contributor records for these compositions, adding new Containers on which these works appear becomes a much simpler task. This work provides a tremendous advantage for the Variations2 system into the future -- by including Work and Creator metadata records with a system, Variations2 can become something much closer to a 'music library in a box.' The second strategy we employed to speed metadata creation was experimentation with the batch loading of MARC records into the Variations2 system, and improving the data we were able to map from MARC into Variations2. The metadata team developed specifications for iterative experiments to test various levels of aggressiveness of mapping, and fully defined mappings for the first iteration of the experiment. Unfortunately, there was not time to carry out these mapping experiments during the course of the Variations2 grant, but the plans for the experiments are still useful in thinking about the future of the Variations2 system. In fact, we have been able to begin the first iteration of the experiment in the time since the Variations2 grant officially ended, and hope to be able to continue with this work in follow-on projects.

Another factor in the future of the Variations2 system is its applicability to types of music beyond that of the Western art music tradition. While the Variations2 metadata model provides superior searching capabilities for work-based musical traditions, scholarly and casual users alike are increasingly interested in other forms and styles of music. The Variations2 metadata team experimented with cataloging many different types of music in the Variations2 metadata model, including popular music and jazz early in the project, and extending to various world music traditions towards the end. A report on the latter initiative can be found at <http://variations2.indiana.edu/metadata/ethnic/>

EthnicMusic.htm>. Our findings were that, overall, some modifications to the Variations2 cataloging interface and metadata model would be necessary to fully accommodate non-Western music into the system. Many changes would be simple, such as adding controlled vocabularies for form/genre/style, instrumentation, and language more appropriate for other genres and styles of music. Others would be procedural, for example, developing an operational definition of a 'work' or procedures for devising a title in the context of other types of music. Still others would require more fundamental changes to the Variations2 metadata model and system itself, for example, accommodating information about the geographic location, cultural context, and provenance of a field recording that is essential to its discovery and understanding.

Metadata, which includes the information that identifies a particular piece of music or the detailed contents of a particular score or recording, allows users to easily find and use scores and recordings in the system. Metadata makes it possible to search by title, for example, or composer, performer, key, publication date or a wide range of other descriptive information.



The final major research contribution of the metadata team in the final phase of the Variations2 project was the development of detailed specifications for how the system should act on known relationships between works to improve discovery. Many types of information resources represent complex relationships between works, and music is particularly rich with such relationships. Our work focused specifically on two types of relationships between works: the derivative (based-on) relationship, and the whole-part relationship. The specifications developed as a result of this work can be found at <<http://variations2.indiana.edu/metadata/workrelationships/specs.pdf>>, and represent various ways of connecting related works to one another in search results and in other parts of the Variations2 interface, to allow users to discover works related to those they are interacting with and provide means for them to seamlessly move between related works. This work was presented at the 2005 International Conference on Music Information

Retrieval. No development time was available during the Variations2 project to implement these specifications, but they are important nonetheless in planning for future versions of the system and for other systems with work-based metadata models.

Satellite Sites and Network Services

An important original goal of this project was to expand access to the Variations2 testbed system, by demonstrating that users at other colleges and universities can have similar interaction with the digital collections and educational applications as were available to students, teachers and scholars at Indiana University.

Over the course of the project, IU project team members made site visits to most of the participating satellite sites: University of Illinois Urbana-Champaign, City University, Kings College-London, Loughborough University, the University of Oxford, City University London, and Goldsmiths College-University of London. The Variations2 client software was installed and made available at each site, and satellite site staff provided valuable input into system requirements and design. However, the degree to which each site worked with the system varied substantially based on interest and availability of staff time. One site (Kings College-London) used the system for real instructional purposes, and another (UIUC) engaged in cataloging activities using the Variations2 metadata model and administrative interface.

Digital Library and Pedagogical Applications

Applications using Variations2 for education, research, and music library services will be designed and developed by faculty from the IU School of Music, the IU Libraries, and others on the Variations2 project team. Applications will build on a successful track record of pedagogical software development and innovation in music education and research at IU, which includes the Multimedia Music Theory Teaching project <<http://theory.music.indiana.edu/mmtt/>>, advance the development of courses in music for non-majors using instructional software from the Oncourse project <<http://oncourse.iu.edu/>>, and provide library users with intellectual access and advanced navigation capabilities to the digital music library, substantially improving upon and advancing beyond the capabilities of the VARIATIONS digital music library system <<http://www.music.indiana.edu/variations/>>.

Music Instruction: Music Theory

A primary objective for the project is to design instructional tools that will allow faculty to use the Variations2 system to create instructional lessons for classroom presentations and student activities (assignments, independent study, tests). A series of classroom observations and interviews with instructors were conducted to determine what kinds of activities members of the music faculty carried out during the course of their teaching. This data was collated and put into a database, and based on this information, system requirements and specifications for the Multimedia Music Theory Teaching (MMTT)

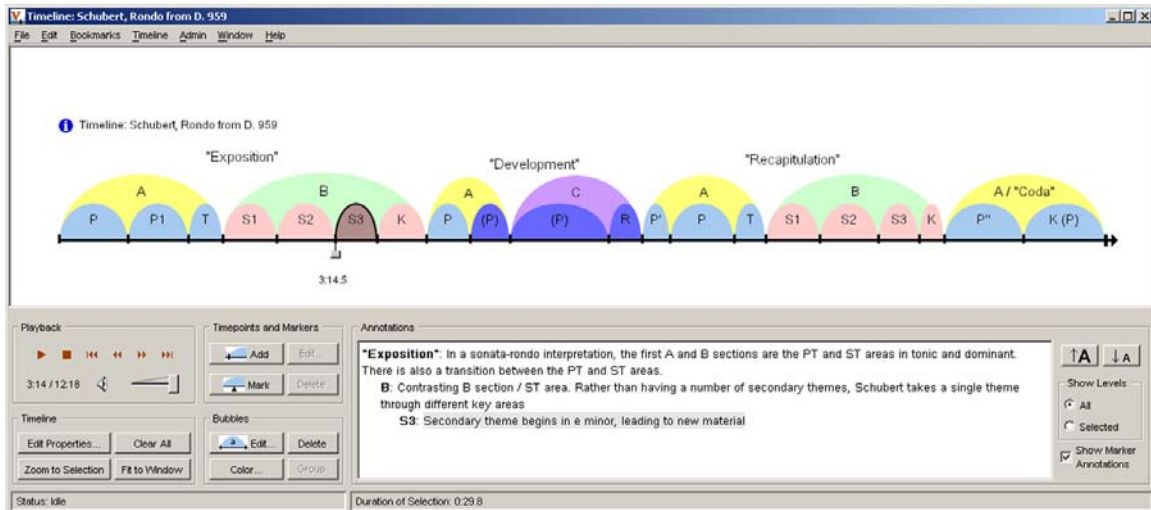
system have been documented. System components specified for the MMTT include the following: Items implemented:

- Librarian (a search feature)
- Media Player (for audio or video)
- Score Viewer
- Timeliner (for music analysis)
- Annotation tools
- Playlist creator/editor
- Authoring environment

The following items proved too complex to implement during the period of the grant and remain on the active 'wish' list:

- Notation Editor
- Question Builder (for use in instructional lessons)

However, work was carried out in support of future development of a Notation Editor: We have completed a lengthy requirements specification for a symbolic music representation, which appeared in a recent issue of *Computer Music Journal*, and is serving as important document in discussions with several people who are developing such representations. In addition, basic support for storing encoded musical scores in MusicXML format and displaying them via an external viewer was implemented as part of Variations2 version 3. Since the deployment of Variations2 within Indiana University, a number of faculty have made use these tools in various ways in their courses and they have proven very useful. The Timeliner tool in particular has been used by several instructors, has been very well received by instructors at other institutions, and seems as though it will be useful in many contexts. Activities relating to the project led Eric Isaacson to form an interest group on music informatics within the Society for Music Theory in 2004. One of the major areas of interest for the group is exploring how a library of encoded scores will facilitate new research activities within the discipline.



The Timeliner tool allows faculty to use the Variations2 system to create instructional lessons for classroom presentations and student activities (assignments, independent study, tests). Students are able to see the structure of a piece of music on their own computers, annotate it, and use this online visualization tool to compare one performance to another. Students themselves can create visual interactive timelines of audio segments -- the opening phrases of a Schubert rondo, for example, and jump to a section of music and listen to it while reading their own associated annotations.

Music Instruction: Music for the Listener, Music History

Major activities involve incorporating digital music content and computer-based instructional elements into undergraduate music history instruction. Work is proceeding in phases.

- Phase One: Incorporating digitized music into the 'virtual' classroom.
- Phase Two: Developing and incorporating tutorials of musical forms into the 'virtual' classroom.
- Phase Three: Developing and incorporating interactive musical resources and digitized video into the 'virtual' classroom.

In 2002, activities included: investigating copyright and fair use issues, evaluating our e-learning platform (Oncourse, IU's course management system) with regard to its authentication and authorization services, digitizing music content, assigning online supplemental listening homework related to students' lessons, assessing the course using "Flashlight" survey tools, developing tutorials, and incorporating tutorials into student assignments.

In 2003, activities included incorporating additional Flash tutorials into the online course, experimenting with the use of the Variations2 bookmarking function in the on-campus course, and experimenting with the use of a threaded discussion forum in the online class to evaluate streaming audio.

In 2004-2005, activities centered around implementing and supporting Variations2 for the online course.

Digital Library Research

“Variations2 will serve as a rich foundation for research in usability and intellectual property rights. Research will be closely coordinated with testbed and application development, so that research outcomes will be incorporated into testbed and application development activities.

