

**Electronic Submission of Undergraduate Theses:  
A Case Study for the Implementation of a University-Wide Program for the Electronic  
Submission and On-line Archiving of Theses and Dissertations**

**A Thesis  
in TCC 402**

**Presented to**

**The Faculty of the  
School of Engineering and Applied Science  
University of Virginia**

**In Partial Fulfillment  
of the Requirements for the Degree**

**Bachelor of Science Computer Science**

**by**

**Mariahna Moore**

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**On my honor as a University student, on this assignment I have neither given nor received unauthorized aid as defined by the Honor Guidelines for Papers in Humanities Courses.**

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## PREFACE

I have worked as a research assistant for Professor Jim French of the Computer Science department since August of 1995. His work and experience in information retrieval and digital libraries provided me with the necessary knowledge needed to undergo a project of this nature. It is exciting to develop a project where success can change the way things are done at the University of Virginia.

Being on the ground-breaking level of a new project with the potential impact of ETDs is hard work. I would like to acknowledge the invaluable help I received from Professor French and from graduate student Allison Powell.

Much of the software required to build this system was obtained from other research facilities. The Dienst software from NCSTRL provides the backbone for my digital library. I would like to thank graduate student Neill Kipp of Virginia Tech for providing information about their ETD program as well as their software which I used to implement the submission portion of my ETD project.

## ABSTRACT

The popularity of electronic publishing and electronic libraries rises as the number of people on the World Wide Web increases exponentially every year. Many students are not suitably prepared for on-line world that faces them in their careers ahead. Additionally, the results of hours of time, energy, and research are seemingly lost as theses and dissertations sit on library shelves unavailable to outside students and research communities. Increasingly, discussions of electronic theses and dissertations and their benefits are gaining strength. In order for the University of Virginia to take full advantage of this educational resource, I have set up a working prototype for undergraduate students in the School of Engineering and Applied Science to submit electronic theses. The current roles of the student, the TCC department, and library are transformed into equivalent parts of the electronic thesis system. This project represents the possibilities of a University-wide system and successfully demonstrates that such a project is feasible.

TABLE OF CONTENTS

<b>1.0 The Concept of Electronic Theses &amp; Dissertations.....</b>	<b>1</b>	
<b>1.1 Problem Definition.....</b>	<b>1</b>	
<b>1.2 Literature Review.....</b>	<b>2</b>	
<b>1.3 Rationale for Developing a SEAS ETD Program.....</b>		<b>3</b>
<b>1.4 Overview of the Development of ETDs for SEAS Students.....</b>	<b>4</b>	
<b>2.0 The Conceptual Model.....</b>	<b>6</b>	
<b>2.1 The Student.....</b>	<b>6</b>	
<b>2.2 TCC Department.....</b>	<b>7</b>	
<b>2.3 The Library.....</b>		<b>8</b>
<b>3.0 The Physical Model.....</b>	<b>10</b>	
<b>3.1 The Submission Process.....</b>	<b>10</b>	
<b>3.2 Accepting the Thesis.....</b>		<b>11</b>
<b>3.3 The Digital Library.....</b>		<b>12</b>
<b>4.0 Results and Recommendations.....</b>	<b>14</b>	
<b>4.1 Submission.....</b>	<b>14</b>	
<b>4.2 Viewing Electronic Theses.....</b>	<b>15</b>	
<b>4.3 Overall Assessment.....</b>	<b>16</b>	
<b>4.4 Recommendations.....</b>	<b>17</b>	
<b>Bibliography.....</b>		<b>20</b>
<b>Appendix A - Glossary of Acronyms.....</b>		<b>21</b>

24 March 1997

## 1.0 THE CONCEPT OF ELECTRONIC THESES & DISSERTATIONS

To take full advantage of the educational opportunities presented by the World Wide Web, the University of Virginia (U.Va.) needs to develop a program for the electronic submission and archiving of theses and dissertations. To prove that such a system is achievable, I have set up a prototype to handle the undergraduate theses in the School of Engineering and Applied Science (SEAS). My prototype is a working system on the same scale as that of a University-wide system, and it demonstrates the benefits of a transition to a system of electronic theses and dissertations.

