

ETD Management in the Texas Digital Library: Lessons Learned from a Demonstrator

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Abstract

As a consortium of libraries from public and private institutions across the state of Texas, the Texas Digital Library (TDL) exists to promote the scholarly activities of its members. One of its earliest initiatives was a federated collection of ETDs from across the state. There are currently 16 participating schools in TDL, four of which are contributing over 4000 ETDs per year, and membership and contributions are growing. A diverse set of content contributors introduces the problems of inconsistent metadata and incompatible storage and access methods, making it difficult to offer effective tools and services. This influenced the decision to create a state-wide system for managing the entire life-cycle of ETDs, from the point of ingestion to final publication; pooling resources to address this common problem was appealing for both technical and economic reasons.

In 2007, we reported on the status of the functional system prototype. This paper reports on the results of the demonstrator event that is taking place in spring 2008 at Texas A&M University and the University of Texas, and discusses the requirements for moving to a production environment. These include testing and scaling the system to handle the large numbers of users dispersed over a significant geographic area (Texas is the third-largest producer of PhDs in the US). Our intention is to embrace international standards for ETD metadata and policies as they continue to evolve through community efforts, such as the NDLTD union catalog of ETDs.

Finally, we will examine the status of the project's release as an add-on component to a DSpace repository through the Manakin interface framework under an open source license. A primary design goal of this project is to create a product that satisfies TDL's requirements and provides a turnkey implementation for ETD management and publication that can be scaled for the broader academic community.

Introduction

The Texas Digital Library (TDL) is a consortium of public and private institutions from across the state of Texas. Founded in 2005, TDL exists to provide a common digital infrastructure for the state, and to promote the scholarly activities of its member schools. Texas universities have significant intellectual capital that is frequently inaccessible to users at sister institutions across the state. TDL seeks to address this challenge; its charge is to serve as a “center for excellence for the creation, curation, and preservation of digital scholarly information for the State” (Leggett 2006).

TDL currently offers a suite of services to its members, each of which play a role in creating an online scholarly community for the state. These services—scholarly blog hosting, wiki infrastructure for collaboration between research groups, online peer-reviewed journals and workflow management, and digital repositories—provide increased visibility for the member schools and their scholarly output, and seek to leverage the economies of scale inherent in collaborative partnerships.

Besides production services in the support of scholarly activities, TDL’s second focus is to encourage innovation in education and knowledge sharing throughout the state. Several TDL projects fall under this “research and development” heading, such as TDL’s continued support of the Manakin interface framework in DSpace (Phillips 2007), the development of a statewide preservation network, and the Texas ETD Repository and its associated technologies (Mikeal 2007). Each of these initiatives directly addresses one of TDL’s central responsibilities: the creation, curation, or preservation of digital scholarly information.

ETDs in the Texas Digital Library

One of the earliest initiatives of the Texas Digital Library was a federated collection of ETDs from several of its member schools. The collection began with contributions from Texas A&M University and the University of Texas at Austin and has been steadily adding contributors. The university systems of the four active participants in the ETD Repository project comprise more than 40 campuses, nearly 400,000 students, and 130,000 faculty and staff. The University of Texas alone processes nearly 1,400 ETDs every semester. Hence, the growth potential of the Texas ETD collection is significant.

The size and diversity of this collection soon introduced challenges of inconsistent metadata and differences in storage and access methods, making it difficult to offer effective tools and services across the collection. These challenges influenced the decision to create a state-wide system for managing the entire life-cycle of ETDs, from the point of ingestion in a centralized student submission interface, through the iterative and distributed verification process with the graduate schools, to the final publication in the TDL Repository. Pooling resources for such a project fell squarely within TDL’s stated purpose; members would see both technical and economic benefits from such an arrangement.

In preparation for this centralized system, TDL conducted a series of surveys to ascertain the policies regarding ETDs across the state. It was discovered that the level of engagement with ETDs varied widely, even within current TDL member institutions. Some of the larger schools—such as Texas A&M University and the University of Texas at Austin—were using sophisticated electronic submission and

management systems (a modified ETD_db system at Texas A&M University, and the ETD Administrator from Proquest at The University of Texas). Others accepted ETDs, but had no infrastructure in place to handle submission or management. Some had no engagement with ETDs whatsoever, and were still operating completely within a paper model. Additionally, some schools maintained centralized offices that managed ETD policy and approval; others relegated this responsibility down to the college or even department level. It became clear that any successful system would have to address significant technical and policy challenges.

