Personal and group spaces: Integrating resources for users of digital libraries

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Abstract

This paper presents an approach to integrate highly diverse resources available in digital libraries via personalizable interfaces and virtual collaboration areas. Digital libraries comprise vast digital repositories and a wide range of services, user environments and interfaces, all intended to support learning and collaborative research activities. We are developing a distributed digital library for which services and interfaces include, for example, mobile agents for federated information retrieval, recommendation agents, 3D visualization aids, and access to digital documents that support specific courses and projects. The diversity of these interfaces, plus the volume and dynamism of the digital library's underlying collections, result in a complexity that has the potential to make the digital library unwieldy for the user. In order to assist users in dealing with this complexity, we have designed environments, termed *personal* and *group spaces*, which provide users with means to access and control all available resources in a uniform fashion from a single vantage point. We discuss our design and development experiences as well as initial usage results.

Keywords: *personalized interfaces, collaborative interfaces, digital libraries, personal spaces, group spaces, agents.*

1. Introduction.

The systems we have come to know as "digital libraries" are not really libraries in the usual sense. The abstractions of *content* and *services* that generally describe physical libraries have been used by researchers to convey some of the functionality enabled by digital libraries, but this metaphor does not even suggest the major differences that the introduction of a new medium entails. In addition to a new substrate, digital libraries comprise new information units and genres, allow for multiple novel organization schemes, and make diverse browsing and searching mechanisms possible. Users of digital libraries require new skills, new tools and new interfaces to cope with the complexity of such a diverse system and to fully exploit its potential.

This paper analyzes some of the major problems faced by users when using collections and services provided by digital libraries and presents an approach for the integration of digital library resources which is based on the concepts of *personal* and *collaboration spaces*. We posit that users should have at their disposal means to create virtual areas within the digital library in which they (or their agents) can place information objects that are relevant to their interests and ongoing tasks. We refer to this sort of virtual place as a personal space. Additionally, digital libraries should also provide users (usually working remotely) with virtual places where they can meet to discuss objects and topics of interest and to work

collaboratively on group projects while maintaining the capability to access materials in digital collections. We refer to this second category of virtual place as a group space.

Our group has been conducting research in the area of digital libraries and has produced advances both in the construction of digital contents and in the provision of services for users in the context of a distributed system architecture. We have implemented and deployed various architectural components which are available to a wide user community. In this context, we have designed and implemented two versions of personal spaces and one of group spaces. We report our design and development experiences in this particular area of our digital library.

The remainder of the paper is organized as follows: Section 2 elaborates on our digital libraries effort focusing on human-computer interaction issues, architectural components and interfaces and services to be integrated. Next, we present the design rationale for personal and group spaces in Section 3. We discuss prototypical implementations for our design in Section 4 and qualitative evaluations and usage results Section 5. We briefly review projects elsewhere that are related to our work in Section 6. Finally, we discuss the status of our project as well as ongoing and future work in Section 7.

2. Digital Libraries Context

Our group has developed a system architecture for a digital library that addresses the needs for information management, communication and collaboration among a highly distributed community of users [Sánchez and Leggett 1997]. We have aimed to build both a practical, functional digital library and a testbed for research of open issues in the field, including aspects of personalized and group interfaces, collaborative work and information visualization. We refer to our digital libraries initiative as "University Digital Libraries for All", or U-DL-A.

2.1 U-DL-A components.

The realization of our digital library has called for research and development efforts in three major areas: building content, designing components to provide general infrastructure (such as information retrieval services, multimedia management and agent essentials) and user interfaces and environments. With regard to digital contents, we have made progress in the construction of collections of digital theses, special collections from our library and university publications. Our advances in the area of general infrastructure include a distributed framework that integrates services and interfaces, with implementations using KQML, CORBA and RMI [Barceinas et al. 1998; Cocoletzi 2001] as well as components implementing various popular information retrieval mechanisms. Finally, in the area of user interfaces and collaboration environments, our work has resulted in various access and visualization mechanisms [Sánchez 2001]. Given the strong relationship of these components with the work presented in this paper, we provide some additional details about them in this section.