### 1.1 PROBLEM DEFINITION

Digital libraries and electronic publishing are increasing in popularity as a way of sharing information among millions of people quickly, cheaply, and with greater availability than physical libraries can provide. Over the past ten years, discussions about applying the digital library technology towards theses and dissertations have developed. The benefits of an electronic thesis and dissertation (ETD)<sup>1</sup> system, such as wider dissemination of research and higher-quality multimedia documents, can help students, researchers, universities, and the public at large (Fox, National Digital Library 2). In the early nineties discussion gave way to research, and in 1996 the U.S. Department of Education presented Virginia Tech with a three-year grant for the *National Digital Library of Theses and Dissertations* (NDLTD) project. The Department of Education grant added to an already existing fund from the Southeastern Universities Research Association (SURA) for developing the *Monticello Electronic Library Thesis and Dissertation Program*. ETDs are a new development in the field of computer science, and few universities have jumped to Virginia Tech's level of involvement. There are opportunities for groundbreaking work by the University of Virginia if it steps in as a leader in electronic theses and dissertations along side Virginia Tech.

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<sup>1</sup> Virginia Tech's own Electronic Thesis and Dissertation project is referred to as ETD; however, throughout my paper the acronym will represent the generic term "electronic theses and dissertations".

## 1.2 LITERATURE REVIEW

In order to fully understand the possibilities of an electronic system for theses and dissertations, I performed a literature search to find articles with in-depth information about ETDs. Because much of the research done in the field of ETDs has been conducted in the early nineties, and because the subject is electronic information, most of the published literature is on-line. In particular, Virginia Tech, the leading force in the attempt to form a digital library of theses and dissertations, provided the most influential documents in developing my prototype.

Virginia Tech's ETD homepage provided valuable information for how to set up a working system (1996). This website includes press releases, explanations of key terms, and a link to the website Virginia Tech students access to submit their theses and dissertations. The site also covers concerns on the part of the student body, the faculty and the administration. Knowing the general concerns that exist about an electronic system helped me better develop my prototype. Professor Edward Fox, director of Virginia Tech's ETD project, co-authored a paper concerning the plans for developing the NDLTD (1996). The information in this paper expands the ideas presented on Virginia Tech's ETD homepage. The information provided by Virginia Tech was invaluable in creating the submission process for my system and in predicting and alleviating concerns that students, faculty, and the library staff may have had.

I found information on digital libraries and their development at another on-line site: the Networked Computer Science Technical Report Library (NCSTRL) homepage (1996). Many universities, including the University of Virginia and Virginia Tech, collaborated on the development of this digital library. The information at this site provides valuable information about solutions for developing the SEAS's digital library for theses and dissertations. I used the software and the on-line documentation to develop my digital library.

Though only a few sources were used during the literature search, the sources used were highly influential in designing my system. The work done on electronic theses and dissertations is new and concentrated at only a few locations, however, the information provided by NCSTRL and the Virginia

Tech ETD project contained the necessary information used to fully develop my prototype.

### 1.3 RATIONALE FOR DEVELOPING A SEAS ETD PROGRAM

Virginia Tech is the leading university in the move towards electronic theses and dissertations. In fact, they no longer accept hard copy submissions of graduate theses and dissertations. But in order for the NDLTD to actually be successful, universities nationwide need to join Virginia Tech's effort and develop comparable systems of their own. My prototype will demonstrate to U.Va. that joining Virginia Tech as a leader in the ETD movement is advantageous and viable. Though referred to as a prototype, I will develop a working system by which any undergraduate student of the School of Engineering and Applied Science can submit his/her senior thesis.

The scope of the project is in keeping with the scope of the system the University of Virginia might implement. The number of SEAS undergraduate theses produced in one year is on the same order of magnitude as the number of total graduate theses and dissertations produced by U.Va. students in a year. The software used to implement my digital library is the same software used by Virginia Tech and was developed for the large-scale NCSTRL collection. Care has been taken to include both the Technology Culture and Communications department (TCC) and the library staff throughout the development of this project to discuss concerns about ETD in general and to demonstrate a successful work in progressive steps.

### 1.4 OVERVIEW OF THE DEVELOPMENT OF ETDs FOR SEAS STUDENTS

The remainder of this technical report explains the development of my thesis project including the specific software used, problems encountered, the results, and recommendations for future systems. In order to understand how my system works and how it could work for U.Va. as a whole, I have explained the three key conceptual areas of my system: the student, the library, and TCC (or the Dean's office). These three "players" differ from the three parts of the actual software used to implement my prototype. The structure of the software will be discussed in a separate chapter. Most importantly, the results of my

24 March 1997

thesis will be discussed along with any repercussions. Because my system is a prototype for a system U.Va. will hopefully soon develop, the results of this project will be considered in detail with recommendations for future work.