Implementation

The Texas ETD Repository project is a large effort that spans multiple separate initiatives, each of which are nominally independent, but interact in such a way as to support the overall task of managing ETDs in Texas. Metadata, identity management, repository interfaces, submission workflows, and data preservation each constitute significant projects in their own right, and these responsibilities are delegated to various groups within TDL.

Metadata Profile

ETDs became a focus very early in the organization of TDL, as the two largest member institutions already had working ETD repositories, and were publishing their ETDs independently. To facilitate a federated collection, these early members agreed upon a common metadata standard, expressed as a MODS XML profile (Surratt 2006).

In 2008, the TDL Metadata Working Group revisited this model, and made minor updates necessary to bring the published standard into compliance with current TDL practices. Additionally, they produced a crosswalk document that specifies how the more specific and granular MODS data should be converted into standard Dublin Core and ETD-MS for sharing over protocols such as OAI-PMH (Rushing 2008). NDLTD's ETD-MS format was specifically addressed because TDL has made interoperability with the NDLTD repository a priority. Engagement with national and international efforts increases the visibility of regional repositories like TDL's and helps build the content available in the larger repository, increasing its usefulness to all participants.

Shibboleth

Any web application that deals with personal information will be dealing with authentication and identity management. In an educational setting, these aspects of the application are critical, and regulated by federal laws governing the security and release of student's personal information (Gilley 2006). Building a system that spans over 15 individual campuses—each with independent authentication systems and mechanisms—adds additional layers of difficulty. Based on the anticipated number of students ultimately using the system, creating new, single-use identities managed by TDL is neither desirable nor scalable. Additionally, that solution fails to address the need to securely obtain data about the student from the home institution.

Shibboleth is an open-source middleware application for providing identity management in a distributed environment (Shibboleth 2008). In support of its scholarly services, TDL established the first state-wide Shibboleth federation in Texas. Under this infrastructure, TDL is a *service provider* that relies on each school to be an

identity provider, so that students authenticate via a familiar interface they know and trust. Once the student is authenticated, certain attributes—such as their school and department, official name and address—are securely sent directly from the home institution to TDL servers. This mechanism allows TDL to offload the tasks of identity management and federal compliance to experts at each institution.

The ETD Submittal application leverages this attribute data to pre-fill many of the questions normally asked of the student during the submittal process. By deferring to the data provided by the institution, we can eliminate many common data entry errors, and prevent data duplication caused by alternate spellings, typos, and other mistakes. Of course, because of the resources available to the different institutions within the federation, not every school will be able to provide the same quantity or quality of attributes. In these cases, the submittal system simply “unlocks” the field and asks the student to type in the value, relying on verification by the graduate school staff to catch any errors.

Manakin

In April 2008, the DSpace community released version 1.5 of the popular digital repository platform. It included a new user-level interface to the repository: *Manakin*, an XML-based interface framework built on the Apache Cocoon platform. Texas A&M University and TDL were the primary contributors to this project (Phillips 2007). *Manakin* provides the ability to easily modify the look-and-feel of individual repository collections and a clean, modular way to introduce new functionality into the repository.

Manakin uses two primary mechanisms to enable customization of the repository: *themes* that modify the interface look-and-feel in a hierarchical manner, cascading down from communities to collections to individual items; and *aspects* that act as a plug-in architecture for introducing new functionality or behavior to the repository. TDL has used *Manakin* since before the official 1.5 release, and uses a customized theme to extend the TDL web presence into the repository space (Phillips 2007a). An aspect is used to cleanly add customized search and filter capabilities into the ETD collection without modifying base repository code.

Preservation Network

A core component of TDL’s mission, data preservation occupies an important place in the long-term plans of TDL services. While still in the early stages of development, TDL is currently investing in a state-wide, distributed preservation network. The central components of this project are geographically distributed storage nodes, migration of supported formats to preserve material access, and de-coupling the mechanics of the network from the services that rely upon it. As TDL is an entity that deals primarily with digital assets, creating a strategy to ensure their long-term storage and accessibility is a primary concern. The ETD Repository will be one of the first services integrated with the preservation network.

Submittal and Management Workflow

A central project necessary to realize the ETD Repository as described above is the creation of a web application to handle the student submittal process and the iterative verification workflow that happens prior to document approval and publication. This application is implemented as a *Manakin* application called *Vireo*. Leveraging

Manakin's ability to modularize functionality enhancements, Vireo consists of a paired aspect and theme. The aspect adds the functionality necessary to implement the customized submittal process and the iterative review and approval workflow for the staff members, and the theme applies the tightly coupled look-and-feel that provides numerous "Web 2.0"-style interface behaviors.

