

# Enhancing Usability in CITIDEL: Multimodal, Multilingual, and Interactive Visualization Interfaces

Saverio Perugini, Kathleen McDevitt, Ryan Richardson, Manuel Perez-Quiñones, Rao Shen, Naren Ramakrishnan, Chris Williams, Edward A. Fox

Virginia Tech

Department of Computer Science

Blacksburg, Virginia USA 24061

1-540-231-6931

{sperugin, kmcdevit, ryanr, perez, rshen, naren, chwilli4, fox} @vt.edu

## ABSTRACT

CITIDEL employs a modular system design to support education in computer science and related fields. By taking advantage of its modular nature, we have made interface enhancements that draw from different fields in computer science. Examples are the incorporation of interactive visualizations, usability enhancements, multimodal interactions, and community multilingual translation. Pilot studies demonstrate the resulting improvements in quality, as measured across a number of metrics.

## Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – *Graphical user interface, User centered design, Natural language*; H.5.4 [Hypertext/Hypermedia]: *Navigation*.

## General Terms

Management, Design, Human Factors.

## Keywords

Interfaces, interactive visualization, community translation, out-of-turn interaction.

## 1. INTRODUCTION

The Computing and Information Technology Interactive Digital Educational Library (CITIDEL) was developed as part of the collection-building effort of the National Science Digital Library ([www.nsdlib.org](http://www.nsdlib.org)). Essentially, it supports a collection of metadata about resources stored at other sites, such as ACM, DBLP, NDLTD, etc., in addition to having a small collection in its own right. As of January 1, 2004, it has 12 source collections, and contains metadata on over 440,000 resources. During the year 2003, it received an average of over 33,000 hits per month, by users from at least 22 countries. With suitable enhancements, we believe CITIDEL can support a much wider base of users, and have significant impact on the teaching and learning of those interested in computing and information technology.

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Conference '04, Month 1–2, 2004, City, State, Country.

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## 2. RELATED WORK

Enhancements to CITIDEL and similar efforts may come from many types of related works. While in subsequent sections we focus in turn on particular types of enhancements, and point therein to specially focused related works, here it is appropriate to address how visualization and open archives may broadly facilitate enhancement.

Visual interfaces to digital libraries (DLs) apply powerful data analysis and information visualization techniques to document collections in DLs. To enhance the interoperability of DLs and visualization systems (VIS), [23][29] proposed a lightweight protocol, that would facilitate modular deployment of a wide variety of visualization methods. Visualization techniques of one important class are those visualizing document attributes that are predefined (author or date) or computed (e.g., query relevance). One example is the Envision system [15] and the enhanced version of Envision [30]. Predefined categories to which documents belong also can be considered as predefined document attributes or as semantic information. Cat-a-Cone [7] assists users by displaying semantic information (categories assigned to each document). Visualization techniques of another class do not make assumptions regarding document attributes. They automatically derive a collection overview via the use of unsupervised learning, such as variants of document clustering. Examples are Scatter/Gather [4], Grouper [33], Vivisimo (<http://vivisimo.com>), Kartoo (<http://kartoo.com>), Galaxy of News [21], and ThemeScapes [32].

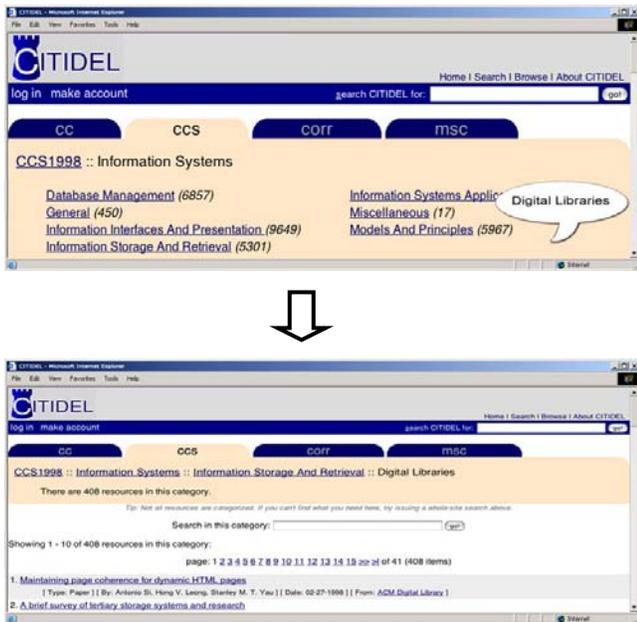
CITIDEL relies heavily on the Open Archive Initiative, specifically its Protocol for Metadata-Harvesting (OAI-PMH) [10][24]. OAI-PMH allows willing archives to share metadata with a straightforward and easily implementable protocol. Within the framework of OAI, CITIDEL serves as a “service provider”; not focused on providing metadata (though it does so to NSDL, to support broader searches), but rather providing value-added services atop others’ metadata. Thus, OAI provides a framework for modularity and enhancement according to a wide variety of approaches, such as those discussed in the following sections.

## 3. Multimodal Interaction in CITIDEL

Our first usability enhancement to CITIDEL extends the interaction paradigm to support multimodal access, e.g., via voice.

Besides improving accessibility, this enhancement enables *mixed-initiative interaction* between the user and the digital library.