- Usability research will be integral to creation of the DML. Formative user testing will be conducted throughout the project, with results incorporated in the design process; summative user testing will be employed for periodic and overall evaluation of the system design.
- Copyright research will help identify particular content for inclusion in the DML. Early stages of the research will identify categories of works that are in the public domain and without copyright restrictions; later stages will identify the possibilities for providing access to protected works under the law and under licensing agreements, including design features that may satisfy these requirements.” (from the Project Proposal)

Usability

1) Indiana University

Research in usability is closely coordinated with software design and development activities so that findings of usability studies are reflected in the emerging Variations2 digital music library software system.

Usability research activities in 2002 included:

- Field studies of students using Variations for listening assignments, using the Contextual Design methodology. This improved our understanding of how students use digital music library resources and had some influence on Variations2 features.
- Usability testing on three prototype Multimedia Music Theory Teaching (MMTT) lessons. Results from these tests will impact version 2 of Variations2 and future releases that include MMTT functionality. Test results were described in an internal technical report.
- Experimentations with visualizations of music metadata. Results were presented at the Second International Workshop on Visual Interfaces to Digital Libraries, held at the ACM+IEEE Joint Conference on Digital Libraries in July.
- A usability test of an early version of Variations2. Results from this test were used to make improvements in Variations2, version1, prior to its release and are detailed in an internal technical report.

In usability research in 2003, apart from our normal usability testing, we have explored and compared methods for assessing usability ‘in the field’--studying actual usage in contrast to merely studying performance on set tasks in a laboratory environment.

The primary aspect of usability compared between lab and field was user satisfaction, as measured with a variant of the Questionnaire for User Interaction Satisfaction. We were particularly interested in whether lab-based satisfaction measurements could predict user satisfaction in actual use situations.

In comparing methods for studying digital library usage in the field, in addition to satisfaction surveys, we also looked at contextual inquiry and session log analysis. We compared our experiences with each of these methods in terms of expertise required, time to set up, time to conduct, time to analyze, and the benefit derived. The results of this analysis offer guidance to digital library implementers and researchers, by helping them choose an appropriate research methodology and by encouraging field-based user studies. In usability research in 2004, we compared contextual design as an HCI-centric design method to a “big-D” design method, finding good alignment and prospects for coexistence between the two. The main area for new user research, beyond our continuing usability testing, was a study of Variations2 timeline usage in a graduate course. We examined the impact on student learning of having annotated timelines available to guide student listening. Findings from a survey of student use and an instructor interview, triangulated with log file analyses, lead us to conclude that having guided listening available through annotated timelines does seem to increase student preparation for class; moreover, students were very enthusiastic about both Variations2 and the timeline tool in particular.

Usability research in 2005 used a field study to examine issues with home installation by students of the Variations2 client. Current wisdom suggests installation of client software should be avoided in favor of web-based interfaces. However, highly interactive interfaces such as Variations2 do not always work well within a browser. Field studies and pilot installation projects helped us smooth and improve installation to the point where it did prove feasible to offer home installation to students, hundreds of whom had successfully installed and were using the Variations2 client by the end of the year.

In 2005 we continued to explore the role of field studies in digital library development, including participation in a JCDL workshop on that theme. Our work helps broaden DL user research beyond mere ‘information retrieval’ to include an emphasis on how retrieved materials are used and how they contribute to activities such as learning. Contextual design models offer a standardized method for capturing and comparing patterns of artifact use across settings and media types.

Drawing lessons from our numerous usability tests, we wrote an article summarizing what we have learned about making digital library usability test tasks more authentic, thus improving the validity of test results. This article was published in OCLC Systems & Services.

2) University of Texas at Austin:

Usability research work was also carried out in 2003-2005 under a subaward arrangement at the University of Texas at Austin, after Andrew Dillon's move from Indiana University to Austin. Major activities were undertaken have included:

- Heuristic evaluation of Variations2 conducted by Jennifer Jobst: This work involved Jobst becoming familiar with and installing a working version of Variations on a computer in Austin. Plans were drawn up for an expert assessment of Variations by faculty in the music department but lack of response to several approaches delayed this activity.
- Producing a state of the art report on learning within hypermedia environments - updating Dillon and Gabbard (1998) for inclusion in a new volume to be edited by Richard Mayer (UCSB) for Cambridge University Press in 2004. The output of this report has recommendations on interface variables for study and serves as a current evaluation of the use of hypermedia for education.

Copyright

Several research studies have been undertaken and findings posted to the Variations2 project website. (See <<http://variations2.indiana.edu/legal/>>.) Areas of study have included detailed study of Section 108 of the Copyright Act governing the reproduction of materials by libraries; the expiration of copyright protection and analysis of Copyright Law for identifying the public domain; and a review of 'A&M Records v. Napster, Inc.' with a view toward the implications of this decision for digital libraries of music. Ongoing and in process is a detailed examination of Section 114 of the Copyright Act, governing the performance of sound recordings in digital audio transmissions. Incidentally, one of the first copyright papers completed for the Variations2 project gained greater importance in January 2003 for two reasons. The study of copyright duration has been underscored by a decision from the U.S. Supreme Court on January 15, 2003 upholding the most recent congressional action to extend the term of protection. Further, one rule that has been part of the law since 1978 took effect, as scheduled, at the beginning of 2003. Only now will unpublished works from before 1978 be subject to a term of protection that can expire; only as of the beginning of 2003 might the Variations2 project be able to include some early archival materials as a result of their entering the public domain.

Much of our attention during 2003 turned to the question of fair use and licensing of music-related works, addressing the question of the fair use of materials that are made available in the digital library.

The papers written in 2004 and 2005 expand the examination of the relationship between the digital library and copyright law. Two major papers explore in depth the possibilities for application of fair use to the activities of V2 and the possible employment of the TEACH Act. The TEACH Act, enacted by Congress in 2002, is a new statutory provision intended to facilitate the use of copyrighted materials in distance education. A major

benefit of V2 is the promise that it can enable students in locations far beyond the local campus to access music files and related materials. Because many of those works are protected by copyright, the TEACH Act could provide a lawful means for loading the works onto a server and allowing instructors and students to utilize them from remote locations.

Unfortunately, the TEACH Act includes numerous restrictions that have largely rendered the law impracticable. Instead, the law of fair use remains the most likely provision of the Copyright Act to offer a lawful means for sharing protected works through the digital library. The paper on fair use explores a wide variety of possible interpretations of fair use, with detailed attention to the structure of V2 and its attributes.

Music Information Retrieval

Investigators on the Variations2 project continue to be among the leaders in the growing international field of music information retrieval. Several have been involved in organizing and giving research presentations at the International Conference on Music Information Retrieval since its inception in 2000.

Jon Dunn and Don Byrd were on the organizing committees for ISMIR 2001, 2002, and 2003, and both have served on the ISMIR Steering Committee. Indiana University coordinated supplements to IU's NSF DLI-2 award for Variations2, directly supporting ISMIR 2001 in Bloomington and allowing a delegation of U.S. researchers to attend ISMIR 2002 in Paris. (See <<http://www.ismir.net/>>)

A conference report on ISMIR 2002 appeared in the November 2002 issue of D-Lib Magazine, as did a brief summary of the history of the development of this conference series on music information retrieval. See:

Report on the Third International Conference on Music Information Retrieval (ISMIR 2002). Bonita Wilson. D-Lib Magazine, Volume 8, No. 11, November 2002.
<<http://www.dlib.org/dlib/november02/wilson/11wilson.html>>

The History of ISMIR - A Short Happy Tale. Donald Byrd and Michael Fingrhut. D-Lib Magazine, Volume 8, No. 11, November 2002.
<<http://www.dlib.org/dlib/november02/11inbrief.html#BYRD>>

Findings

In the area of systems and application architecture, the principal result is the successful creation of a digital music library software system (Variations2) aimed at students, teachers, and researchers at the university level, that provides access to music in audio, score image, and encoded score notation formats, along with a music-specific metadata search mechanism, and a set of tools to enhance use of the content in research and pedagogical applications. This system has been tested in the real-world environment of

the Indiana University Jacobs School of Music and has stood up to the use of its demanding students and faculty. In addition, it has supported the other research areas of this project.

The successes of this system and project have led to a new National Leadership Grant awarded in 2005 by the federal Institute of Museum and Library Services in support of a three-year project to take the software developed with NSF support and extend it to be broadly applicable to meet the digital music library service needs of conservatories, colleges, and universities throughout the US. Despite this new funding from IMLS, there remain other areas of inquiry for which we are keen to pursue additional funding, including the use of Variations2 as a 'real-world' integrating platform and testbed for a variety of content-based music information retrieval techniques and systems. This idea is described in our July 2006 article in the Communications of the ACM (see Publications). The overall findings of our metadata research are that while the entity-relationship data model developed for the project offers improved music discovery for users and the Work-based structural metadata offers very useful capabilities for the simultaneous navigation of multiple version of a musical work, the costs of creating this metadata is extremely high. Further work is needed on developing more automated methods for creating music metadata, drawing upon multiple sources such as library bibliographic records, commercial databases, and user-contributed metadata. Research in this area will be continued under the new grant from the Institute for Museum and Library Services. We are also interested in working on integrating automated means of score-sound synchronization such as those discussed at recent ISMIR conferences, but will need to pursue additional funding for that work.

Investigators in the area of music theory instruction have been involved in evaluation of musical representations for Variations2. Findings of this work are summarized in the paper, 'A Music Representation Requirement Specification for Academia' (D. Byrd and E. Isaacson), which is has been published in the Computer Music Journal, and a preliminary version of which is available on the project web-site at <http://variations2.indiana.edu/pdf/v2-music-rep-req-11.pdf>.