As mentioned above, each of the various ETD projects interact to varying degrees. Most significantly, each other project affects the development of Vireo by providing a base set of technologies or standards upon which Vireo depends. The TDL MODS profile is the authoritative metadata standard for the internal data storage, and a MODS XML document is written into the DSpace item as a new bitstream when the item is moved into a **Published** state. Shibboleth allows Vireo to scale up to a state-wide system without adding the complexity of identity management, and provides authentication and a secure method to transmit user attributes between systems. This also improves the quality of the metadata in the repository, since reducing the amount of manual data entry eliminates potential fail points in the software.

Finally, Manakin is the application framework on which Vireo is built, and its modular design allows Vireo to be added to an existing DSpace repository without affecting existing functionality or data. In a sense, Vireo can be thought of as a highly customized workflow extension on top of a DSpace repository, which means that any existing publication and dissemination features of DSpace are also available in Vireo, such as an OAI-PMH interface. Vireo extends the default feature set of DSpace to create a complete solution for ETD management: point of submission, approval workflow, and publication.

Development

Because Vireo handles very different workflows for two completely different audiences, it required two unique interfaces: one for students, and another for the administrative staff in the university graduate schools. In many ways, Vireo is two applications that share the same underlying data, each modifying that data in different ways, according to differing rules. The student submittal interface will be used by thousands of students each semester, all from various cultures and backgrounds, each with differing levels of comfort regarding technology. In almost all cases, this interface will only be used by a particular individual *once*, and that person will never return to the interface again. The student submittal application is a *novice interface*, as each user approaches the interface fresh, and remains inexpert throughout the short time he interacts with it, not staying in the interface long enough to develop expertise (Schneiderman 1997).

The administrative workflow interface is a canonical example of an *expert interface*. It will be used by only a handful of users at each institution, and most of these users will interact with the interface for several hours each day, as it will be integral to their job. It performs a highly complex set of tasks, and seeks to optimize for staff time and efficiency over user-friendliness. The set of users is always known, and the technology platforms are relatively controlled. In order to provide an interface that will maximize the available screen space and make repetitive tasks easy, we can rely on the fact that training is available, and that complex interface concepts can become familiar over time.

Student Submittal Interface

The student submittal interface was approached using the multiple step “wizard” paradigm familiar to users of modern graphical operating systems such as Windows or OS X (Weile 2000). The number of steps was set at five, with the last step comprising a recap of all previously requested data. A large progress bar dominates the top of the screen, signifying the stage of the submission. The goal was to make it obvious to the student at a glance where they are in the process and how much work is remaining (see Figure 1).

The screenshot displays the 'Verify Your Information' step of a five-step wizard. At the top, a progress bar shows five steps: 1. Verify Your Information (active), 2. License Agreement, 3. Document Information, 4. Upload Your Files, and 5. Confirm & Submit. The page header includes the Texas Digital Library logo and the text 'THESIS & DISSERTATION SUBMITTAL SYSTEM'. The main heading is 'Verify Your Information', followed by a paragraph of instructions and a note about required fields. The form is divided into three sections: 'Personal Information', 'Affiliation', and 'Phone & Address'. The 'Personal Information' section includes fields for First Name (Adam), Middle Initial, Last Name (Mikeal), Suffix, Email (adam@tamu.edu), and Year of Birth. A callout box prompts the user to enter a suffix. The 'Affiliation' section includes fields for School (Texas A&M University), Department (Computer Science), Degree (M.S.), and Discipline (Philosophy). The 'Phone & Address' section includes fields for Permanent Phone (123-456-7890), Permanent Address (123 Main Street, Sometown, Tx 12345), Permanent Email, and Current Phone. Three yellow callout boxes provide additional instructions: one about name formatting, one about degree and major selection, and one about permanent vs. current address.

TEXAS
DIGITAL LIBRARY

THESIS & DISSERTATION
SUBMITTAL SYSTEM

1 Verify Your Information 2 License Agreement 3 Document Information 4 Upload Your Files 5 Confirm & Submit

Verify Your Information

Please verify all of your personal information. Some of the information has been provided by your school; if this information is in error, you will need to correct it through the appropriate office at your school.
Required fields are indicated with an asterisk.

Personal Information

* First Name: Adam
Middle Initial:
* Last Name: Mikeal
Suffix:
* Email: adam@tamu.edu
Year of Birth:

Enter your suffix, for example Jr., Sr., III

Your name should appear as it does on your title page. You can use Unicode characters, if your computer supports them.