UVA. U-DL-A Visualization Aid (UVA) is a component of our digital library that allows users to visualize large information spaces that are organized hierarchically as 3D trees [Proal et al. 2000]. UVA has been tested and has received good reviews when used with collections

that classified according to the schema of the US Library of Congress and other domain-specific taxonomies.

TD (Digital Theses). Our library is now providing means to store and retrieve the theses produced by the university's graduating students. We offer guidelines for students to produce TD-compliant digital documents, mechanisms to convert from various word processing formats into our TD data model, and a wide range of access and retrieval options.

Zeus. We also have developed an environment for collaborative revision and annotation of digital theses [Fernández et al. 2000a]. This is an asynchronous, role-aware interface, highly personalizable system component that allows theses advisors and committee members to review and annotate digital theses via user-defined conventions.

Viajerus. We are collaborating with other digital library efforts in different institutions. In order for our users to benefit from this collaboration, we have devised mobile agents that attend to user queries and visit digital collections at our partner's libraries and gather information in a transparent fashion [Chevalier et al. 2001].

SyReX. Users of U-DL-A's digital library can receive content-based and collaboratively generated recommendations about relevant information resources via this software component [Ramírez 2001].

RDU (U-DL-A Digital Reserve). This component provides access to digitized materials that are traditionally available at the Reserve section of academic libraries. Users have priority access to materials made available for their courses or research projects. Materials may be viewed on graphical computer displays and searched over according to various criteria [Rodríguez 2001].

2.2 Aiming for seamlessness

One distinctive element of our work in digital libraries is our view of information and collaboration spaces as comprising both the digital and physical realms. We believe the needs posed by scholarly activities can be best satisfied if traditional resources as well as the novel digital facilities are accessible to users at any given time in a seamless fashion. In this regard, we have been integrating traditional on-line catalogs and user services (such as lending materials, selective information dissemination and other notification services) into our new developments. As can be expected, software components such as UVA, SyReX and RDU consider that both digital and physical resources should be accessible to users.

Even though each software component may facilitate seamless access to some library resources, the diversity of such components as well as the size and dynamic nature of digital collections and user communities have the potential to make the digital library a complex and unwieldy environment for end users. Means are needed to ensure that individual users have access to exactly the resources they are entitled to according to their roles, needs and preferences. Providing more than a user needs unnecessarily increases the system's complexity and the user's cognitive overload. On the other hand, limiting access excessively would result in system under-utilization (and user frustration). The needed compromise should be the result of eliciting and addressing every user's needs and preferences.

Digital library users typically need to work collaboratively. More often than not, a given user belongs to more than one regular group of users. It is also possible that library resources are disjoint for every group a user belongs to, or that some materials need to be used in several work groups. Thus, for example, a user may participate in a class discussion for which she is the instructor or facilitator and also in a technical committee that is reviewing a paper submitted to a conference. For her class, she may suggest a reading (available at the digital library) which happens to be, say, a missing reference in the paper being reviewed by the other group in which she participates.

The work described in this paper aims to advance along these lines: facilitating the creation and maintenance of personalized areas (which we call personal spaces) that integrate resources relevant for a given user, and making it possible for users to seamlessly move from personal to work group areas and between various group areas (which we call group spaces).

3. Personal and group spaces.

In the context of a digital library, we define a *personal space* as a virtual area that is generated, owned and maintained by a user to persistently keep resources (objects, agents, etc.) or references to resources which are relevant to a task or set of tasks the user needs to perform in the digital library. Personal spaces may thus contain digital documents in multiple media, personal schedules, visualization tools, and user agents that have been delegated various tasks. Resources within personal spaces can be pre-assigned according to the user's role. For example, a graduate student would have access to course-specific reserve materials, visualization tools and interfaces to upload thesis chapters for revision by a committee. Agents may be available for recommending library materials that are relevant to the thesis and the personal space could be enriched by the agent's suggestions.