24 March 1997

## 2.0 THE CONCEPTUAL MODEL

The concept of electronic theses and dissertations has been around since the late 1980s. In the early 1990s, research into digital libraries escalated as Virginia Tech took a leading role in converting the concept of ETDs into actuality. Virginia Tech has begun the process of implementing the NDLTD and already require that all theses and dissertations be submitted electronically only (<http://etd.vt.edu/etd/>).

In order to make the concept of ETDs a reality at the University of Virginia, the electronic model must provide the same functionality as the current system. In order for the new system to be compatible with the SEAS's requirements for undergraduate theses, the same steps that occur in the current process needed to be addressed before I began to actually build my prototype. In the current system there are three involved parties: the student, the TCC department, and the Science and Engineering Library (SEL). Each party has a certain set of tasks that need to be paralleled in the electronic system.

### 2.1 THE STUDENT

It is important for the success of the prototype that the new system be usable and convenient for students. For the purpose of this system, the process for generating a technical report remains the same; students will submit hardcopies to both their technical and TCC advisors and wait for approval signatures. Once the student's thesis has been approved, a different path for submitting the thesis to the library will be followed. Instead of submitting a hardcopy to the library, the student will provide an electronic copy by accessing the submission page on the World Wide Web.

With Netscape installed in all public computer labs at U.Va., students are already familiar with the World Wide Web. The University Library switched their main catalog system, VIRGO, to an on-line version this year and when the University held recent student elections on-line, the number of voters almost doubled. Students are comfortable with the World Wide Web and with appropriate on-line help, the transition from hard-copy to electronic theses should be simple. In addition, the student saves the cost of binding their final report. The student's effort is no more than what is currently required and perhaps less as every step for submitting the thesis to the library can be done sitting at a single computer.

## 2.2 TCC DEPARTMENT

As with the student, TCC's role in the new electronic system is very similar to its current role. Each TCC advisor will continue to review hardcopies of the technical reports. The changes from the current system occur with the final binder. Rather than submitting the final binder to his/her TCC advisor, the student will submit it on-line. The TCC department will no longer have to physically transport several hundred undergraduate theses to the library every year. In order to verify that the student prepared the final binder and received approval from both advisors, a copy of the title page with signatures from both advisors will be supplied to the TCC department. In addition, the student will receive an approval e-mail from the library when his/her thesis submission has been received and approved by the library cataloger. The student can forward this e-mail to the TCC department to verify submission of his/her thesis to SEL.

Future systems will involve the Dean's office of individual schools within the University of Virginia. Because each school has different requirements for theses and dissertations, the electronic submission process will need to be revised to allow for the requirements of individual schools.

## 2.3 THE LIBRARY

The Science and Engineering Library will feel the greatest effects of an electronic system. The library will no longer handle hardcopies of theses. The shelf-space used for storing theses will be freed and the amount of materials and manpower needed for physically cataloging theses will drop. My system allows the library cataloger to receive, catalog, and store theses in the SEAS Undergraduate Theses Digital Library (SUTDL) without having to leave the computer.

Once the student has submitted his/her thesis the library is notified by e-mail that a thesis is ready to be cataloged and stored in SUTDL. The e-mail will include a url where the librarian can view the information supplied by the student, verify the submission was legitimate and contains the appropriate information, and either accept or reject the student's submission. As with the current system,

the librarian will assign a catalog number to the thesis for use in VIRGO. This same number will be used by the librarian to catalog the thesis's bibliographic information and the full thesis document in SUTDL.

Separate from VIRGO, the SEAS Undergraduate Theses Digital Library is a searchable, browseable index of undergraduate theses. The library allows a user to browse the collection by author, year or technical advisor within any SEAS department. Each browseable field can be viewed entirely, by segment, or by individual section. For example, all authors in the Computer Science (CS) department, authors in the CS department whose last names begin with either 'A', 'B', or 'C' can be browsed, or all CS authors whose last names begin with 'H' can be viewed.

The student can search the database with a simple search or a fielded search. The fielded search allows for queries by author, advisor, keywords in the title or abstract, and/or a document identifier (VIRGO catalog number). The simple search will look for matches to the query in the author, title, and abstract fields.