Usability findings that contribute to the systematic implementation of user-centered design practices are focused in two areas. First, we have identified confounding factors in using user-test-based measures of user satisfaction to predict end-user satisfaction. Second, in applying contextual inquiry and design methodologies, we have demonstrated the usefulness of the methods for educational software development and digital libraries while simultaneously identifying expressiveness gaps in the commonly used work models. Both of these areas warrant further work to provide continuing contributions to the field of usability: by identifying ways to measure and minimize the test-subject/end-user satisfaction gap, and by extending contextual inquiry and design methods to better deal with individual learning activity. Our work has also contributed an early and significant understanding of how learning tools can be integrated usefully into digital libraries for the improvement of learning. Although other timeline-style tools have existed for exploring and annotating music, ours is the first to make it easy for people to use such a tool with an arbitrary piece of music, whether streamed from the digital

collection or residing on one's own hard drive. The success of this tool in our pilot study suggests an unmet opportunity for flexible learning tools that integrate well with both DL and personal content.

Findings in the area of copyright research may be summarized as follows:

- Through the expiration of copyrights, much material that might be useful to the Variations2 digital music library is available for use without copyright restriction. The law of copyright expiration is complex and often difficult or impossible to apply in all cases. Some classes of works nevertheless are clearly in the public domain.
- Many of the uses of works in Variations2 implicate the rights of the copyright owners. Few of the statutory exceptions to those rights have application to the intended operation of Variations2.
- Section 108 will allow a library to make many uses of copyrighted works consistent with some of the functions of Variations2. Section 108 perhaps applies most easily and generously with respect to preservation of materials that are at risk in the library.
- Fair use law is broad and flexible, and its meaning is usually open to debate and differences of interpretation. Few court rulings have applied fair use to situations that are relevant to Variations2. A reasonable argument is possible for some fair use of materials on a scale appropriate to the successful functioning of Variations2.
- The TEACH act contains numerous restrictions that have largely rendered the law impracticable.
- Overall, much of our work drifts to a common result: The law is no ally in the development and use of the digital library. The law was clearly not crafted with the objective of supporting projects such as Variations2. We are constantly struggling with the misfit between Variations2 and the limitations of the law. We are also finding that the systems for licensing of music are aimed more toward meeting the needs of industry, rather than the needs of academics and students.

Training and Development

The Variations2 project has provided training and development opportunities to an interdisciplinary group of graduate research assistants, including:

Michelle Cooper, a master's student in Information Science, worked on the Variations2 project from 2003-2005 as a graduate assistant working on usability and general project administrative support. Michelle has been able to enhance her skills in web design and

information architecture and to gain experience in designing and running usability experiments.

Maggie Swan, a graduate student in the School of Library and Information Science, has had the opportunity to design and run usability tests, successfully propose research to the human subjects committee, design and run a survey study and perform statistical analysis on the results. Maggie has also participated in user interface design for Variations2, and has had the opportunity to write extensive reports of usability testing activities and findings, and has presented these findings to the project technical team. She designed and created the online help for Variations2, gaining experience in web design, and refined it based on usability test results. She has co-authored and presented conference papers.

All of the usability graduate assistants working on the project have had opportunities to contribute to learn new research methods and write technical reports, journal articles and conference papers. One GA presented a position paper at the ACM SIGCHI conference in Vienna. Two others co-authored a peer-reviewed journal article with a staff member. Graduate assistants had primary responsibility for producing technical reports summarizing usability testing and field studies, having participated directly in research projects in cooperation with full-time faculty and staff.

Caitlin Hunter, a dual master's student in Musicology and Library Science, began working with the Variations2 project in August 2002 as the graduate research assistant in the area of metadata. Caitlin's primary responsibilities have been to create metadata records and to test the cataloging functionalities leading to improvements in the administrative interface. Caitlin reports that her research skills in music have been considerably honed by this project, as a result of having to track down detailed information about so many musical works, entailing far wider exploration of music reference resources than previously known to her. She also gained considerable expertise in her work with the Library of Congress Name Authority File. Because we are a NACO contributor in music, she was able to transmit the results of a good bit of her research to that national database, thus aiding the progress of music cataloging in general. Caitlin did the bulk of the metadata work during the final phase of the Variations2 project has been an invaluable member of the project team. She gained and honed skills in project management, problem solving, report writing, resource description, and musical research during this time. The experience of working on Variations2 will supplement her degrees in Musicology and Library & Information Science to give her a wide variety of career opportunities, and the practical nature of her experience will make her an attractive candidate for many types of positions.

Jennifer Jobst, a Ph.D. student in the School of Information at the University of Texas at Austin, worked as a research assistant in the area of usability in 2003-2004. As part of her work on the project, she has received training and experience in heuristic usability evaluation methods, critiquing experimental design, and the theoretical basis of learning in hypermedia environments. The evaluation experience will enable her to practice and teach introductory students on usability methods. The training in experimental research methods and learning theory will advance the preparation for her own doctoral studies.

Yoon Lee was a master's student in the information science program in the School of Library and Information Science who worked as a graduate research assistant participating on the Variations2 software development team. This work has provided him with practical experience and skills development in software design, computer programming, and collaborative software development in a research context. Natalia Minibayeva, a master's student in Information Science and a doctoral student in Musicology, served as the metadata research assistant on the Variations2 project, July 2001-July 2002. Natalia was instrumental in helping define and document both the data model and metadata elements. Natalia also participated in user interface design and usability studies for the project. She collaborated as principal or secondary author with two different investigators in presenting papers about the project at national conferences. Erik Scull, a master's student in Music Technology, was responsible for the preparation, digitization, and streaming of supplemental audio materials used in Dr. Roberta Lindsey's online distributed course, M174 Music for the Listener at IUPUI. Erik also authored a series of Macromedia Flash-based tutorials for online delivery covering various musical forms: 12-bar blues, theme and variations, minuet and trio, etc. Erik has co-presented papers at both regional and national conferences of the College Music Society, as well as at the 11th Annual International Computer Music Technology Conference and Workshop at IUPUI.

Ding Wang, a graduate student in the Computer Science department, served in a graduate research assistant position on the Variations2 project throughout 2002. Ding worked in the network research area of the project, studying network quality of service (QoS) methodologies, and the network requirements and constraints, e.g. bandwidth, latency and jitter, of streamed audio. Ding constructed an initial implementation of a testbed to simulate various network quality and audio streaming scenarios.

Brent Yorgason, a doctoral student in Music Theory, was able to continue developing his skills in prototype development and interface design as a graduate research assistant on the project. He learned Java programming and contributed in important ways on the production end of the project as well. Brent was the primary person responsible for the detailed design and coding of the Timeliner tool, score annotation features, and the Lesson Editor.

Several students in the IUPUI School of Law worked in the copyright area of the project, including David A.W. Wong, Bobak Jalaie, and Deborah Wattier. In addition to exercising and expanding their skills in legal research, law students who worked on this project had an opportunity to examine legal issues in an applied context. For example, rather than simply inventorying and explaining principles of fair use, they were able to test the meaning of the principles in the context of a complex project that has multiple facets and is using a rich variety of materials: text, scores, recordings, and more. While we have been careful not to take on the role of legal counsel, or to reach specific conclusions about the applicability of the law, this project has allowed students to undertake significant projects that connect pure research to important and complex applications.

Outreach Activities

Outreach Activities 2005: Presentations, Conferences, etc. (in chronological order)

When Audio Becomes Data: The Storage and Management of Digital Audio Files
Jon Dunn
Association for Recorded Sound Collections annual conference, Austin, TX, March 2005

Using Contextual Design for Digital Library Field Studies
Mark Notess
ACM/IEEE-CS Joint Conference on Digital Libraries workshop, 'Studying Digital Library Users In the Wild: Theories, Methods, and Analytical Approaches', Denver, CO, June 10-11, 2005
Paper: http://www.dlib.org/dlib/july05/khoo/07_notess.pdf

Incorporating Student Learning Styles in the Distance Music Appreciation Class by Employing Various Technologies
Roberta Lindsey
Fourth International Conference on Technology in Teaching and Learning in Higher Education, Beijing, China, July 11, 2005.

What You See Is What You Get: On Visualizing Music
Eric Isaacson
ISMIR 2005: 6th International Conference on Music Information Retrieval, London, September 12-15, 2005.

Professional Users of Music Information Retrieval
Eric Isaacson
Participant on panel discussion. ISMIR 2005: 6th International Conference on Music Information Retrieval, London, September 12-15, 2005.

Exploiting Musical Connections: A Proposal for Support of Work Relationships in a Digital Music Library
Jenn Riley
ISMIR 2005: 6th International Conference on Music Information Retrieval, London, September 12-15, 2005.
<http://www.dlib.indiana.edu/~jenlrile/presentations/ismir2005/riley.pdf>

Understanding and Representing Learning Activity to Support Design: A Contextual Design Example
Mark Notess
Association for Educational Communications and Technology annual conference, Orlando, Florida, October 18-22, 2005.
Paper: <http://variations2.indiana.edu/pdf/notess-aect05.pdf>

Music Information Retrieval

Invited talk at Los Angeles Chapter of the Association for Information Science and Technology, Orange, CA, November 2005.

Flipping the Switch: Lessons Learned from a Major Digital Library Migration Project

Jon Dunn, Mark Notess, Ryan Scherle

Digital Library Federation Fall 2005 Forum, Charlottesville, Virginia, November 7-9, 2005.