Mixed-initiative interaction is a flexible dialog management strategy whereby the user and the DL can each change the flow of interaction. This approach increases the expressiveness by which partial information can be supplied by the user, and in this manner, achieves personalized interaction [18]. For instance, mixed-initiative interaction permits the user to supply *out-of-turn* inputs, namely values for facets that are not responsive to the DL’s solicitation but nevertheless are pertinent to the information-seeking goals of the user. Intuitively, this form of access subsumes traditional browsing and provides the same form of customized interaction that is typically targeted using cumbersome faceted browsing classifications [8]. This means that the user and the DL can take turns exchanging initiative over the course of an interaction. For example, as can be seen in Figure 1, CITIDEL “expects” the user to continue moving downward through ACM’s 1998 Computing Classification System, but when told “Digital Libraries” (through the interface mechanism described in Section 3.1.1, and illustrated in Figure 2), will jump directly to that part of the hierarchy.



**Figure 1. A mixed-initiative dialog via voice in CITIDEL to reach the webpage containing links to papers classified under "Information Systems :: Information Storage And Retrieval :: Digital Libraries"**

A salient feature of our approach is the use of program transformations (e.g., partial evaluation) to *stage* the interaction [3]; this provides a functional approach to supporting dialogs, without explicitly manipulating state information.

To make this work, the DL needs interaction interfaces to capture input, a robust transformation engine, and a manager to mediate interaction and coordinate activities among the constituent subsystems. The engine, which is deployed as a web service, is general enough to enable out-of-turn interaction with a variety of DLs without requiring the designer to anticipate the points at

which out-of-turn interaction can occur. It handles in-turn (responsive) and out-of-turn (unsolicited) inputs (passed from interaction interfaces) in a uniform manner. The engine was designed based on metaphors from program transformations and implements a form of forward, followed by backward, slicing.

The transformation engine is a core sub-system, and besides applying the appropriate program transformations, conducts a whole host of other activities, including automatic query expansion. The architecture (see Figure 2) affords a customizable software framework for augmenting DLs with aspects of personalization, including the support for mixed-initiative interaction [14]. Due to space considerations we only describe the interaction interfaces and manager below as they are the components primarily concerned with usability and interaction.

## 3.1 Interaction Interfaces

### 3.1.1 Extempore

The Extempore toolbar [19] was developed using the XML User interface Language (XUL), and JavaScript for the cross-platform Mozilla web browser. It was designed to be non-invasive and to become active only when the user is visiting a DL capable of out-of-turn interaction. By displaying a lightweight, text-based interface, Extempore leverages users’ prior knowledge to provide a familiar and easy method of interaction. It is important to note that Extempore is embedded in the web browser, and not the DL pages. It also is not a DL-specific search tool which returns a flat list of results.

### 3.1.2 SALTII

The SALTII interface is built using the SALT XML-based markup language, allowing one to embed speech tags in HTML to realize webpages capable of speech input and output. The current SALTII implementation requires the SALT voice recognition plug-in for Microsoft Windows Internet Explorer 6.0. Using this interface, users could potentially carry out an entire dialog with speech alone, using speech not only for out-of-turn interaction, but in-turn as well. This interaction interface is patterned after speech recognition technologies such as VoiceXML.

## 3.2 Interaction Manager

The interaction manager primarily coordinates communication between the transformation engine and the interaction interfaces. Recall that the PIPE framework treats in-turn inputs no differently from out-of-turn inputs, so it is desirable that the interaction manager also preserve this uniformity. We first outline the overall process by which interaction is established and managed (see Section 3.2.1), followed by descriptions of the three constituent subsystems (see Figure 2).

### 3.2.1 Preparing for Out-of-Turn Interaction

To situate the interaction manager as a dialog facilitator of both in-turn and out-of-turn inputs, we have investigated a variety of mechanisms, ranging from those that involve the full participation of the DL, to proxy-based bypass schemes. The former requires a DNS re-direct so that HTTP GET requests are forwarded to the interaction manager (notice that out-of-turn inputs are received directly from the interaction interfaces). This solution also has the attractive property that mixed-initiative interaction can be enabled at as fine or coarse a level of granularity as desired (e.g., it can be enabled for only certain subtrees). The proxy-based approach is a

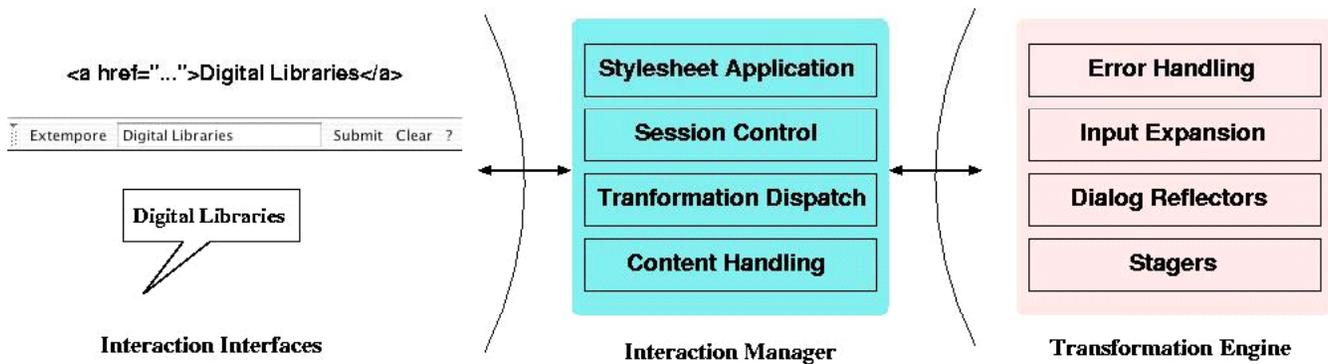


Figure 2. Multimodal DL interaction framework architecture, depicting the central role played by the interaction manager.