Select the degree and major that are listed on your title page.

You must enter a permanent, long-term address. If your present address is different, use the Current Address field.

Affiliation

* School: Texas A&M University
* Department: Computer Science
* Degree: M.S.
* Discipline: Philosophy

Phone & Address

* Permanent Phone: 123-456-7890
* Permanent Address: 123 Main Street
Sometown, Tx 12345
Permanent Email:
Current Phone:

Figure 1: Screen capture of student submittal interface

Since many students tend to submit their manuscripts very close to the deadline for a given semester, and since the submission of this manuscript is critical to their degree

(and career), they are frequently under a significant amount of stress. It is critical that the interface be as straightforward and intuitive as possible and conform to as many of the expected conventions of web applications as possible. This application is not an appropriate venue to force students to learn a “creative” interface widget. Finally, help text was integrated directly into the interface, as user testing indicated that students are not likely to read external documentation.

Staff Administrative Interface

The administrative interface was approached using the “job queue” paradigm. The basic screen shows an unfiltered list of all submissions in the system, sorted by submission date (see Figure 2). There is a list of *filters* available to the left of the list, which provides for a faceted browsing experience, allowing the staff member to create a customized query that shows exactly the set of submissions most amenable to performing her job at the moment. Staff users are granted significant control over their environment, with the option of showing or hiding the filters that appear on the left, and even which columns appear in the main listing.

THESIS AND DISSERTATION MANAGEMENT SYSTEM adam@tamu.edu Help Logout

List View Log Settings

ETDs currently in the system

Student name	Status	Document title	Submission date	Discipline	Graduation semester	UMI release
Creel, James S.	Approved	Intention Is Commitment with Expectation	18 Jan 2008	Underwater Basket Weaving	May 2005	
Pampell, Stephen M.	Needs Correction	I like titles	18 Jan 2008	none :)	January 2050	
Green, Cody B.	Under Review	Underwater left-handed basket weaving	18 Jan 2008	Underwater basket-weaving	December 2001	
Tarpley, Jeremy	Submitted	DETERMINING THE VALIDITY AND RELIABILITY OF THE CULTURAL AWARENESS AND BEL...	18 Jan 2008	Molecular - Nuclear Bio Home Economics	May 2008	
Maslov, Alexey	Pending Publication	On the breeding habits of porcupines	18 Jan 2008	Computer Science	May 2009	
Messinger, Christina	Submitted	how stuff works	18 Jan 2008	Visualization Sciences	May 2007	
Mikeal, Adam	Needs Correction	Fear and Trembling: A Fresh Look	18 Jan 2008	Philosophy	May 2008	
Tarpley, Jeremy	Submitted	How to dig holes of various sizes.	18 Jan 2008	asdf	May 2008	
Liles, Benjamin F., IV	Needs Correction	Implementing Persistent Identifiers	18 Jan 2008	Computer Science	May 2008	
Ponsford, Bennett	Submitted	A PROCESS FOR CREATING CELTIC KNOT WORK	22 Jan 2008	History	May 2003	
Ponsford, Bennett	Submitted	Beatrix and Autti of Huntingdon and Their Daughter Theodora: Parent/Child ...	22 Jan 2008	Engineering	August 1996	
Hammons, Laura	Under Review	My Dissertation	30 Jan 2008	Educational Human Resource Development	May 2008	
Mikeal, Adam	Submitted	How We May Think	01 Feb 2008	Computer Science	May 2008	
Tarpley, Jeremy	Submitted	Depressed Candidate Runs Attack Ad About Self	05 Feb 2008	Shop	June 2009	
Hammons, Laura	Waiting On Requirements	Test Title2	12 Feb 2008	Education	May 2008	
Hammons, Laura	Submitted	Ag History	12 Feb 2008	Ag	May 2008	
Mikeala, Adam	Waiting On Requirements	My cool thesis title	13 Feb 2008	Computer Science	May 2008	
Mikeal, Adam	Submitted	asd	28 Feb 2008	asdfsdf	May 2008	
Mikeal, Adam	Submitted	kjhq	29 Feb 2008	kjh	may 2008	
Peschel, Joshua M.	Submitted	TRADE, PIRACY, AND NAVAL WARFARE IN THE CENTRAL MEDITERRANEAN: THE MARITIM...	29 Feb 2008	Civil Engineering	May 2008	
Krueger, Cara B.	Submitted	Cara's Dissertation	29 Feb 2008	Human Resource Development (EAHR)	May 2008	
Catanach, Therese A.	Submitted	t	29 Feb 2008	ENTO	may 2008	
Adair, Irene N.	Submitted	Interactive Storytelling Engines	29 Feb 2008	Masters of Urban Planning	August 2008	
Wyckoff, Robert T., II	Submitted	Laying Claim to the Domestic	29 Feb 2008	English	May 2009	
Ji, Yue	Submitted	aaaa	29 Feb 2008	statistics	july 2008	
Karadkar, Umilshilg P.	Needs Correction	MIDAS	29 Feb 2008	Computer Science	August 2008	
Pang, Chengzong	Submitted	PhD Dissertation	29 Feb 2008	ECE	Dec 2010	
Sosa, Gabriela	Submitted	Trade, Piracy, and Naval Warfare in the Central Mediterranean	29 Feb 2008	Ecosystem Science & Management	May 2009	
Ponsford, Bennett	Submitted	adjalfskj	29 Feb 2008	History	May 2008	
Ponsford, Bennett C.	Submitted	"THAT TRUTH THAT LIVES UNCHANGEABLY": THE ROLE OF ONTOLOGY IN THE JUST WAR...	03 Mar 2008	History	December 2006	
Holt, Diane R.	Waiting On Requirements	Help Is on the Way	06 Mar 2008	Educational Administration	May 2008	
Motquin, Amy C.	Needs Correction	Fat Boys, Fat and Doss Run	06 Mar 2008	zoology	August 2008	