Abstract: <http://www.diglib.org/forums/fall2005/fall2005abstracts.htm#session4>

Slides: <http://www.diglib.org/forums/fall2005/presentations/dunn1105.htm>

Outreach Activities 2004: Presentations, Conferences, etc. (in chronological order)

Can You See What I Hear? Utilizing Indiana University's Variations2 Tools in the Music Appreciation Classroom

Roberta Lindsey

E.C. Moore International Symposium for Teaching Excellence, IUPUI, Indianapolis, IN, March 5, 2004.

Variations2 demonstration

Mark Notess

Eastman School of Music, Rochester, NY, March 17, 2004.

Slides: http://variations2.indiana.edu/html/eastman/eastman_frame.htm

Discipline-Specific Online Learning Tools for Humanities Students: Exploring the Tool Gap

Mark Notess

IU Instructional Systems Technology Annual Conference, Bloomington, Indiana, April 2, 2004.

Slides: http://variations2.indiana.edu/html/ist-conf-version_files/frame.htm

Variations2 Help: Moving Help Closer to Users

Margaret B. Swan and Mark Notess

ACM CHI 2004 Workshop, Helping Users Use Help, Vienna, Austria, April 24-29, 2004.

Paper: <http://variations2.indiana.edu/pdf/chi-2004-swan-help.pdf>

Studying Digital Library Use

Mark Notess

IU Digital Library Program Brownbag Series, Indiana University, April 30, 2004.

Slides: <http://www.dlib.indiana.edu/workshops/studyingusebb/studyingusebb.ppt>

The Technology of Music Scholarship and the Scholarship of Music Technology

Eric Isaacson

Presented as the fifteenth William Poland Lecture in Music Theory, Ohio State University, May 24, 2004.

Variations2: Improving Music Findability in a Digital Library Through Work-Centric Metadata

Mark Notess and Jon Dunn

Poster, ACM/IEEE-CS Joint Conference on Digital Libraries, Tucson, Arizona, June 7-10, 2004.

Abstract: <http://variations2.indiana.edu/pdf/p084-notess.pdf>

Timeliner: Building a Learning Tool into a Digital Music Library

Mark Notess and Margaret B. Swan

EDMEDIA 2004, Lugano, Switzerland, June 21-26, 2004.

Paper: <http://variations2.indiana.edu/pdf/timelinerfinal-preprint.pdf>

Slides: http://variations2.indiana.edu/html/ed-media-2004/ed-media-2004_frame.htm

Variations and Variations2 at Indiana University

Mary Wallace Davidson

Music, Technology and Research Seminar, Symposium of the International Music Society

2004, Melbourne, Australia, July 16, 2004.

Slides: <http://variations2.indiana.edu/html/davidson-sims/>

Can You See What I Hear? Utilizing Indiana University's Variations2 Tools in the Music Appreciation Classroom(revised)

Roberta Lindsey

EISTA '04, Orlando, Florida, July 22, 2004.

Creating, Maintaining and Improving Digital Music Library Services at Indiana University

Mary Wallace Davidson

Joint Congress of the International Association of Music Libraries and the International Association of Sound Archives, Oslo, Norway, Aug. 10, 2004.

Online Music Distribution Systems from a Music Library Perspective [panel discussion]

Mary Wallace Davidson

Joint Congress of the International Association of Music Libraries and the International Association of Sound Archives, Oslo, Norway, Aug. 13, 2004.

Variations2: Teaching and Learning Music Online

Mark Notess

Presentation for the ArtsSites group, August 11, 2004, at TappedIn.org.

Slides: http://variations2.indiana.edu/html/tappedin/tappedin-2004_frame.htm

From Abstract to Virtual Entities: Implementation of Work-Based Searching in a Multimedia Digital Library

Mark Notess, Jenn Riley, and Harriette Hemmasi
ECDL 2004: The European Conference on Digital Libraries, Bath, UK, September 12-17, 2004.

Slides: http://variations2.indiana.edu/html/ecdl-04-talk/ecdl-04-talk_frame.htm

Paper: <http://mypage.iu.edu/~mnotess/ECDL/ecdl-04-reprint.pdf>

The Technology of Music Scholarship and the Scholarship of Music Technology
(revised)

Eric Isaacson

IU Music Theory Colloquium Series, Bloomington, IN, September 15, 2004.

Variations2: Moving Beyond Access to Pedagogy

Mark Notess

IU Digital Library Program Brownbag Series, Indiana University, September 24, 2004.

Slides: <http://www.dlib.indiana.edu/workshops/bbfall2004slides/dlp-bb-v2pedagog.ppt>

Variations2 Overview and Demonstration

Mark Notess

JISC Online Audio Evaluation Workshop, British Library, London, England, October 11, 2004.

Slides: http://variations2.indiana.edu/html/british-library-JISC-workshop_files/frame.htm

Can Course Management Systems Embrace Discipline-Specific Media and Learning Tools?

A Case Study of Music

Mark Notess

IS-SOTL 2004: International Society for the Scholarship of Teaching and Learning, Inaugural Conference, Bloomington, Indiana, October 21-24, 2004.

Slides: http://variations2.indiana.edu/html/is-sotl-cms_files/frame.htm

Integrating Human-Centered Design Methods from Different Disciplines: Contextual Design and PRInCiPleS

Mark Notess and Eli Blevis

FUTUREGROUND 2004 (International conference of the Design Research Society), Melbourne, Australia, November 17-21, 2004.

Paper: <http://variations2.indiana.edu/pdf/drs2004-paper-notess-v1.3.pdf>

Donald Byrd organized and served as chair of the Industry Panel at ISMIR 2004.

Outreach Activities 2003: Presentations, Conferences, etc. (in chronological order)

Sharing Digital Scores: Will the Open Archives Initiative Protocol for Metadata Harvesting Provide the Key?

Jon W. Dunn (with Constance Mayer, Harvard, and Peter Munstedt, MIT)

Music Library Association Annual Meeting, Austin, TX, February 10-16, 2003.

Variations2 Metadata: Why not MARC?

Harriette Hemmasi

Music Library Association Annual Meeting, Austin, TX, February 10-16, 2003.

Slides: <<http://variations2.indiana.edu/html/hemmasi-mla2003/>>

Creating a Distributed Music Education Classroom

Roberta Lindsey and Erik Scull

E.C. Moore Symposium on Teaching Excellence, Indianapolis, IN, March 7, 2003.

Variations2 Demonstration

Mark Notess

Virginia Tech, Blacksburg, Virginia, March 20, 2003.

Applying Contextual Design to Educational Software Development

Mark Notess

Indiana University Instructional Systems Technology conference, Bloomington, IN, April 4, 2003.

User Satisfaction from Subject Satisfaction

Maggie B. Swan and Mark Notess

Indiana University Instructional Systems Technology conference, Bloomington, IN, April 4, 2003.

Predicting User Satisfaction from Subject Satisfaction

Mark Notess and Maggie B. Swan

CHI 2003 Conference on Human Factors in Computing Systems, Ft. Lauderdale, FL, April 5-10, 2003.

Paper: <http://variations2.indiana.edu/pdf/Notess_Swan-CHI_03.pdf>

Slides: <http://variations2.indiana.edu/html/Notess_Swan-CHI_03/>

Pedagogical Tools for a Digital Music Library

Eric Isaacson and Brent Yorgason

Music Theory Midwest, Bloomington, IN, May 17-19, 2003.

Paper: <http://variations2.indiana.edu/pdf/isaacson_yorgason_MTMW_2003.pdf>

Slides: <http://variations2.indiana.edu/html/isaacson_yorgason_midwest_2003/>

Music Representation in a Digital Music Library

Eric Isaacson and Donald Byrd

ACM/IEEE-CS Joint Conference on Digital Libraries, Houston, TX, May 27-31, 2003.

Paper: <http://variations2.indiana.edu/pdf/Byrd_Isaacson_JCDL_2003.pdf>

Slides: <http://variations2.indiana.edu/html/isaacson_byrd_jcdl_2003b/>

Jon W. Dunn and Ryan Scherle (with William Birmingham and Kevin O'Malley,

University of Michigan)

V2V: A Second Variation on Query-by-humming (demonstration)

ACM/IEEE-CS Joint Conference on Digital Libraries, Houston, TX, May 27-31, 2003.

Abstract: <<http://variations2.indiana.edu/pdf/JCDL2003Demo-web.pdf>>

Content Visualization in a Digital Music Library

Eric Isaacson

Third International Workshop on Information Visualization Interfaces for Retrieval and Analysis, Houston, TX, May 31, 2003.

Paper: <http://variations2.indiana.edu/pdf/isaacson_ivira_2003.pdf>

Slides: <http://variations2.indiana.edu/html/isaacson_ivira2003/>

Digital Audio/Digital Video: Is Your Library/Media Center Digital Ready?

Jon W. Dunn (panel member)

American Library Association Annual Conference, Toronto, Ontario, June 19-25, 2003.

Slides: <<http://variations2.indiana.edu/html/dunn-ala2003/>>

Variations2 and the Music Appreciation Class

Roberta Lindsey

IUPUI Music Technology Conference, Indianapolis, IN, June 27, 2003.

Slides: <http://variations2.indiana.edu/html/lindsey_v2_music_tech_6-03/>

The Digital Music Library: Progress & Prognostications

Mary Wallace Davidson

International Association of Music Libraries Annual Conference, Tallinn, Estonia, July 6-11, 2003.

Slides: <http://variations2.indiana.edu/html/IAML_2003/>

Creating and Maintaining a Distributed Music Appreciation Classroom

Roberta Lindsey

3rd International Conference on Technology in Teaching and Learning in Higher Education, Heidelberg, Germany, July 15, 2003.