less configurable solution and must be targeted carefully, to avoid loss of functionality. We adopt the former approach. Once such an initial handshake is established, the interaction manager is responsible for providing concurrent access to the transformation engine, from multiple interaction interfaces.

The interaction manager, now placed in the loop, evaluates if out-of-turn interaction is possible, activates the interaction interfaces as appropriate, and mediates all interactions from this point. Notice that intermediate dialog states might not correspond to any of the DL's existing pages (especially after some out-of-turn interaction), so the interaction manager must mediate the dialog to the fullest.

### 3.2.2 Content Handling

Content handling determines the feasibility of out-of-turn interaction, caches dialog states, and ensures currency of the DL browsing representations. It also is responsible for retrieving, caching, and updating content from websites. To determine the feasibility of out-of-turn interaction, the content handler uses a simple HTTP GET request for a well-formed XML document named 'content.xml' located at the DL's root directory (e.g., this file for the website <http://www.smallbox.org> would be at the location <http://www.smallbox.org/content.xml>). This document, if present, is meant to supply the representation of the DL's browsing sequences, and when annotated with stager tags, helps initialize the dialog representation. It then is stored in a local database for fast transformation computations. It also initiates the activation of the Extempore toolbar or the SALT tags, as appropriate. From this point, the content handler is responsible for ensuring the currency of the representation and re-retrieving the file as appropriate. Notice that caching is trivially implemented by associating intermediate dialog states with content files generated over the course of an interaction. A more sophisticated solution is to develop a caching policy that exploits the structure of program transformations. For instance, if a user is requesting a partial evaluation w.r.t. 'digital library multilingual,' but the cache only contains a document that has been evaluated w.r.t. 'digital library,' we can partially evaluate this document internally w.r.t. the remaining input (namely, 'multilingual'), thus removing the need to partially evaluate from the root document. While reducing storage complexity, this approach also creates interesting design tradeoffs (including concerns about session and user security).

### 3.2.3 Transformation Dispatch

The transformation dispatch is responsible for handling communication with the transformation engine. It handles connecting to the transformation engine as well as notifying the interaction interfaces if such a connection cannot be made. (When the transformation engine receives partial input, recall that it does not know, or need to know, whether the partial input is a result of browsing or of supplying some information out-of-turn.) Finally, transformation dispatch supports the marshalling and un-marshalling of transformation requests into messages, as well as the transmission and reception of those messages.

### 3.2.4 Session Control

Session control has a responsibility that differs from most web systems' concept of session management. Notice that our notion of 'state' in a dialog is just the representation, since it succinctly summarizes all remaining dialog options. Furthermore, the transformation engine does not explicitly manipulate state and so is a purely functional entity. Thus the goal of session control is merely to distinguish one user's interaction from another. Due to our uniform handling of in-turn and out-of-turn inputs, session tokens (i.e., ten decimal digit identifiers) are required to be kept in two different places, the interaction interface and the browser itself. This two-headed session format negates the application of most modern session management packages, which are primarily concerned with tracking browsing interactions. A session manager was specifically designed to handle this issue as well as to handle the normal session management issues (e.g., back button browsing and threaded browsing).

### 3.2.5 Stylesheet Application

Stylesheet application is responsible for transforming the information returned from the transformation engine into the site's native presentation format. In addition, it must introduce suitable grammar tags into the HTML page (for the voice interface) by analyzing the remaining dialog options. Currently we support [X]HTML, WML, SALT, SVG, or any XML-based presentation format, and this is determined by the interaction interface making the request.

## 3.3 User Studies

User experiences with out-of-turn interaction are described in [17]; 25 users were given information-finding tasks and were free to use either in-turn or mixed-initiative interactions to

complete these tasks. Some of these tasks were *non-oriented* (meaning they could be performed with browsing alone, if desired) and some were *out-of-turn-oriented* (meaning they would be cumbersome to perform via plain browsing). We found that 100% of the users utilized the out-of-turn interfaces when presented with an out-of-turn-oriented task. Since the task type was not disclosed *a priori*, this result demonstrates that users are adept at discerning when out-of-turn interaction is desirable. Extempore and SALTII interfaces were utilized equally effectively.

#### 4. VISUALIZATION SYSTEM

The framework of our visualization system is component-based. Communication between components is XML-based. The system architecture is shown in Figure 3. There are three types of components: Data Source Components, Clustering Components, and Visualizing Components. The first two were implemented and wrapped into Java servlets to enable web access. The Visualizing Components communicate with those servlets via XML.