Figure 2: Screen capture of staff administrative interface

Selecting an individual submission from the list takes the user to the detail view. All aspects of the submission are editable, and every action taken within the system is written to an secure log that stays with the submission permanently. The user can assign the application to himself, to indicate to others that it is being worked on, and

can release it for others to acquire. Notes and files can be attached to the submission, and feedback or changes to the manuscript can be requested of the student. The state of the submission can be changed according to the “standard” workflow provided by Vireo, or the submission can be set directly to any state that is possible.

In all respects, Vireo assumes that the greatest amount of knowledge in the system resides in the graduate school staff, and does not try to “protect” them from making potentially dangerous changes. A good example of this principle is seen in the transitions from one state to another. The typical workflow that Vireo supports is represented in Appendix A, where each rounded rectangle represents a potential state that a submission can pass through en route to publication. The administrative interface makes walking a manuscript through this workflow easy; the next potential state or set of states is available as a simple button in a dialog box. However, there are times that a staff member may need to bypass the typical state transitions and move the manuscript directly into a particular state, such as **Published**. In this case, Vireo will allow the staff member to jump directly to almost any state from any other state (Cancelled and Deleted are special cases).

Deployment

As with any project of this magnitude, there are issues of scale that must be managed. In the case of the Texas ETD Repository, the scalability concerns cross several axes: there is geographic scale, since TDL member schools are distributed across an area nearly the size of France and Germany combined; the submitted application and repository must scale to handle thousands of simultaneous requests and submissions; the workflow model must be flexible enough to accommodate the differences in policy and procedure at many different institutions; and the interface must be accessible to a wide cross-section of students from various cultural and educational backgrounds.

Accessibility & Usability Testing

Web applications developed by state entities in Texas are required to meet various guidelines from both state and federal agencies that dictate accessibility compliance. Bringing Vireo into compliance with these guidelines ensured that students using alternative browsers or screen-readers would still be able to utilize the system. Formal accessibility testing was contracted early in spring of 2008, and the results of the testing incorporated back into every revision of the interface since that time.

Although accessibility guidelines ensure a level of access to the application itself, the system’s *usability* will determine its success in serving the students of TDL member schools. To that end, formal usability testing was conducted for the student submittal interface in February of 2008. Two rounds of test subject were scheduled, one with native English speakers, and the other with non-native English speakers. All participants were graduate students at Texas A&M University nearing their degree completion. The results of the tests were overwhelmingly positive, with only a few students experiencing uncertainty regarding the submittal process. Feedback was gathered on interface design—from on-screen instructions to language choices—and that feedback (mostly language changes to reduce ambiguity) has been incorporated into the interface.