Slides: <http://variations2.indiana.edu/html/lindsey_heidelberg_2003/>

Music Representation Needs of Variations2 and of MusicNetwork

Donald Byrd

MusicNetwork Workshop on Music Notation, Leeds, UK, September 2003.

Three Looks at Users: A Comparison of Methods for Studying Digital Library Use.

Mark Notess

Toward a User-Centered Approach to Digital Libraries, Espoo, Finland, September 8-9, 2003.

Paper: <<http://variations2.indiana.edu/pdf/notess-3way-v2-prepub.pdf>>

Slides: <<http://variations2.indiana.edu/html/3-looks-talk/>>

Variations2 Demonstration

Mark Notess

Sibelius Academy, Helsinki, Finland, September 10, 2003.

Enhancing College Teaching With the Digital Music Library

Eric Isaacson

College Music Society Annual Meeting, Miami, FL, October 2-5, 2003.

Slides: <http://variations2.indiana.edu/html/isaacson_CMS_2003>

The Implications of Digital Music Libraries for Music Theory

Eric Isaacson and Brent Yorgason

Society for Music Theory, Madison, WI, November 6-9, 2003.

Paper: <http://variations2.indiana.edu/pdf/isaacson_yorgason_smt_2003.pdf>

Slides: <http://variations2.indiana.edu/html/isaacson_yorgason_SMT_2003>

Variations2 in the Classroom: Enhancing Learning with the Digital Music Library

Eric Isaacson

NSF/IMLS Principal Investigators Meeting, Washington, DC, December 2, 2003.

Slides: http://variations2.indiana.edu/html/NSF_2003/

Outreach Activities 2002: Presentations, Conferences, etc. (in chronological order)

The Distributed Music Appreciation Class and the Indiana University Digital Music Library Project: Phase One

Jay Fern, Roberta Lindsey, and Erik Scull

College Music Society - Great Lakes Chapter Meeting, Northfield, MN, March 15-16, 2002.

Slides: <<http://variations2.indiana.edu/html/dml-cms2002/>>

Indiana University Digital Music Library Project

Michael A. McRobbie

EU/NSF Digital Libraries All Projects Meeting, Rome, Italy, March 25-26, 2002.

Slides: <<http://variations2.indiana.edu/html/mcrobbe-nsfec2002/>>

The Distributed Music Appreciation Class and the Indiana University Digital Music Library Project/Variations2

Jay Fern, Roberta Lindsey, and Erik Scull

Music Technology Conference, Indianapolis, IN, June 17-21, 2002.

Slides: <<http://variations2.indiana.edu/html/fern-lindsey-skull-mtc2002/>>

The Indiana University Digital Music Library

Doug Pearson (Indiana University, Digital Media Network Services)

JISC/NSF Digital Libraries Initiative (DLI) All Projects Meeting, Edinburgh, Scotland, June 24-25, 2002.

Music Digital Libraries (training session/tutorial)

Jon W. Dunn

Second DELOS International Summer School on Digital Library Technologies, Pisa, Italy, July 8-12, 2002.

<<http://delos-noe.iei.pi.cnr.it/activities/trainingforum/SummerSchool/handouts2/dunn.pdf>>

A Digital Library Data Model for Music (conference paper)

Natalia Minibayeva and Jon W. Dunn

ACM/IEEE-CS Joint Conference on Digital Libraries, Portland, OR, July 14-18, 2002.

<<http://variations2.indiana.edu/pdf/minibayeva-dunn-jcdl2002.pdf>>

Indiana University Digital Music Library Project (demonstration)

Jon W. Dunn and Eric J. Isaacson

ACM/IEEE-CS Joint Conference on Digital Libraries, Portland, OR, July 14-18, 2002.

<<http://variations2.indiana.edu/pdf/jcdl02-demo.pdf>>

Variations2: Towards Visual Interfaces for Digital Libraries (workshop presentation)

Mark Notess and Natalia Minibayeva

Presented at Second International Workshop on Visual Interfaces to Digital Libraries at the ACM/IEEE Joint Conference on Digital Libraries, Portland, OR, July 18, 2002.

<<http://variations2.indiana.edu/pdf/notess-minibayeva-jcdl2002.pdf>>

Music IR for Music Theory

Eric J. Isaacson

Presented at Workshop on the Creation of Standardized Test Collections, Tasks, and Metrics for Music Information Retrieval (MIR) and Music Digital Library (MDL)

Evaluation, at the ACM/IEEE Joint Conference on Digital Libraries, Portland, OR, July 18, 2002.

Impact of Metadata on the Variations2 Project

Harriette Hemmasi

DLI/IMLS/NSDL PI Meeting, Portland, OR, July 18, 2002.

Variations2: The Digital Music Library Project at Indiana University - Concepts and Demonstration of Version One

Mary Wallace Davidson and Jon W. Dunn

International Association of Music Libraries, Archives, and Documentation Centres Annual Conference, Berkeley, CA, August 4-9, 2002.

Slides: <<http://variations2.indiana.edu/html/davidson-dunn-iaml2002/>>

Variations2: A 'Progress, Promise, and Potential' Report

Eric J. Isaacson

Indiana University Music Theory Colloquium Series, September 18, 2002.

In Transition and Out of Sync: Technology, Education, and Copyright Law

Kenneth D. Crews
Committee for Institutional Cooperation, Bloomington, IN, October 14, 2002.

Why Not MARC?
Harriette Hemmasi
ISMIR 2002, 3rd International Conference on Music Information Retrieval, IRCAM,
Paris, October 13-17, 2002.
<<http://ismir2002.ircam.fr/Proceedings/02-FP08-3.pdf>>

Similarity in Music
Eric J. Isaacson
Panelist (panel moderated by Ludger Hofmann-Engl), at ISMIR 2002, 3rd International
Conference on Music Information Retrieval, IRCAM, Paris, October 17, 2002.

The Digital Music Library: New Tools for Learning and Research
Eric J. Isaacson
Presented and discussed in a panel, at Information and Musical Documentation for Music
Lovers, Citas de la Musique, Paris, October 18, 2002.

Variations2: The Indiana University Digital Music Library Project
Jon W. Dunn and Mark Notess
Digital Library Federation Fall Forum, Seattle, WA, November 4-6, 2002.
Slides: <http://variations2.indiana.edu/html/dunn-notess-dlf2002/>

Outreach Activities 2001: Presentations, Conferences, etc. (listed by research area)

Music Theory and Music Instruction: Eric Isaacson.

'Music Learning Online: Evaluating the Promise,' presentation at National Association of
Schools of Music Annual Meeting, Region 3 session (20 November 2001, Dallas)

'Digital Music Library Project' (with Jon W. Dunn and Mary Wallace Davidson),
presentation at International Symposium on Music
Information Retrieval (15-17 October 2001, Bloomington, IN)

'Digital Music Libraries, Research and Development' (with David Bainbridge, Mary
Wallace
Davidson, Andrew P. Dillon, Jon W. Dunn,
Matthew Dovey, Michael Fingerhut, and Ichiro Fujinaga) panel discussion at
ACM/IEEE-CS
Joint Conference on Digital Libraries (27 June 2001, Roanoke)

'Indiana University Digital Music Library Project' (with Jon W. Dunn), demonstration
given at ACM/IEEE-CS Joint Conference on Digital
Libraries (25 June 2001, Roanoke)

Metadata: Mary Wallace Davidson and Harriette Hemmasi.

Davidson discussed our work briefly in joint presentations about the project (with other investigators) at the Joint Conference on Digital Libraries (Roanoke, VA, June), and at the Music Information Retrieval Symposium 2001 (Bloomington, October). Music librarians offered constructive feedback at the latter.

At the meeting of the Music Thesaurus Project Advisory Task Force, and its Form/Genre Terminology Working Group during the annual meeting of the Music Library Association (New York City, February), Hemmasi gave a progress report and sought feedback.

Mary Wallace Davidson. Attended Coalition for the Future of Music Policy Conference, Washington, DC, Jan. 10-11, 2001. Held informal meetings with other music librarians and music educators with respect to music copyright.

Usability: Andrew Dillon.

Participant in panel discussion: Digital Music Library Research and Development. ACM/IEEE-CS Joint Conference on Digital Libraries, Roanoke, VA, June 24-28, 2001.

Music Instruction - Music for the Listener: Jay Fern and Roberta Lindsay.

Poster session for E.C. Moore Symposium, March 9, 2001. 'Use of Interactive Concert Report Forms in the Music Appreciation Classroom (and their relation to Principles of Undergraduate Learning)'

College Music Society (CMS) Great Lakes Chapter, March 31, 2001. 'Interactive Computer Forms in the Music Appreciation Classroom'

Presentation: Campus Brown Bag Lunch 'OnCourse and the Music Appreciation Distance Classroom: Past Present and Future.' May 11, 2001.

Presentation at the Third Annual Susan M. Porter Symposium in Boulder, Colorado at the American Music Research Center.

Intellectual Property: Kenny Crews, Kristine Brancolini, Mary Davidson.

Crews: During the year I have given these presentations that have led to discussion of the DML: 'Looking Ahead and Shaping the Future: Provoking Change in Copyright Law,' Interdisciplinary Conference on the Impact of Technological Change on the Creation, Dissemination, and Protection of Intellectual Property, The Ohio State University College of Law, March 8-10, 2001, Columbus, Ohio.

'Intellectual Property Issues for Online Education,' Northern Illinois University, September 28, 2001, DeKalb, Illinois.

'Copyright in the Digital Age: A Practical Workshop,' University of California, October 25 & 26, 2001, Irvine & Berkeley, California.

'Copyright Updates and Issues for Librarians,' Health Science Librarians of Illinois, November 15, 2001, Urbana, Illinois.