##### 4.1 Data Source Components

Data Source Components send a user query to CITIDEL and other DLs, and parse the retrieved HTML pages into XML files conforming to XML schemas we developed. Those XML files are then input to Clustering Components to be processed.

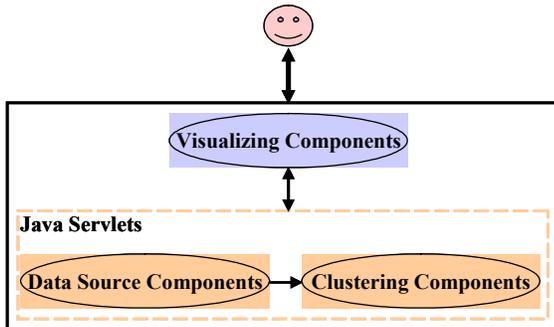


Figure 3. Visualization system architecture

##### 4.2 Clustering Component

Clustering Components are implementations of different document clustering algorithms. We developed a new clustering component and incorporated the clustering components of the Carrot2 system [31]. The interface is shown in Figure 4.

##### 4.3 Visualizing component

There are two major visualizing components. They are a hyperbolic tree of a hierarchical concept map and a 2D scatter-plot graph. The initial interface is shown in Figure 5. On the top left of the screen is a hyperbolic tree view of the ACM Computing Classification System [1998 Version] (CCS1998, <http://www.acm.org/class/1998/>). On the top right is a query box. By default, a user will retrieve results from a member (source) DL (here, ACM DL) of CITIDEL. A user also has an option to retrieve results from all CITIDEL member DLs. In the middle of the screen, there is a 2D scatter-plot graph. At the bottom, there are fields for the details, represented by way of values of various attributes of a selected document. The

visualizing components support exploration, browsing, and analysis. The following examples illustrate the types of insights afforded, illustrated in the following three example scenarios.

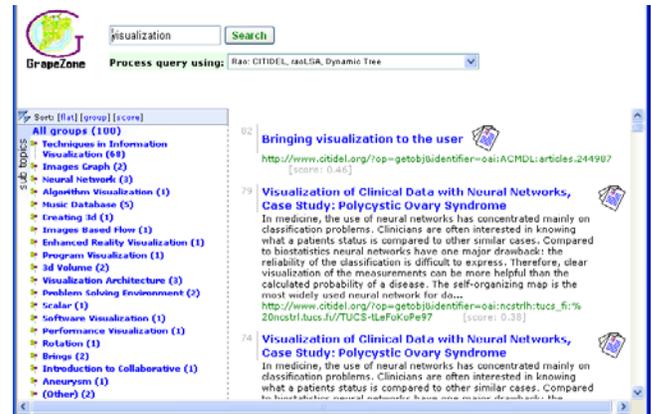


Figure 4. Clustering interface

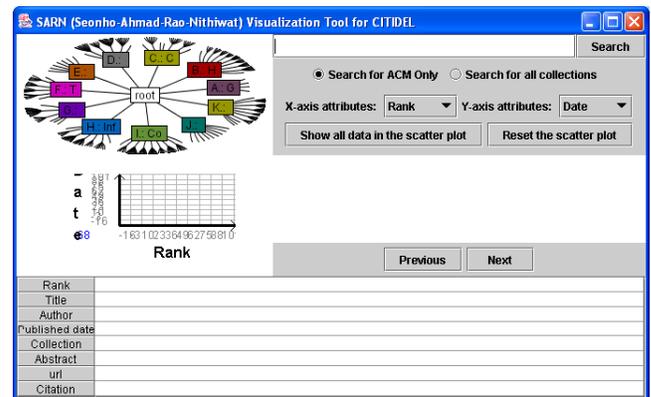


Figure 5. Initial Interface

##### Example of Insights:

1. How are the retrieved documents clustered according to the ACM Computing Classification System?
2. How are the retrieved documents clustered according to inter-document similarity?
3. Which cluster has the largest document collection?
4. To what category does the 1st ranked document belong?
5. Which document is cited most among the selected clusters of documents?
6. Which documents cite a selected document?
7. What's the most recently published paper by an author?

##### Scenario 1: Show Me the Retrieved Results from ACM DL

A user enters the query: 'Information Visualization'. By default, she gets results from the CITIDEL member DL named 'ACM

DL'. A hierarchical concept map organized by the ACM Computing Classification System then is displayed as a hyperbolic tree on the top left of the screen. Node name represents a category and a bubble attached to a node represents a document collection belonging to that category. Bubble size attached to a node indicates the size of the document collection clustered to that category. The hyperbolic tree supports 'focus+context' navigation.

After the user clicks the 'Show all data in the scatter plot' button, all the retrieved documents from the ACM DL are scatter plotted in the 2D space as shown in Figure 6. Each document is visually mapped to a dot. On the right of the screen, there is a list of colorful bars representing the categories to which those retrieved documents belong. Moving the mouse over a bar invokes animation of blinking dots in the 2D scatter plot space. Those blinking dots represent documents belonging to the category visually mapped to a colorful bar pointed to by the mouse. And those dots are in the same color as the bar and the corresponding bubble in the hyperbolic tree. A user can change the color of a bar to distinguish different categories. This will change the color of the corresponding dots in the 2D space and the corresponding bubble in the hyperbolic tree.