Similarly, we define a *group space* as a virtual area in which library users can meet to conduct collaborative activities synchronously or asynchronously. *Explicit* group spaces are created dynamically by a group leader or facilitator who becomes the owner of the space and defines who the participants will be. *Implicit* group spaces can be generated automatically when a number of users have been detected to have similar user profiles or interests around a given topic or task. In addition to direct user-to-user communication, users should be able to access library materials and make annotations on them for every other group participant to see.

Ideally, users should be able to move seamlessly (and carry digital library materials with them) between personal and group spaces or among group spaces to which they belong. Figure 1 illustrates a system with four users (each with one personal space, P1-P4) and two group spaces (G1, G2). Each personal space includes a number of library resources (Ri's), some also included as part of one or more group spaces. For example, resources R4, R5 and R8 in personal space P2 have been carried to group space G1 to be shared with the user who owns P1. Moreover, resource R8 is also being shared through group space G2 with the users who own personal spaces P3 and P4. It can be noted also that all resources in personal space P4 (R12 and R13) are being shared with all other users via group space G2.

We can also regard this scenario as involving only three users, one of which has defined two personal spaces (say P3 and P4) to handle resources R9-R13 and sharing some of the resources in P3 and all resources in P4 with the other users via the G2 group space.

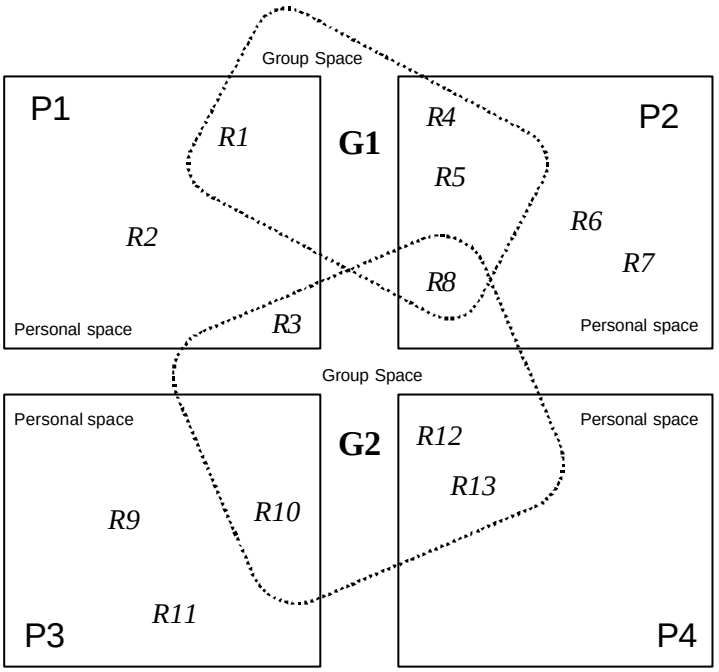

Figure 1. Four personal spaces and two group spaces
(P_i = Personal Space; G_i = Group Space; R_i = Library resource).

For the sake of clarity, in Figure 1 we have considered only disjoint resource sets for each personal and group space. It may also be the case, however, that a given resource is referenced in multiple personal or group spaces.

Basic functionality required for personal spaces include the capabilities for viewing, launching and monitoring library services, agents and applications. As for group spaces, they should provide users with means to easily become aware of users and resources that are present in a given group space at any time, as well as mechanisms to communicate with other users and make annotations on library resources. Naturally, there should also be means to move from personal to group spaces and to carry materials from

4. Implementation

We have produced prototypical implementations of the personal and group spaces concepts to provide a homogeneous interface to the various user services and environments described in Section 2.1. We based our designs on the well-known *room* metaphor [Greenberg and Roseman 1998; Henderson et al. 1986]. Personal spaces are thus conceived as rooms that every user may configure by defining physical characteristics (color, furniture, layout) and by adding library resources that are used frequently or support user tasks. We also have emphasized the role of every user in our interface design [Shneiderman and Plaisant 1994]. When users register to access the digital library, they specify the role(s) they will be playing in the system. Typically, a user selects or is assigned a combination of the various existing roles: graduate or undergraduate student, researcher, full-time or part-time professor, librarian, administrative staff, or system administrator. The initial room configuration is determined by the user's role(s).