Each entry in the browseable lists as well as the results of any search query are hyperlinks to bibliographic data, abstracts, and a hyperlink to the full-text document. Students no longer need to visit the SEL stacks to look over past theses. In addition, electronic theses erase the problem of checked out, lost, or misfiled hardcopies. The electronic theses will always be available for people to access. The library requires the most change in crossing over from the current system to the system I developed. Care has been taken to include members of SEL during the design on my prototype and they are providing strong support for switching to electronic theses and dissertations.

24 March 1997

### 3.0 THE PHYSICAL MODEL

Just as the conceptual model was made up of three separate components, the physical layout of my prototype can be broken down into three elements: submitting the thesis, archiving the thesis, and searching the theses database. Software has already been developed by different research institutes for each portion of the ETD system. In order for the system to work for SEAS, each part had to be modified to fit the University of Virginia's conceptual model.

### 3.1 THE SUBMISSION PROCESS

The first step in submitting an electronic thesis is creating the electronic thesis in the correct format - PDF. PDF, Portable Document Format, is Adobe's document format ideal for presenting documents on the World Wide Web. Creating PDF documents is as simple as printing the document to a printer. The Adobe PDF print driver can be installed on most common computer platforms. This allows students who have used commercial applications such as Microsoft Word to create their technical reports turn those documents into PDF documents. Within a word processor, the PDF print driver should be chosen from available printers. A file name is entered and then the student "prints" his technical report. The technical report is printed in PDF format to the file specified. It is an ideal format for storing theses and dissertations because it cannot be edited.

The submission process consists of several webpages generated from CGI programs using the scripting language PERL. CGI programs allow dynamic HTML documents to be created that change depending on the information the student presents. This software was made available from Virginia Tech which currently uses it to support their ETD program. I downloaded the appropriate files and configured the PERL scripts for the needs of my system. The url for the initial submission page is:

<http://univac.cs.virginia.edu:3066/cgi-bin/etd-cgi/etd.cgi>

The student inputs the information required by the library to catalog the technical report. After all the information has been entered the student presses the "preview" button which runs another script creating another HTML document which presents the information the student previously entered. The student

can then review the information and using Netscape's "browse" technology, select his/her PDF file from a disk or the computer's harddrive to be uploaded to the library file system. Once the student is satisfied with the information he/she provided, the "submit" button is pressed. A final HTML page is created which notifies the student that the submission was completed and is awaiting approval by the library staff. E-mail is automatically sent to the library and the PDF and HTML files are stored in a temporary directory until the librarian accesses them for archiving in the SUTDL.

### 3.2 ACCEPTING THE THESIS

Once the student completes the submission and uploads his/her technical report, an HTML file is generated from a PERL script which contains the information supplied by the student. It is important at this interval to include a person in the electronic process to verify the quality of submissions. The librarian reviews the information and either accepts or rejects the submission. Either way, e-mail will be sent to the student informing him/her of the technical report's status. If the thesis is rejected, the HTML file and the PDF document are deleted from the temporary directory in which they were stored. If the thesis is accepted, the librarian must supply a catalog number and the current date as approval verification. Once this information is provided, a bibliographic file is created by the PERL script for use in the digital library. The librarian then needs to complete the archiving process from the UNIX system the digital library software is running on. The bibliographic file and PDF document are moved to a permanent directory in the document database and PERL scripts are run which incorporate the newest submission into the database.

### 3.3 THE DIGITAL LIBRARY

The SEAS Undergraduate Theses Digital Library is based on software used to run the Networked Computer Science Technical Reports Library. This collection of computer science technical reports is an open, distributed system based on the Dienst protocol. NCSTRL documentation describes the Dienst system as "a conceptual architecture for digital libraries, a protocol for communication in that

24 March 1997

architecture, and a software system implementing that protocol." As with the submission software received from Virginia Tech, the Dienst software is composed of many PERL scripts and is designed for a UNIX system.

Each document in the SUTDL has a unique document identifier and is associated with one department in the Engineering School. The bibliographic files are written in RFC-1807 format with the added field "ADVISOR:". Stored with the bib file is the PDF document the student submitted. When the bib information for a particular thesis is accessed by a user through either browsing or search queries, he/she has the option of viewing the full document on-line. Acrobat Reader, Adobe's software needed to view PDF documents, is installed on all public ITC machines. In addition, it is available free for downloading from the Web for users who are not accessing the digital library from a University computer lab.