'Copyright and Fair-Use Challenges in On-line Course Delivery,' Illinois State University, November 27, 2001, Normal, Illinois.

Brancolini: Presented two copyright-related presentations at major conferences; presentations included a description of the project and discussion of the copyright issues that the project explores.

'Indiana University Digital Library Program: Multimedia Electronic Reserves.' American Library Association Conference, San Francisco, California, June 17, 2001.

'VARIATIONS as a Repository for Digital Sound Files.' Midwest Archives Conference, Chicago, Illinois, May 5, 2001.

Satellite Sites and Network Research: Doug Pearson

IU staff members who are engaged in the activities of the DML network architecture research area have been involved in network performance analysis and quality-of-service development for videoconferencing over IP networks; leading to the implementation of IP Precedence-based QoS mechanisms on the IU wide area network. Although these activities don't directly relate to the DLI project, the skills, techniques and team work will translate directly to the DLI network architecture and testbed development.

Doug Pearson, leader of the DML network research area, working in collaboration with individuals from Georgia Institute of Technology and the University of Tennessee, developed a grant proposal to develop, prototype and promulgate a digital rights management solution based on the integration of XML rights metadata with standards-based directories and digital object access technologies - the Secure Econtent Attribute Management (SEAM) project. At the SURA/ViDe-Internet2-CNI Managing Digital Video Content workshop, August 15-16, 2001, Pearson was a co-presenter of Rights Metadata: XrML and ODRL for Digital Video; and at the March 2001 SURA/ViDe Digital Video Workshop, he presented on the ViDe MPEG-4 Working Group: Results of MPEG-4 RFI and Solicitation of Interest.

Testbed System Development: Jon Dunn

Demonstration: 'Indiana University Digital Music Library Project.' ACM/IEEE-CS Joint Conference on Digital Libraries, Roanoke, VA, June 24-28, 2001. [with Eric J. Isaacson]

Participant in panel discussion: 'Digital Music Library Research and Development.' ACM/IEEE-CS Joint Conference on Digital Libraries, Roanoke, VA, June 24-28, 2001.

Presentation: 'Indiana University Digital Music Library Project.' International Symposium on Music Information Retrieval, Bloomington, IN, October 15-17, 2001. [with Mary Wallace Davidson and Eric J. Isaacson]

Presentation: 'Indiana University Digital Music Library Project.' Music Library Association Midwest Chapter Meeting, Bloomington, IN, October 18-20, 2000

Outreach Activities 2000: Presentations, Conferences, etc. (in chronological order)

Jon Dunn. Invited talk: 'Beyond VARIATIONS: Creating a Digital Music Library.' International Symposium on Music Information Retrieval, Plymouth, MA, Oct. 23-25, 2000. <<http://ciir.cs.umass.edu/music2000/>>

Jon Dunn, Mary Wallace Davidson, Eric Isaacson. Attended International Symposium on Music Information Retrieval, Plymouth, MA, Oct. 23-25, 2000. Held informal meetings with other music researchers.

Jon Dunn and Gerry Bernbom. Presentation: 'Digital Music Library at Indiana University.' Digital Library Federation Forum on Digital Library Collections and Library Trends, Chicago, IL, Nov. 18-20. <<http://www.clir.org/diglib/forums/fall2000.htm>>

Journal Publications

Isaacson, Eric J., "Music Learning Online: Evaluating the Promise", Proceedings of the 2001 National Association of Schools of Music Annual Meeting (forthcoming), p. , vol. , (2001). Accepted

Dillon, Andrew, "Technologies of Information: HCI and the Digital Library", In Carroll, J. (ed.) HCI and the New Millennium. New York: ACM Press, p. , vol. , (2001). Accepted

Donald Byrd and Eric Isaacson, "A Music Representation Requirement Specification for Academia", Computer Music Journal, p. 43, vol. 27, (2003). Published

Jon W. Dunn and Eric J. Isaacson, "Variations2: A Digital Music Library System", Proceedings of the Second ACM/IEEE-CS Joint Conference on Digital Libraries, p. 374, vol. , (2002). Published

Harriette Hemmasi, "Why Not MARC", Proceedings of the Third International Conference on Music Information Retrieval, p. 242, vol. , (2002). Published Natalia Minibayeva and Jon W. Dunn, "A Digital Library Data Model for Music", Proceedings of the Second ACM/IEEE-CS Joint Conference on Digital Libraries, p. 154, vol. , (2002). Published

Mark Notess and Margaret B. Swan, "Predicting User Satisfaction from Subject Satisfaction", Proceedings of the Conference on Human Factors in Computing Systems, p. 738, vol. , (2003). Published

Donald Byrd and Eric Isaacson, "Music Representation in a Digital Music Library", Proceedings of the Third ACM/IEEE-CS Joint Conference on Digital Libraries, p. 234, vol. , (2003). Published

William P. Birmingham, Kevin O'Malley, Jon W. Dunn, and Ryan Scherle, "V2V: A Second Variation on Query-by-Humming", Proceedings of the Third ACM/IEEE-CS Joint Conference on Digital Libraries, p. 380, vol. , (2003). Published

Mark Notess, Jenn Riley, and Harriette Hemmasi, "From Abstract to Virtual Entities: Implementation of Work-Based Searching in a Multimedia Digital Library", Research and Advanced Technology for Digital Libraries: Proceedings of the Eighth European Conference, ECDL 2004: The European Conference on Digital Libraries, p. 157, vol. , (2004). Published

Ryan Scherle and Donald Byrd, "The Anatomy of a Bibliographic Search System for Music", Proceedings of the Fifth International Conference on Music Information Retrieval (ISMIR 2005), Barcelona, Spain, October 10-14, 2004, p. 489, vol. , (2004). Published

Mark Notess, "Three Looks at Users: a Comparison of Methods for Studying Digital library Use", Information Research, p. n/a, vol. 9, (2004). Published

Mark Notess and Margaret B. Swan, "Timeliner: Building a Learning Tool into a Digital Music Library", Proceedings of EDMEDIA 2004: World Conference on Educational Multimedia, Hypermedia & Telecommunications, p. 603, vol. , (2004). Published

Mark Notess, Inna Kouper, and Maggie B. Swan, "Designing Effective Tasks for Digital Library User Tests: Lessons Learned", OCLC Systems & Services, p. 300, vol. 21, (2005). Published

Jon W. Dunn, Donald Byrd, Mark Notess, Jenn Riley, and Ryan Scherle, "Variations2: Retrieving and Using Music in an Academic Setting", *Communications of the ACM*, p. 8:53, vol. 49, (2006). Published

Jenn Riley, "Exploiting Musical Connections: A Proposal for Support of Work Relationships in a Digital Music Library", *Proceedings of the 6th International Conference on Music Information Retrieval (ISMIR 2005)*, London, England, September 12-15, 2005, p. 123, vol. , (2005). Published

Eric J. Isaacson, "What You See Is What You Get: On Visualizing Music", *Proceedings of the Sixth International Conference on Music Information Retrieval (ISMIR 2005)*, London, England, September 11-15, 2005, p. 389, vol. , (2005). Published

Donald Byrd and Megan Schindele, "Prospects for Improving Optical Music Recognition with Multiple Recognizers", *Proceedings of the 7th International Conference on Music Information Retrieval (ISMIR 2006)*, p. , vol. , (2006). Accepted

Raphael Glifford, Richard Groult, Costas Illiopoulos and Donal Byrd, "Music Retrieval Algorithms for the Lead Sheet Problem", *Proceedings of Sound and Music Computing*, p. 141, vol. , (2004). Published

Kenneth D. Crews, "Copyright Duration and the Progressive Degeneration of a Constitutional Doctrine", *Syracuse Law Review* 55, *Intellectual Property Law Reporter* (St. Paul, NM: West Publishing Company, 2005), p. 189, vol. , (2005). Published

Kenneth D. Crews, "Copyright Issues in Higher Education: A Legal Compendium", *National Association of College and University Attorneys*, p. , vol. , (2006). Accepted

Books or Other One-time Publications

J. Stephen Downie and David Bainbridge (editors), "Proceedings of the 2nd Annual International Symposium on Music Information Retrieval", (2001). conference proceedings, Published Bibliography: A limited number of copies were produced in hard-copy format. The Proceedings are available as a single file for download at <http://ismir2001.indiana.edu/proceedings.pdf>

Fuhrman, Michelle; Gauthier, Dawn; Dillon, Andrew, "Usability Test of VARIATIONS and DML Prototypes", (2001). electronic publication, on the web Bibliography: <http://dml.indiana.edu/pdf/VariationsTest.pdf>

Dillon, Andrew; Gauthier, Dawn; Fuhrman, Michelle, "Task Analysis for DML: Final report on classroom observations", (2001). electronic publication, on the web Bibliography: <http://dml.indiana.edu/pdf/DML-taskanalysis-July2001.pdf>

Swan, Maggie; Dillon, Andrew; Fuhrman, Michelle, “Hypermedia and Learning: the State of the Art - Extended Bibliography”, (2001). electronic publication, on the web Bibliography: <http://dml.indiana.edu/pdf/HyperBiblio.pdf>

Crews, Kenneth D., “The Expiration of Copyright Protection: Survey and Analysis of U.S. Copyright Law for Identifying the Public Domain”, (2001). electronic publication, on the web Bibliography: <http://dml.indiana.edu/pdf/dml-copyright-duration-report.pdf>

Crews, Kenneth D., “Copyright Law for the Digital Library: Framework of Rights and Exception”, (2001). electronic publication, on the web Bibliography: <http://dml.indiana.edu/pdf/CopyrightLawforDLibFramework.pdf>