Dots in the 2D space can be arranged according to attributes of rank, date, and citations. Clicking a dot causes animation of the shining dot. The details of the selected document are then displayed at the bottom of the screen.

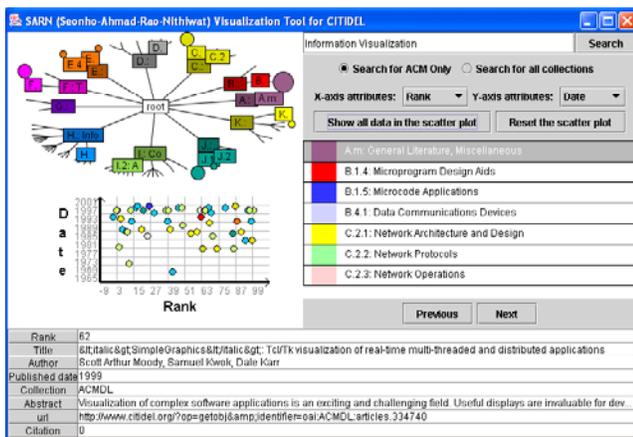


Figure 6. Visual Results of Scenario 1.

**Scenario 2: Show Me Papers by 'Chris North' from CITIDEL**

A user inputs the query 'Chris North'. She selects the option 'Search for all collections'. The retrieved results from CITIDEL then are clustered via cluster components. The clustering results are displayed as a hyperbolic tree. The user navigates the hyperbolic tree and finds a category named 'Visualization Displays' as her interest. She then clicks the green bubble attached to that interesting category. This causes all the eight documents belonging to this cluster to be plotted as eight green dots in the 2D scatter plot space shown in Figure 7. She continues to browse the hyperbolic tree and finds another interesting category named 'Case Study of the Visible'. She clicks the yellow bubble attached to the category named 'Case

Study of the Visible', which causes three yellow dots to be plotted in the 2D space as shown in Figure 8.

**Scenario 3: Show Me Papers Written and Cited by 'Edward Fox' from ACM DL**

A user inputs the query 'Edward Fox'. By default, she gets retrieved results from the CITIDEL member DL named 'ACM DL'. After she clicks the "Show all data in the scatter plot" button, all the retrieved documents from ACM DL are scatter plotted in the 2D space as shown in Figure 9. When she clicks a dot representing the document with the title 'toward a worldwide digital library', a link pointing to a dot enclosed in a square is dynamically created on demand. She then follows this link to get details of the cited paper authored by Edward Fox.

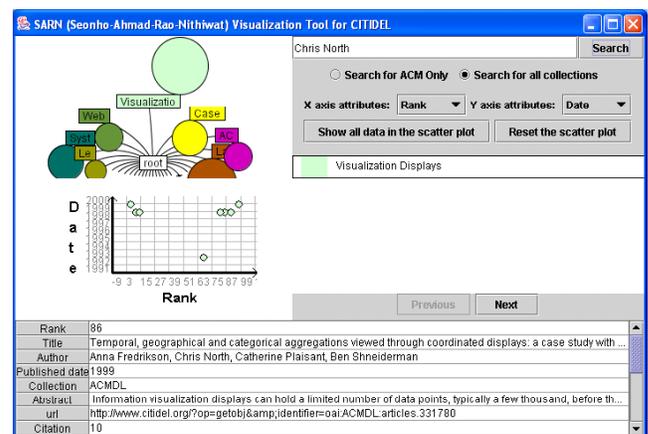


Figure 7. Scatter Plot Documents in One Cluster

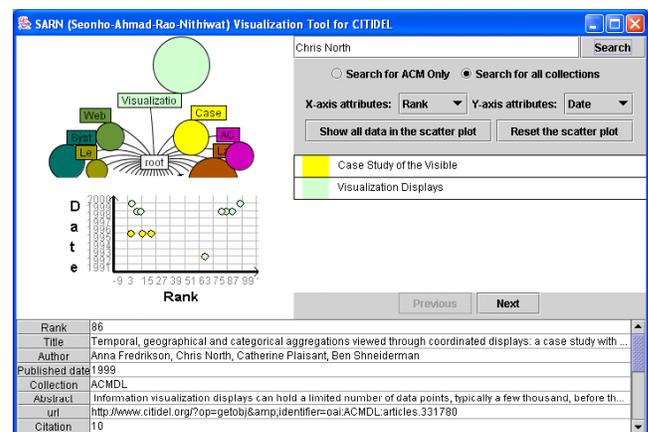


Figure 8. Scatter Plot Documents in Two Clusters.

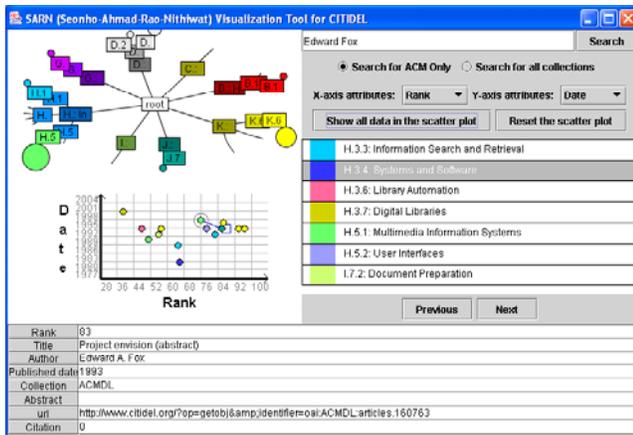


Figure 9. Show Citation in Scatter Plot Graph.