Live-data Demonstrator

Staff members in the graduate schools of Texas A&M University and The University of Texas have been involved in the development process since fall of 2007. Their feedback was gathered periodically throughout the development phase, and many of their suggestions have been incorporated into the current version of the software. In order to assess the performance of the system in a production environment, a demonstrator version of the application was deployed for those two schools in spring of 2008. A number of students were asked to use this system to submit their manuscripts rather than the published methods. The staff then used the new management interface to completely process and approve the submissions. This exercise produced valuable feedback and exposed some potential complications in the workflow model, which were subsequently addressed in the development cycle.

Because the ETD submission and approval process is a mission-critical service for university graduate schools, the transition to a new system must be handled with care. TDL has adopted a phased rollout to the member schools, starting with the two largest schools in the consortium, Texas A&M University and The University of Texas. The demonstrator run in the spring will be repeated in the summer and fall, each time with larger segments of the student population: several departments for the summer, and several colleges for the fall. In the spring 2009 semester, these two schools can make the switch from their existing systems completely, and will be fully hosted on the TDL service. Also in spring 2009, Texas Tech University will begin its own demonstrator exercise, and will follow a similar pattern for gradually expanding to a production system. New schools will be added in a staggered manner, ensuring that any emergent scalability concerns can be met as they arise.

Addressing Scalability & Performance

Throughout the summer of 2008, a series of scalability tests will be conducted to assess the capabilities of the hardware, network infrastructure, repository technology, and Vireo software. Any serious performance bottlenecks will be identified and resources allocated to resolve them according to their severity. In early fall, a state-wide load test will be coordinated, with participants from TDL member schools spread across the state participating in order to test real-world performance prior to the first full rollout in the following spring.

Conclusion

Since the beginning of the ETD Repository project, the scope and complexity of the requirements have grown considerably. The demonstrator version deployed to Texas A&M University and The University of Texas has been instrumental in exposing overlooked assumptions and technical challenges that went undetected during the development process. In many cases, the assumptions were policy-related as often as they were technical. Even with iterative feedback from graduate school staff, the nature of the data used during a live exercise was different enough that unanticipated issues were encountered. This process was necessary to ensure the stability and trustworthiness of the final system.

The Texas Digital Library has been an active participant in the open source community since its inception and remains committed to the philosophical perspective of the free

software movement. In that spirit, once documentation and testing is completed for the initial release cycle, Vireo will be released under an open source license, including all generic documentation and training materials produced. Under the current timeline, this places the open source release in summer of 2009.

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References

- Gilley, Ann, Jerry Gilley. "FERPA: What Do Faculty Know? What Can Universities Do?" *College and University*, Vol. 82, No. 1, p17-26 (2006).
- Leggett, John, Mark McFarland and Drew Racine. "The Texas Digital Library: A Business Case". Prepared for and published by the Texas Digital Library, July 2005, revised July 2006.
- Mikeal, Adam, Tim Brace, Scott Phillips, John Leggett and Mark McFarland. "Developing a Common Submission System for ETDs in the Texas Digital Library". In *Proceedings of the 10th International Symposium on Electronic Theses and Dissertations*, Uppsala, Sweden. June 13-16, 2007.
- Phillips, Scott, Cody Green, Alexey Maslov, Adam Mikeal, and John Leggett. "Introducing Manakin: Overview and Architecture". In *Proceedings of the 2nd International Conference on Open Repositories*, San Antonio, TX, USA. January 23—26, 2007.
- Phillips, Scott, Cody Green, Alexey Maslov, Adam Mikeal and John Leggett. "Manakin: A New Face for DSpace". *D-Lib Magazine*, Vol. 13 No. 11, November 2007.
- Rushing, Amy. "Texas Digital Library Descriptive Metadata Guidelines for Electronic Theses and Dissertations, Version 1.0". Prepared for and published by the Texas Digital Library, May 2008.
- Schneiderman, Ben. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. Addison-Wesley Publishing Company, 1997.
- Surratt, Brian. "MODS Meets Manakin: Innovations in the Texas Digital Library's Thesis and Dissertation Collection". In *Proceedings of the 9th International Symposium on Electronic Theses and Dissertations*. June 7—10, 2006. Quebec City, Canada.
- Shibboleth (Internet2). In *Wikipedia, The Free Encyclopedia*, [http://en.wikipedia.org/wiki/Shibboleth_\(Internet2\)&oldid=205883216](http://en.wikipedia.org/wiki/Shibboleth_(Internet2)&oldid=205883216) (accessed May 31, 2008).
- van Welie, Martijn, H. Trætterberg. "Interaction Patterns in User Interfaces". In *Seventh Pattern Languages of Programs Conference*, 13-16 August 2000, Illinois, USA.

Appendix A: Vireo state flow diagram