Crews, Kenneth D., “A&M Records, Inc. v. Napster, Inc.: Implications for the Digital Music Library”, (2001). electronic publication, on the web Bibliography: <http://dml.indiana.edu/pdf/AnalysisOfNapsterDecision.pdf>

Crews, Kenneth D., “Digital Libraries and the Application of Section 108 of the U.S. Copyright Act”, (2001). electronic publication, project working paper/web-posted Bibliography: Project Working Paper-Intellectual Property, December 2001. (<http://dml.indiana.edu/html/crews-sec108/>)

Dunn, Jon W., “DML Testbed System Overview”, (2001). electronic publication, on the web Bibliography: <http://dml.indiana.edu/pdf/DML-Overview-03May2001.pdf>

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Donald Byrd., “Extremes of Conventional Music Notation.”, (2002). Working Paper, locally published/web posted Bibliography: Project Working Paper-System Design, Indiana University, 2002. (<http://php.indiana.edu/~donbyrd/CMNExtremes.htm>)
<<http://php.indiana.edu/~donbyrd/CMNExtremes.htm>>

Maggie Swan, Mark Notess, Eric J. Isaacson., “MMTT Prototypes Usability Testing: First-Round Report.”, (2002). Working Paper, locally published/web-posted Bibliography: Project Working Paper-Usability, Indiana University, May 10, 2002. (<http://variations2.indiana.edu/pdf/mmtt-usab-test-1.pdf>)
<<http://variations2.indiana.edu/pdf/mmtt-usab-test-1>.

Maggie Swan., “Early Usability Test Results for Variations2, version 1.”, (2002). Working Paper, locally published/web-posted Bibliography: Project Working Paper-Usability, Indiana University, September 5, 2002. (<http://variations2.indiana.edu/pdf/v2v1-early-test.pdf>)

Brent Yorgason., “Music Symbol Language (preparatory work for an auto-formatting control for music symbols).”, (2002). Working Paper, locally published/web-posted
Bibliography: Project Working Paper-MMTT, Indiana University, June 18, 2002. At: (<http://theory.music.indiana.edu/mmtt/int/>)

Brent Yorgason., “Authoring Steps in Creating the MMTT Prototypes (a description of user-interface tasks used/needed to create the prototypes).”, (2002). Working Paper, locally published/web-posted

Bibliography: Project Working Paper-MMTT, Indiana University, July 22, 2002. At: (<http://theory.music.indiana.edu/mmtt/int/>)

Brent Yorgason., “Label Tool Specifications”, (2002). Working Paper, locally published/web-posted
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Bibliography: Project Working Paper-Intellectual Property, Indiana University, January 2003.

Kenneth D. Crews., “Copyright Law and the Digital Library: Fair Use and the Digital Music Library.”, (2003). Working Paper, locally published/web posted
Bibliography: Project Working Paper-Intellectual Property, Indiana University, June 10, 2003. (<http://variations2.indiana.edu/pdf/V2-2002FairUsePaper.pdf>)

Mary Davidson, Harriette Hemmasi, Natalia Minibayeva., “Data Dictionary: Metadata Elements for Version 1.”, (2002). Working Paper, locally published/web-posted
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Mary Davidson, Harriette Hemmasi, Natalia Minibayeva., “Metadata Model Multiplicity Requirements.”, (2002). Working Paper, locally published/web-posted
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Mary Davidson, Harriette Hemmasi, Natalia Minibayeva., “Controlled Vocabularies.”, (2002). Working Paper, locally published/web-posted

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Maggie B. Swan, "IU Digital Music Library Version 2.0 Usability Test Report", (2003).
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(<http://variations2.indiana.edu/pdf/v2v2-test.pdf>)

Maggie B. Swan, "IU Digital Music Library Version 1.0 Usability Test Report", (2003).
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(<http://variations2.indiana.edu/pdf/timeliner-early-test.pdf>)

Dawn Adams, Kenneth D. Crews, "Copyright Law for the Digital Library: A
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Bibliography: Project Working Paper-Intellectual Property, Indiana University,
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Dawn Adams and Kenneth D. Crews, "Copyright Law for the Digital Library: A Web
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Bibliography: Project Working Paper-Intellectual Property, Indiana University,
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(http://variations2.indiana.edu/pdf/V2_web_bibliog_version_010504.pdf)

Harriette Hemmasi, "Community Based Content Control", (2004). Book, Accepted
Editor(s): Diane Hillman and Elaine Westbrook
Collection: Metadata in Practice: A Work in Progress
Bibliography: ALA Editions, 2004.

Andrew Dillon, "Report on learning within hypermedia environments (title TBD)",
(2004). Book, Accepted
Editor(s): Richard Mayer
Collection: TBD
Bibliography: Cambridge University Press

Mark Notess, "Applying Contextual Design to Educational Software Development",
(2003). Book, Published
Editor(s): Anne-Marie Armstrong
Collection: Instructional Design in the Real World: A View from the Trenches

Bibliography: Information Science Publishing (an imprint of Idea Group Inc.), Hershey, PA, 2003.

Jon W. Dunn, Mary Wallace Davidson, Jan R. Holloway, and Gerald Bernbom, “The Variations and Variations2 Digital Music Library Projects at Indiana University”, (2004). Book, Published
Editor(s): Judith Andrews and Derek Law
Collection: Digital Libraries: Policy, Planning, and Practice
Bibliography: Ashgate Publishing, 2004, pp. 189-211.

Margaret B. Swan and Mark Notess, “Variations2 Help: Moving Help Closer to Users”, (2004). conference workshop paper, locally web-posted
Bibliography: Position paper presented at CHI 2004 workshop: Helping Users Use Help, Vienna Austria, April 24-29, 2004
(<http://variations2.indiana.edu/pdf/chi-2004-swan-help.pdf>)

Mark Notess and Eli Blevis, “Integrating Human-Centered Design Methods from Different Disciplines: Contextual Design and Principles”, (2004). conference paper, locally web-posted
Bibliography: Paper presented at FUTUREGROUND 2004, Melbourne, Australia, November 17-21, 2004
(<http://variations2.indiana.edu/pdf/drs2004-paper-notess-v1.3.pdf>)

Mark Notess, “Using Contextual Design for Digital Library Field Studies”, (2005). position paper, web-posted
Bibliography: Position paper for workshop “Studying Digital Library Users in the Wild: Theories, Methods, and Analytical Approaches.”
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Bibliography: Paper presented at Association for Educational Communications and Technology Annual Conference, Orlando, Florida, October 18-22, 2005 (<http://variations2.indiana.edu/pdf/notess-aec>)

Mark Notess, “Contextual Design of Online Learning Technologies”, (2005). Book, Published
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Collection: Encyclopedia of Distance Learning
Bibliography: Hershey, PA: Idea Group Reference, 2005, pp. 400-407.

Donald Byrd, “Written Vs. Sounding Pitch”, (2005). electronic publication on the web,
Bibliography: http://variations2.indiana.edu/system_design.html

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Bibliography: <http://mypage.iu.edu/~donbyrd/MusicSimilarityScale.HTML>

David Wong, "Variations2 and Fair Use: Copyright, the Digital Music Library, and Possibilities for Application of Fair Use", (2005). working paper, Published

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<http://mypage.iu.edu/~donbyrd/DonMusicIRBibliography.HTML>

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publication, Published Bibliography: <http://mypage.iu.edu/~donbyrd/CMNExtremes.htm>

Donald Byrd, "Musical Themes and Occurrences of Melodic Confounds", (2004).

electronic publication, Published Bibliography:

<http://mypage.iu.edu/~donbyrd/ThemesAndConfoundsNoTabs.txt>

Donald Byrd, "Written vs. Sounding Pitch", (2004). electronic publication, Published

Bibliography: http://variations2.indiana.edu/pdf/byrd_WrittenVsSoundingPitch_0104.pdf

Donald Byrd, "Variations2 Guidelines for Encoded Score Quality", (2004). electronic

publication, Published Bibliography:

http://variations2.indiana.edu/pdf/byrd_V2MusicQualityGuidelines.pdf

Inna Kouper, "Usability Test: Installation and Playlist", (2004). electronic publication,

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Inna Kouper and Mark Notess, "Usability Test Report: Working with Scores", (2005).

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Inna Kouper and Mark Notess, "Variations2 Contextual Observations Report: Installation and Use", (2005). electronic publication, Published Bibliography:

<http://variations2.indiana.edu/pdf/home-install-report.pdf>

Inna Kouper and Mark Notess, "Survey Report: Listening and timeline use", (2005).
electronic publication, Published Bibliography: <http://variations2.indiana.edu/pdf/m544-listening-and-timeline-use.pdf>

Web/Internet Site

URL(s):

<http://variations2.indiana.edu/research/>, <http://theory.music.indiana.edu/mmtt>,
<http://ismir2001.ismir.net/>, <http://ismir2002.ismir.net/>

Description:

<http://variations2.indiana.edu/research/>

Main web-page for Digital Music Library project, with links to subspecialty areas (Copyright, Metadata, Music Theory Instruction, Music Instruction / Oncourse, Usability, System Design, Satellite Sites, and Networking), and links to all project work documents cited above under Project Activities.

<http://theory.music.indiana.edu/mmtt>

Music Theory and Music Instruction: Web page for the Multimedia Music Theory Teaching (MMTT) project.

<http://ismir2001.ismir.net/>

Web page for the 2nd annual International Symposium on Music Information Retrieval, held at Indiana University, October 15-17, 2001.

<http://ismir2002.ismir.net/>

Web page for the 3rd annual International Conference on Music Information Retrieval, held at IRCAM-Centre Pompidou, Paris, October 13-17, 2002.