#### 4.4 Pilot User Study

We conducted pilot user studies for both the clustering interface shown in Figure 4 and our interactive visualization system. We found that less time was spent locating a given document via the clustering interface than via traditional flat lists. We asked users the last three questions of the example insights mentioned in Section 4.3, and found that it was relatively easier for them to answer the questions using our visualization system versus the original CITIDEL interface [1].

### 5. GENERAL USABILITY ENHANCEMENTS

#### 5.1 Initial User Study

To improve the usability of CITIDEL, a focused user study was conducted in late 2002 through early 2003. We had 50 respondents, which consisted of 41 students, 7 professors, and 2 others. Users were asked to perform certain tasks such as searching, browsing, and creating an account, etc. They were asked to rate their effectiveness at finding documents and other tasks. Users also were asked to provide feedback on what they found helpful or confusing about the system. When asked to provide an overall rating of the CITIDEL system, 74% rated it as 'above average'. However, many issues were discovered. Table 1 gives a summary of some of the most interesting points and how we addressed them.

#### 5.2 Discussion

One interesting point raised by users was their unfamiliarity with the classification schemes supported by CITIDEL (ACM/IEEE Computing Curricula 2001, ACM Computing Classification System [1998 version], Computing Research Repository (CoRR) Subject Areas, and AMS Mathematics Subject Classification [2000 version]). Given that few educators would be familiar with more than one of these, it is not surprising that students would find them daunting. In fact, based on browse logs, 64% of all browse events were for MSC2000, 26% were for CCS1998, with the other two schemes receiving very few browse events. The finding that MSC2000

was the most popular is surprising given that CCS1998 is CITIDEL's default classification scheme. Users can personalize their browsing experience, however, and set the default to any one of the schemes. To educate users on the less commonly used schemes, we added links from the main browsing page to an explanation of these classification schemes, summaries of each scheme, and to the hierarchies themselves.

Also, users seemed unaware of the breadth and depth of resources CITIDEL contains. To improve this, we added a 'Pseudo-Random Resource' to the main page, which randomly shows an image from an interesting resource in CITIDEL (see Figure 10).

Table 1. Summary of significant usability issues that we addressed:

Section	Issue	How it was resolved
Main	Users want a sample of what is in the digital library.	Added an image of a pseudo-random resource to the front page, that links to an interesting resource
Browse-by-category	Users are not familiar with ACM, IEEE-CS, and the various chosen classification systems.	Included more information about the classification schemes, including a link to details of each scheme from the main browsing page.
Search	Users did not understand that they could add items they had found to their binder.	Reworded and reordered the page to make this more clear.
Search	Users want to know how much of a resource is available (e.g., abstract, full-text, etc.).	Not possible to determine this at present. Since metadata points to other sites, we would have to poll these sites periodically. An extension to the OAI protocol might handle this. Left as future work.
Search	Users were unclear about the different uses of various filters, and when they were being applied.	Changed wording so that users would understand when documents were filtered due to not matching the category and when they were filtered due to the user's preferences.

A more fundamental problem is that it appeared that many users did not understand the distinction between metadata and data, and that they were unclear when they were actually in CITIDEL (working with metadata), and when they had followed a link that took them to another site (working with target data, such as resources). To help with this we gave all CITIDEL pages a consistent look and feel to give users visual clues when they were in CITIDEL and when they had departed.



Figure 10. Screenshot of part of the main page of CITIDEL, showing 'Pseudo-Random Resource'.

The above issue led to another request by users. Many users wanted CITIDEL to show how much of a resource is available, such as abstract-only, an extended summary, or full-text. For the vast majority of the resources, CITIDEL only has metadata about resources and not the resources themselves. CITIDEL provides links to the resources that are found on many other sites. There is currently no practical way for CITIDEL to keep track of how much of a resource may exist on another site, since these sites will change over time. Perhaps such information could be gleaned as part of an archiving effort, like that undertaken for NSDL by SDSC. Alternatively, perhaps an extension to the OAI Protocol for Metadata Harvesting, like the one described in [22], could be employed to periodically poll the external collections, but that is outside the scope of this project.

### 5.3 Future Work

In addition to the possible future work described above, some users said that they would prefer to browse the hierarchies via an interface similar to Microsoft Windows® Explorer. This is a style many are familiar with and would allow them to more quickly understand the hierarchies, and to see the depth of the hierarchy with just a few clicks. We will evaluate if this changing of the browsing style is worthwhile.