The most important change in configuring the Dienst software for my prototype was adding the advisor field to the database. Useful to upcoming fourth-year students who are trying to pick a technical advisor, browsing a list of theses directed by a specific advisor can help the student decide if that advisor would be appropriate to direct his/her thesis. The advisor search and browse technology is identical to the author search and browse, but it provides a unique opportunity that is unavailable from VIRGO. The submission system set up with software from Virginia Tech and the digital library which uses NCSTRL's Dienst software, are interfaced by a human component needed for quality control. My working prototype is a successful blend of the current system with new technology.

#### 4.0 RESULTS AND RECOMMENDATIONS

Because real submissions will not occur for approximately one more month (the time it takes for a student to receive approval from both advisors), I performed several submissions of my thesis proposal and sections of my technical report to test the performance of my system. In addition, the bibliographic entries in VIRGO for all fourth-year undergraduate SEAS theses (approximately 4000) were added to SUTDL in order to demonstrate the search and browse capabilities of the digital library as well as to show that the Dienst software is well equipped to handle the size of an ETD library.

#### 4.1 SUBMISSION

The submission process worked smoothly after configuring Virginia Tech's software for a SEAS's system. Correct submissions store the appropriate information accurately and provide the librarian with the appropriate files for cataloging. If a student submits a thesis with incomplete information, the PERL script flags the error and asks the student to edit the submission form and input the correct data. Each correct submission resulted in the bibliographic data in HTML format and the PDF document to be stored in the temporary directory waiting for access by the librarian.

The archiving process is mainly a function controlled by a qualified member of the SEL staff. After reviewing the information, the librarian must supply an approval date before the thesis can be cataloged. If a date is left off the approval webpage, the librarian will be flagged before the approval request is processed. I tested several approvals and rejections and both options worked smoothly. Rejections result in the bibliographic data and the PDF document being deleted from the file system as specified. When a document was approved, an RFC-1807 bibliographic file was created with the appropriate fields. Correctly cataloging the thesis in SUTDL relies on the creation of a document identifier by the librarian. Once this has been added to the bib file, the librarian can then run Dienst PERL scripts to assimilate the newest entry into the digital library database. With correctly formed bibliographic data the scripts work correctly. If errors are added to the bib file, the PERL scripts will send error messages informing the user that the entry was not successfully added to the database.

#### 4.2 VIEWING ELECTRONIC THESES

The SEAS Undergraduate Thesis Digital Library can be accessed by a web browser at:

<http://univac.cs.virginia.edu:3066/Welcome.html>

This database contains all bibliographic records of fourth-year engineering school theses that are listed in the University's library database, VIRGO. Along with bibliographic records, this database will contain the full-text of undergraduate theses from Professor Pfaffenburger's TCC 402 classes as well as any other SEAS students who want to use the system. These documents are stored in PDF which is viewable by Acrobat Reader. To demonstrate that storing and viewing full-text documents is feasible, I submitted several different papers, including portions of this technical report and my initial proposal, to the digital library. Each document was successfully viewed with Acrobat Reader.

The second function of the digital library is to provide proficient search capabilities. The Dienst software used for the database was developed for the NCSTRL system and has been proven adequate for searching technical reports. To demonstrate its abilities with SUTDL, I ran several searches on VIRGO (specifying only fourth-theses) and repeated the same searches on the SUTDL. The searches resulted in similar outcomes. In fact, several entries that did not appear in the VIRGO search were returned by the SUTDL query (ex: Keyword="engine" resulted in an entry whose title contained the phrase "internal combustion engines" which was not contained in the results from the VIRGO search.)

In order to test the unique feature of advisor searching, the advisor field of computer science theses from 1992 and all 1996 SEAS theses were added to the bibliographic entries (Not all advisors were actually available as this information was retrieved from the theses stored in the SEL stacks which are in various states of order.). Searching by "advisor=Hutchinson" yielded all the theses Professor Thomas Hutchinson directed across several different majors. Browsing the list of advisors worked equally well, for example, searching advisors in the computer science department whose last name begins with 'W' resulted in all the entries for Professors A. Weaver and W. Wulf.