Figure 2. The interface of MiBiblio

4.1 MiBiblio

Our first prototypical implementation of personal spaces, which we termed *MiBiblio* [Fernández et al. 2000b], was made available to users as Java applets that could be downloaded and run at the client level. Figure 2 illustrates the interface of MiBiblio. The idea is straightforward: Users may configure their personal space by changing a room's physical characteristics and placing book icons (representing library resources) into bookshelves that can be added and moved around at will. Drag-and-drop functionality can be applied practically to any element in the interface. The figure also shows icons for mobile search agents (owls) and recommender and reference librarian agents (animistic books). Pull-down menus include options for adding or removing elements from a room, associating library resources with icons, and adding or removing rooms from a personal space. New elements can be added by specific user actions or as a result of agent recommendations or search processes.

4.2 MiStudio

Our primary target community of users includes some 8,000 students, professors, researchers and librarians and administrative staff at our university. Given that not all the available computer facilities (mostly SunRay clients and Macintosh personal computers) necessarily comply with the requirements imposed by MiBiblio, we developed a "lighter" version of the interface, which we termed MiStudio.

Figure 2 shows a typical configuration of the MiStudio interface. Although the graphics used for this representation are of higher quality, the elements in the interface are pre-defined and

the user can only modify the associations between specific objects in the room and library resources. MiStudio is based on dynamic HTML pages, which implement the functionality required to launch applications as needed by the user.

Figure 3. The Interface of MiStudio

4.3 EGA

We also have implemented a prototype for group spaces which we refer to as *EGA* (Spanish acronym for Learning Group Spaces). Our current version of EGA implements explicit group spaces (as per our definition in Section 3): any user of the digital library may create (and subsequently own) a group space and send invitations to users who are members of a team or who are potentially interested in a particular discussion subject.

Figure 4 illustrates a session of five users who have started a discussion in EGA. Upon entering the "room" representing the group space, every user sees a picture of himself, images of the other users currently logged in, as well as icons that represent library resources (in the bookshelves at the bottom), which have been brought to the room to support the discussion. Users participate in the discussion by posting their comments via a text interface and pointing to digital library resources. Users can make annotations on shared materials and see other users' annotations. The entire discussion can be saved so latecomers may join a meeting and get up to speed quickly, or the discussion may be suspended and retaken by the group at a different time.

In EGA, users can drag their own images and drop them near another user, group of users or library resources. This is intended to reflect positions in a discussion in a visual fashion that can be perceived by all group participants. Alternatively, new rooms (or sessions) may be created to include different sets of users for addressing sub-topics or new discussion topics.

5. Evaluation

Our implementations of personal and group spaces have undergone various usability and performance tests with encouraging results. We have focused initial tests to our main target communities: college students, professors and administrative staff. Test participants have included over 20 library personnel, ten faculty members, 20 undergraduate students and five

graduate students. For our tests we have used mainly our collection of digital theses and the online catalog of our physical library, which comprises over 230,000 physical volumes.

Figure 4. The interface of EGA – Learning Group Spaces.

In addition to usability inspection tests, we have been observing users experiment with the prototypes. With only minimal initial guidance, users of MiBiblio have been able to personalize their information space by creating rooms, changing their appearance, and more importantly, by gathering library materials (mostly theses) and references (online catalog entries) and placing them in bookshelves. From their personal space, users also have been able to open digital documents and launch applications such as UVA and Zeus, and to generate and monitor instances of the SyReX recommender agent. MiBiblio has been in use for about nine months. However, some of the services and applications described in this paper have become available more recently.