## 6. COMMUNITY MULTILINGUAL INTERFACE

Providing a multilingual interface is one way to expand the user population of a digital library. In our case, we wanted to allow users who are more comfortable using languages other than English to access CITIDEL. Because most of the content in CITIDEL is harvested from other digital libraries, we have little control over the language used in many resources. However, CITIDEL also allows users to add their own resources that may be in other languages and create content in the form of lesson plans, and online discussion forums. We also are planning on harvesting collections from other countries where English is not the first language (e.g., resources in Portuguese from Brazil). Thus, it is expected that CITIDEL will have many different users who might be more comfortable using other languages to

not only access the resources in this digital library but possibly also contribute their own resources to be used by others.

To support this multilingual access to CITIDEL, we decided to provide the CITIDEL interface itself in multiple languages. The initial implementation focused on providing a Spanish interface, mostly to support Hispanics in the USA. But the system here described has no restrictions in implementation that would exclude other languages and has since been expanded to support six different languages.

### 6.1 Approaches to Multi-lingual Interfaces

There have been many efforts used to translate interfaces and technical sites. Several different approaches are popular, and quite a number of tools to make translating easier have been developed. To successfully cross the language translation divide, Dilts [5] presents many suggestions for both writing clear, translatable content as well as choosing a suitable translation service. Among these are leaving proper space for translations in languages which require more space, and providing translators with definitions of computer industry jargon.

We explored three approaches to interface translation. These are: machine translation, human translation, and community-based translation. The following three sections briefly describe what these are and provide our evaluation of the quality of the translation by each of these methods.

#### 6.1.1 Machine Translation

There are a number of ways to go about providing translations of interfaces. One such way is translating interfaces with an automated translation program, though the quality of these results can vary greatly. This is not to say such systems are without some benefit. There is, however, still a long way to go before the best quality machine translation systems are readily available, and, moreover, are readily usable for specialized purposes such as web sites, which often contain computer jargon. Tucker classified machine translation systems into three categories: first-generation, second-generation, and third generation [28]. First-generation systems give rough translations, mostly based on word-to-word mappings, independent of the context of use. Second generation systems have an interlingua (language-free) approach and have transformational grammars and/or ATN-type recognizers that aid in the process. Third-generation systems have much more understanding built in, and thus produce higher quality results.

A popular example of a machine translation system is AltaVista's Babel Fish Translation [1] in which users may receive translations for words, sentences, or paragraphs by entering these directly, or translating a full web page by providing a URL. Babel Fish is based on a product by Systran [25]. It is a first-generation translation system, and is therefore rough grammatically, with no semantic understanding capabilities of structure and connections of the text being translated. However, it does afford quick and free translation.

#### 6.1.2 Human Translation

Another approach for translation is for the designer or administrator of a site to translate the interface. The problems that can arise in this approach are discussed well in

“Internationalizing Online Information” by Merrill and Shanoski [13]. It is common for developers to either translate their own sites or hire special translation teams. Sites like CNN and Yahoo take this approach. Often this results in translations in good time and of good quality. However, it is a costly approach especially when site content quickly changes.

### 6.1.3 Community-Based Translation

A third option, and the one we followed for CITIDEL, is to appeal to a site’s user-base and allow this community of volunteers to translate the interface. This approach has been successful in translating online newsletters (e.g., TidBITS [26]), desktop applications (e.g., OmniWeb [16], Translation Project [27]) and even entire websites (e.g., ‘Google in your language’ beta translation initiative [6]). The key to this approach lies in the willingness of the online community of users to volunteer their time and expertise to create quality translations.

### 6.1.4 Evaluation of Approaches

We conducted a brief evaluation of the three approaches above, to assess the quality of the translation. The details of the evaluation [12] are beyond the scope of this paper. We present a brief summary of the findings here. The benefit of this particular study was to have a principled way to evaluate the quality of the resulting language from the three approaches. The pages that were evaluated were all of a technical nature. They were translated by automated programs, by developers, and by community.

We developed a rubric and used it to evaluate a group of pages. A maximum score of 13 was possible; the higher the score the better the translation. The quality of the translation took into consideration: language structure, vocabulary (cognates, meanings, and spellings), style, and message. The following pages were evaluated:

- Commercial website (Apple’s web page about their Mail program that is included in OS X) in English from their US web page and in Spanish from their Latin American page. These Spanish pages were translated by Apple’s internal personal.
- Technical online newsletter page (TidBITS) in its original English form and the same page translated by a community of volunteers)
- Two English CITIDEL pages.

We also translated all pages to Spanish or English (depending on the original form) using AltaVista’s Babel Fish. The results of this evaluation were as expected: human translation and community translation produced higher quality translations than machine-translations (for the particular software used).

None of the pages translated by Babel Fish received higher than a 2. It is worth noting, however, that the pages translated via Babel Fish for a second time, back to the original language, scored higher than their first translation. That is, pages translated to Spanish and then translated back to English produced higher quality translations (scores of 8 and 4) than the original translations. Upon closer inspection of these pages, we noticed that the translated page retained much of the structure of the source language. The result of translating back into the

source language is that the resulting structure is appropriate because it is the structure from the source language.

The pages translated by the community (TidBits) or by a development team (Apple’s Mail page) received perfect scores. In the case of Apple’s page, the translation is even better than is possible with the machine-translation because they made use of images that contain text in them and these cannot be translated by a system like Babel Fish. Furthermore, this site used some marketing slogans regarding the Mail’s Junk Mail filter that could only be translated properly with human intervention. For example, the Spanish (“Correo basura a la basura”) and English (“The end of junk mail”) versions of the slogans were very different, though conveying the correct message in both languages.