Other Specific Products

Digital Video of Native American Instruments for on-line distance M174 Music Appreciation classroom site. On the web at:
<http://www.iupui.edu/~mlt/streaming/native/>

Interactive 12-tone Practice Matrix implemented within the M174 OnCourse environment (both on-campus and distance-ed classes). On the web at:
<http://www.iupui.edu/~mlt/general/pm1a.htm>

Metadata and Testbed System: DML Data Model for Version 1. On the web at:
<http://dml.indiana.edu/pdf/DML-DataModel-V1.pdf>

Metadata: DML Version 1 Metadata Model Diagrams. On the web at:
<http://dml.indiana.edu/pdf/DML-metachart.pdf>

Metadata: DML Version 1 Data Dictionary. On the web at:
<http://dml.indiana.edu/pdf/DML-metadata-elements-v1.pdf>

Metadata: MARC Mapping for DML V1. On the web at:
<http://dml.indiana.edu/pdf/DML-MARC-mapping.pdf>

Testbed System: DML Requirements Specification for Version 1. On the web at:
<http://dml.indiana.edu/pdf/DML-Requirements-V1.pdf>

Testbed System: DML User Interface Specification for Version 1. On the web at:
<http://variations2.indiana.edu/pdf/DML-UI-V1.pdf>

Online tutorial to support online music education: Tutorial on 12-Bar Blues, created by Erik Scull. On the web at: (<http://www.music.iupui.edu/escull/12barblues2.swf>)

Also submitted to MERLOT web site for educational software at:
(<http://www.merlot.org>). Online tutorial to support online music education:
Tutorial on Mouret “Rondeau”, created by Erik Scull. On the web
at:<<http://www.music.iupui.edu/escull/rondeau.swf>>

Online tutorial to support online music education:
Tutorial on Theme and Variation featuring Copland’s Appalachian Spring, created by Erik Scull. On the web at: <<http://www.music.iupui.edu/escull/variationswcopland.swf>>

Online tutorial to support online music education:
Tutorial on Minuet and Trio featuring Mozart, “Minuet” from Eine Kline Nachtmusik, created by Erik Scull. On the web at:
<<http://www.music.iupui.edu/escull/minuettrio1.swf>>

Online tutorial to support online music education:
Tutorial on 12-tone Matrix, created by Roberta Lindsey (with Erik Scull's assistance). On the web at: <<http://www.music.iupui.edu/escull/matrix/index.htm>>

Variations2 Digital Music Library software system.

Four major releases and many minor releases of the Variations2 system were developed over the course of the grant period. This software, as described in Project Activities, provides a complete research and pedagogical environment for searching, viewing, playing, annotating, and using music audio and score images from a digital library. Version 2 of the Variations2 system was completed in 2003, and adds support for score printing, synchronized audio playback/score display, the Timeliner tool for creating and editing musical form diagrams, and a number of general interface and performance improvements.

The latest version is in use at Indiana University Bloomington. In October 2005, we received a three-year grant from the Institute of Museum and Library Services (IMLS) to take the Variations2 system developed as part of this research project and generalize it such that it could be used as a digital music library and learning system at a variety of institutions beyond IU. See <<http://www.dlib.indiana.edu/projects/variations3/>> for further details.

Sample Variations2 timeline files. Available at <http://theory.music.indiana.edu/mmtt/int/SampleTimelines.htm> These files are made available to users of the Variations2 system at Indiana University and satellite sites for use in demonstrating the Variations2 system and in teaching.

Music theory instruction: Timeliner user interface specs. On the web at: http://theory.music.indiana.edu/mmtt/int/Documents/Timeliner_UI_Spec_First_Draft.doc

Music theory instruction: List of timeliner user actions to log. On the web at: http://theory.music.indiana.edu/mmtt/int/Timeline_user_actions_to_log.doc

Testbed System: Variations2 Version 2 Requirements. On the web at: <http://variations2.indiana.edu/pdf/DML-Requirements-V2.pdf>

Testbed System: Variations2 Version 2 User Interface Specification. On the web at: <http://variations2.indiana.edu/pdf/DML-UIspec-V2.pdf>

Testbed System: IU Digital Music Library Data Model Specification V2. On the web at: <http://variations2.indiana.edu/pdf/DML-DataModel-V2.pdf>

Testbed System: Data Model Changes Proposed for Version 2. On the web at: <http://variations2.indiana.edu/pdf/DML-DMspec-V2.pdf>

Metadata: Variations2 Metadata Internship. Various documents and recommendations prepared by Jenn Riley related to Variations2 metadata, data model, and cataloging process. On the web at: <http://www.dlib.indiana.edu/~jenlrile/variations2/>

Metadata: Variations2 Cataloging Manual. On the web at: <http://variations2.indiana.edu/metadata/manual/>

Metadata: Variations2 Work Relationships Specification. On the web at: <http://variations2.indiana.edu/metadata/workrelationships/specs.pdf>

Metadata: Work Relationships Display Issues. On the web at: <http://variations2.indiana.edu/metadata/workrelationships/display.pdf>

Metadata: Addressing Ethnic/World Music in the Variations2 System. On the web at: <http://variations2.indiana.edu/metadata/ethnic/EthnicMusic.htm>

Variations2 Digitization: Recording Container Structure Guide. On the web at: <http://variations2.indiana.edu/metadata/manual/RecCS.htm>

Contributions within Discipline

Testbed Development

The most significant contributions from Variations2 testbed system development and metadata work have been:

1) The development of a data/metadata model specific to music content. This model was developed by the original Variations2 metadata team (Davidson, Hemmasi, Minibayeva), working with the systems development team, and then refined over the course of system implementation. It is based in part on past research and development in the area of bibliographic relationships by Sherry Vellucci, Richard Smiraglia, the International Federation of Library Associations (IFLA) and others, and in part on the Variations2 system requirement of supporting synchronization between media formats. The model is very much in line with current thinking in bibliographic control based on entity-relationship models, resembling the IFLA FRBR (Functional Requirements for Bibliographic Records) model, and has been referenced as an example in a number of international and national discussions regarding FRBR.

2) The design and development of a metadata-based search interface which takes advantage of the Variations2 data model to offer what we feel will be more effective search capabilities for the music searcher. Traditional library catalog systems have been designed primarily for text-based print materials, with music, video, and audio as somewhat of an afterthought. By designing a search interface which utilizes concepts and terminology specific to music, we hope to offer a more useful and usable system for music search tasks.

3) Design and development of an extensible Java-based multimedia digital library system architecture to support metadata and content storage, searching, format-independent media playback and display, user personalization (persistent audio and score bookmarks and playlists), and pedagogical tools (Timeliner, Lesson Editor, score annotation). As described earlier under 'Findings', the success of this system has led to a new grant from the Institute of Museum and Library Services to further extend the system to be used by a variety of institutions outside IU.

Usability

We believe our ongoing work represents a contribution to the systematic implementation of user-centered design practices in two areas. First, we have identified confounding factors in using user-test-based measures of user satisfaction to predict end-user satisfaction. Second, in applying contextual inquiry and design methodologies, we have demonstrated the usefulness of the methods for educational software development and digital libraries while simultaneously identifying expressiveness gaps in the commonly used work models. Both of these areas warrant further work to provide continuing contributions to the field of usability: by identifying ways to measure and minimize the test-subject/end-user satisfaction gap, and by extending contextual inquiry and design methods to better deal with individual learning activity.

Our work has also contributed an early and significant understanding of how learning tools can be integrated usefully into digital libraries for the improvement of learning. Although other timeline-style tools have existed for exploring and annotating music, ours is the first to make it easy for people to use such a tool with an arbitrary piece of music, whether streamed from the digital collection or residing on one's own hard drive. The success of this tool in our pilot study suggests an unmet opportunity for flexible learning tools that integrate well with both DL and personal content.

Music Representation

The development of a requirements specification for a symbolic music representation (published in 2003 in *Computer Music Journal*) directly and significantly affected the development of two major representations, including MusicXML, which is now a widely used format for interchange of music information.

Contributions to Resources for Research and Education

Intellectual Property

While the IP papers for this project are naturally and necessarily focused on many of the needs and circumstances of the Variations2 digital music library, they have been produced with an eye toward some broader issues. Many of the legal issues raised here will be important to many, perhaps all, of the other digital library projects developed throughout the country under the auspices of the NSF or not. While copyright law has some distinctive application to musical works, the fundamentals of the law apply to the

vast range of potentially copyrightable works. Thus, a digital library system that may focus on text, images, or anything else, will also have dilemmas centering on whether a work is in the public domain, whether the activity is within the scope of Section 108, and whether a use of the system is within the boundaries of fair use.

In addition, a number of the IP reports produced by the project describe problems and limitations with copyright law as applied to digital libraries in research and education that may be of interest to the NSF and other governmental policymakers.

Contributions Beyond Science and Engineering

Music Instruction

The Variations2 digital music library system developed by this project has drawn substantial interest from the music library and music school communities worldwide, and as a result, we are currently extending the software to be usable by institutions outside IU with the help of a three-year grant from the Institute of Museum and Library Services. The software will most likely be released as open source and will thus benefit a wide community of music learners, teachers, and researchers.

One specific component of the Variations2 software developed by this project—the Timeliner tool—has drawn particular attention, as it is the first product to provide a general-purpose tool for the visualization of structure in music audio files in a digital music library. It has been used successfully in several classes in the IU Jacobs School of Music, and there is broad interest outside IU in its use.

In addition, the Timeliner has been used in areas beyond music: Tufts University is using it as part of the workflow for creation of transcripts for audio recordings of oral history interviews.