As stated earlier, MiStudio was developed in response to infrastructure limitations to support the tools used in MiBiblio, as many of our target users have Macintosh computers and the required version of the Java plug-in is not available for this platform as of this writing. Users who have tried both alternatives have preferred MiBiblio's highly personalizable functionality, but have rated MiStudio favorably with regard to its performance. MiStudio has been available for about only one month and hence a more formal comparative evaluation has yet to be undertaken.

As for EGA, we have observed how it has been used formally as a means for supporting a graduate course and also as an environment for the discussion of project ideas. Users have been able to start new group spaces easily and to join existing groups or ongoing discussions

without any significant problems. Minutes (saved discussions) have been used extensively to record discussion results or just as a mechanism to suspend collaborative work to be resumed at a later time. Digital theses and book references have been carried to group spaces and users have been able to make annotations and examine their contents when suggested by other group participants.

In general, users of MiBiblio, MiStudio and EGA have found the interfaces attractive and intuitive. In response to explicit surveys, over 80 percent of the users considered personal and group spaces useful and a unifying view of library resources. In all cases, close to 70 percent of the users were able to carry out the tasks they were asked or intending to do.

6. Related Work

There is a significant amount of work that has nurtured, or has been developed in parallel to, our notions of personal and group spaces. In the area of personalization of information spaces, DLITE [Cousins et al. 1997] introduces the concept of personal *workcenters*, in which users can perform tasks and access distributed information in a transparent manner. Among the differences with our work we can mention our emphasis on the integration of physical and digital resources and the incorporation of agent representations in personal spaces.

The impact of "one-stop" library portals on libraries, information providers and users, from the organizational, cultural and learning perspectives is discussed at length by Lakos and Gray [2000]. An example of library portal is Cornell University Library's *MyLibrary*. This project comprises two main services: MyLinks, a tool for collecting and organizing resources for private use by a patron, and MyUpdates, a tool to help scholars stay informed of new resources provided by the library. This is an important effort in personalizing a commercial online catalog. Our emphases on digital contents, graphical interface components and agent-based interaction are distinguishing aspects of our work with respect to Cornell's.

An architectural proposal for personalized information environments that is more oriented to digital libraries is presented by French and Viles [1999]. They consider personalized collections built from centrally maintained indices or indices constructed by a client from distributed repositories. In our architecture, we also consider the participation of mobile agents that travel through a federation of digital libraries so users may transparently access distributed repositories from a uniform interface.

Work aimed at supporting group activities is abundant in the CSCW/groupware literature. Our concept of group spaces particularly has built upon advances in group awareness, annotation, and synchronous learning spaces. In particular, the awareness mechanisms in our implementation of group spaces have been used before in early collaborative environments such as the Grove [Ellis et al. 1991] and Sasse [Baecker et al.1993] group editors.

7. Ongoing and future work

As our digital library work becomes more widely used both within our community and among external users, we are continually receiving feedback, adapting our software development plans and finding new application areas. We are currently working on a better integration of personal and group spaces. In upcoming versions of MiBiblio and MiStudio, "doors" will appear in rooms representing personal spaces for each of the available group spaces. Users

will be able to exit a personal space to enter a specific group space by traversing the appropriate door. We have defined various formal tests of the prototypes, particularly in the areas of usability, robustness and scalability. We are currently in the process of applying these tests.

One feature of EGA that has not been experimented with more fully is the capability of group participants to move their individual images around the group space to create user clusters that reflect positions in a discussion. We intend to encourage users to take advantage of this facility and report results in the near future. We also plan to explore the definition of implicit group spaces to supplement EGA's current functionality. Our own previous work in a related project [Sánchez et al. 1998] will be adapted to our ongoing digital libraries initiative. In this area, we are currently exploring the use of videoconferencing as a way to widen the relatively limited communication channel provided by our text-based conversational component. Finally, we are working on the definition of an appropriate upper limit for the number of participants in group spaces, as in some cases problems have been observed when the number of users grows.

From our results thus far, we believe personal and group spaces are a promising approach to the integration of highly distributed, heterogeneous information spaces. Our design and prototypical implementations show that our approach may effectively help users in coping with the size, complexity and dynamism of digital libraries.

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