From this simple evaluation, it is clear to see that the translation services provided by one of the common services available on the web do not produce enough quality to trust the translation of the interface for CITIDEL.

## 6.2 Design of the Translation Center

The main goal of the translation center (see Figure 11) was to create a center that could foster the creation of an online community helping with translation. An online community has many definitions; one that we will use for the following discussion is from Preece [20]: In general, an online community is a computer-supported place where people interact socially with a common/shared purpose and voluntarily following a series of norms, protocols, and practices.

The design of a user interface that would foster an online community should go beyond providing user-tasks for accomplishing the basic functionality the computer application is intended to accomplish. It should provide functionality that increases the sense of membership in the community, functionality that keeps members of the community informed about what others are doing, and enforces the will of the community over the individual needs/desires of particular users without imposing too many norms/protocols.

To that end, we studied online communities, and conducted several online surveys to identify the functionality that was needed in our translation center. We identified and implemented 23 different tasks, covering five different categories: informative, assistance, community, encouragement, and task-oriented. We put as much effort into building functionality that supports the online community as we did into building functionality that supports the translation task.

### 6.2.1 Architecture

The Translation Center was build using Java Server Pages. The focus of the software architecture was to provide a way to translate CITIDEL pages without changing the layout of the interface. We believe that the architecture could be easily extended to support language specific layouts, but in our initial design that was considered beyond the scope of our project.

Each page is formed from an HTML layout and a series of database retrievals for “items”, which are words or phrases used in the interface. The key to retrieving each translation is a unique number associated with each English “item” and a language tag representing the language being viewed. The

whole CITIDEL site then becomes a series of HTML pages with embedded JSP code to retrieve the particular words to be used. The length or complexity of the “items” depends on the content of the page, and not on the translation center.

The Translation Center works independently of CITIDEL, with a common backend of “items” and translations. The Translation Center provides the functionality that allows volunteers to retrieve “items” to be translated and provide translations, as well as rating different translations for quality and correctness.



Figure 11. Screenshot of main page of the Translation Center.

### 6.2.2 Interface Design

Figure 11 shows the main page design of the Translation Center. Volunteers must register with the center before they are allowed to translate items from the CITIDEL interface. The main tasks that volunteers do are to translate items and to rate other item translations.

A priority of translation is calculated for each item. Those items that have no translation are given high priority. The rating of an item identifies good translations and poor translations. As items can be re-translated many times, each translation has a separate rating and the one with the highest rating is displayed on the CITIDEL page. Additionally, shared vocabulary tools and conflict resolution tools are provided to assist in deciding which version appears. Also each CITIDEL page has a link at the bottom that allows CITIDEL users to rate the quality of the overall page translation. Overall, the goal is to make it very easy for volunteers to select an item to translate which will have maximum impact on the site.

We conducted a multi-step evaluation of the Translation Center. The details of the evaluation are beyond the scope of this paper. Briefly, we evaluated the interface of the translation center itself, the sense of community that volunteers perceived, and the quality of the translated page. Overall, our system was rated very successful in its design and implementation. In a limited testing environment without the needed community to provide checks and balances, one half-translated page was rated a 5 on

the 13 point scale. This far surpasses the rating of translations done by machine translation, and is well on its way even at an early stage to the perfect score achieved by the other community translation projects. We are now ready to deploy it together with CITIDEL and assess how well it helps a community of volunteer translators develop.

## 6.3 Future Work

To truly internationalize a website, it not only needs to be readable to users of another language but understood. In many cases, it is not simply enough to translate words into another language. Languages with scripting systems that read from right to left, for example, should have layouts and menus adjusted accordingly when translated from English. Furthermore, as Marcus and Gould suggest, interfaces for countries of different cultures should look and feel very different [11]. Although our implementation supports having multiple layouts, our Translation Center currently only supports translation of content keeping a single layout. As the international community of our system grows, we will be adding functionality to the Translation Center to support layout changes on a language-by-language basis, based on community desires and needs.

## 7. CONCLUSIONS AND FUTURE WORK

This paper has described four kinds of enhancements to the usability and functionality of CITIDEL, a large DL effort to promote teaching and learning in computing and related areas. Each type of enhancement has been designed, implemented, and improved through user studies. Our modular architecture has made that possible, and should allow similar enhancements to be applied to other DLs with minimal effort.

We are continuing our research and development efforts with CITIDEL on many fronts, including more complex visualizations, inclusion of concept maps in multiple languages, and more powerful interaction techniques.

## 8. ACKNOWLEDGEMENTS

This research work was funded in part by the NSF through grants DUE-0136690, DUE-0121679 IIS-0086227, and IIS-0136182. We would like to thank ACM, DBLP, and others for sharing their content and classification schemes with us. We particularly want to thank Aaron Krowne, now at Emory University, for his support of prior work on CITIDEL. We also thank colleagues in the Digital Library Research Lab at Virginia Tech, as well as colleagues at Villanova University, Hofstra University, Penn State University, and the College of New Jersey for their useful suggestions.

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