#### 4.3 OVERALL ASSESSMENT

Both the submission process and the digital library work as designed and prove that electronic theses are realistic. The software exists and is available for configuration for specific systems. Acrobat's PDF provides a portable format that is ideal for viewing full-text documents on the World Wide Web. Designed specifically for SEAS 4th-year theses, the thesis acceptance process works smoothly. It is important to realize that this step, however, is contingent on a knowledgeable person following the correct procedures for accepting and archiving the student's technical report. My thesis is a working prototype of a digital library that could be modified and integrated with the NDLTD currently being developed by Virginia Tech. The search and browse capabilities are fully functional and provide more than adequate results.

There are still a number of opportunities to further develop my system. Perhaps the next effort should be in making the archiving process more automated which would also decrease the opportunities for human error. Changes could be made to the PERL scripts which would allow the librarian to input the catalog number into a field in the approval HTML page. With this information, a complete bibliographic file can be created and the Dienst scripts to integrate the thesis into the digital library can automatically be called when the librarian accepts the thesis.

My prototype represents the possibilities of an ETD system for the entire University of Virginia. Over the next several months as students begin to submit their theses to SUTDL, the ease with which this system could be adapted in order for U.Va. to join the NDLTD will be clearly demonstrated.

#### 4.4 RECOMMENDATIONS

My thesis illustrates that a digital library of theses and dissertations is an achievable goal. The scope of my project is equivalent to that of a system designed for graduate theses and dissertations. The technology is available and easily adaptable to create a system for undergraduate and graduate theses and dissertations for the entire University of Virginia. Concerns about developing a digital library are more political and theoretical than technological. U.Va.'s administrative system involves separate

schools, with separate deans, and individual submission processes. Acceptance is needed from each school and a universal system needs to be adapted that each school can use. In addition, concerns about intellectual property rights and plagiarism will need to be addressed. Virginia Tech allows submission of theses and dissertations to be unavailable outside of the Virginia Tech domain for 3 months or a year pending, for example, a journal publication or patent rights. Passwords and restricted domains can be used to limit outside access to the acceptance and archiving process. If someone suspects their work has been plagiarized there are computer programs which can compare two documents more efficiently than the human eye. With the right safeguards, copyright threats will be no more likely with an on-line system than with the hardcopy sitting on a library shelf.

A more fundamental concern that will absolutely have to be addressed before a large-scale system for U.Va. can be developed is converting the many different document formats into PDF or another appropriate document format. Adobe has taken great efforts to ensure that PDF becomes a de facto standard similar to its predecessor Postscript (Fox, Dept.of Educ.Proposal 14) They have provided capabilities for creating PDF documents for most software run on common computer platforms such as PCs or Macintoshes. And if a PDF document cannot be directly created but a Postscript document can, Adobe has a program to convert Postscript into PDF. A particular format, files created in LaTeX, are widely used in graduate theses and dissertations because of excellent capabilities for representing complex mathematical equations. There is a problem, however, with converting LaTeX to PDF; many fonts used in LaTeX convert poorly to PDF rendering a document extremely difficult to read. This will need to be addressed in order to satisfy the needs of the academic community.

An ETD system for the University of Virginia is an obvious next step in ever-continuing efforts to better the education students receive while attending U.Va. The benefits to the students are extensive: better preparation for an electronic career-world, more opportunities to create dynamic, multi-media theses and dissertations, relief from much of the financial cost related to publishing hardcopies. The University will also benefit in many ways: increased shelf-space in its libraries and reduced costs for maintaining and storing hardcopies, increased knowledge sharing among other universities and research

24 March 1997

associations, an influential role as a leader in the increasingly popular move towards ETDs. The concerns raised, though not trivial, should not undermine efforts to join the University of Virginia and Virginia Tech in developing the NDLTD. Concerns need to be weighed against the benefits, and my project has successfully demonstrated that the work needed to create an ETD system is practical in the face of the potential benefits.

24 March 1997

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**Sustainable Approach to Unlock University Resources." D-Lib Magazine September 1996.**

**Virginia Tech's main information page about their ETD project**

**<http://etd.vt.edu/etd/>**

**NCSTRL's homepage**

**<http://www.ncstrl.org>**

**APPENDIX A**

**GLOSSARY OF ACRONYMS**

**ETD - Electronic Thesis and Dissertation**

**NCSTRL - Networked Computer Science Technical Reports Library**

**TCC 402**

**SEAS Undergraduate ETD Program**

**24 March 1997**

**NDLTD - National Digital Library of Theses and Dissertations**

**PDF - Portable Document Format**

**SEL - Science and Engineering Library**

**SUTDL - SEAS Undergraduate Theses Digital Library**