Guest Editor's Conclusion: Reflections on the Evolution of Library Computing

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As evidenced by the *IEEE Annals of the History of Computing*'s two special issues on library applications of computing, library computing activities were generally motivated by two major factors. The first was the improvement of internal work processes, which were often regarded as back-office functions. These improvement efforts were meticulously described in the articles on automation efforts at Toronto and the University of Illinois at Urbana-Champaign as well as Williams' article on punch cards in the April–June issue. The other factor was the development and provision of new or improved services to library constituents, as the articles in this issue of *Annals* exemplify. These factors are of course not mutually exclusive: Often, efforts directed toward an improved workflow resulted in direct or indirect facilitation of services.

Dizzying advances in both computing power and network capacity, combined with the increasing availability of networked resources, have provided a range of new activities for libraries in the period following that covered by the articles in these special issues. While a brief account here can in no way do justice to the range and scope of such efforts in the past several years, I hope to illustrate that libraries continue to be early adopters and developers of technology. The new developments can be attributed to the factors noted earlier or to what Cliff Lynch has identified as the third phase of information technology as applied to libraries—"the availability of content in electronic form."[1]

As Dennis Reynolds pointed out in his introduction to *Library Automation: Issues and Applications*, "applications of library automation must be viewed within the context of the broader issues surrounding them in the external environment."[2] For higher-education institutions and the libraries that serve them, the current context is one of rapidly changing technological, organizational, and social dynamics, such as

- advent and growth of virtual classrooms and remote students,
- increasing availability of and the concomitant demand for networked electronic resources,
- increasing costs for these networked electronic resources, and
- reenvisioned scholarly communication and publishing processes.

No single aspect of these phenomena has been the sole motivator for the initiatives of the past decade. Their collective emergence, however, along with underlying technological advances has driven a range of new developments in library automation that are perhaps even more profound than those historical developments discussed in these special issues of *Annals*. The impact of increasingly available electronic resources, to consider just one of the previously mentioned trends, illustrates the effective range and diversity of these phenomena.

Using vendors and adapting within

Acquiring, cataloging, and delivering resources is at the heart of libraries' business. Historically, libraries have dealt with physical materials; consequently, libraries have become reasonably adept at developing and providing services tailored to these physical objects.

Networked resources, whether locally created or vendor licensed, represent a complex and detailed microcosm of libraries' challenges. Technology has provided the means for networked resources and will no doubt provide solutions as well. Technology has also afforded opportunities to revisit, for example, scholarly communication and publishing. But what is

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evident is that the impacts reach beyond technology and affect library organizations in myriad ways.

I am, of course, referring specifically to materials that libraries acquire through license agreements and which are then delivered via the network. Libraries are also dealing with digitized resources in the form of either copies of print works from their collections or materials referred to as "born digital," which have no print predecessor or companion. Although there are overlapping issues related to both types of resources in terms of discovery, preservation, and archiving, *electronic resources*—unless otherwise stated—refers to those journals, databases, indexes, and so on that libraries acquire access to through license agreements.

Integrated library systems that have evolved from those discussed in the April–June issue of *Annals* have proven inadequate for managing electronic resources. Initially developed to manage the acquisition and use of print materials, these systems' ineffectiveness in dealing with resources not physically a part of the library's collection—and which in many cases libraries do not own—has became readily apparent. While libraries have attempted to "fit" electronic resources into legacy systems, the attempt has met with generally limited success. The dynamic nature of electronic resources significantly differs from the printed books and journals with which librarians have long been accustomed to working. Changes in these online resources can have numerous and serious consequences for library staff and patrons. Changes in provider can result in a new URL for the resource, which in turn requires cataloging and/or Web page changes. A new search interface might be required, driving the need for special training of staff and users. And changes in the delivery mechanisms underlying electronic resources may require new or additional systems for IT staff to implement and manage.

Vendors in the integrated library systems market are developing new modules and so are trying to address libraries' problems associated with licensed as well as with digital resources. At the same time, a growing number of institutions have undertaken in-house development of electronic resource systems in an effort to address problems both of internal workflow and resource access.[3] The systems that vendors are developing supplement existing integrated systems in two critical areas:

- Web interfaces being developed as part of the overall system, and
- the management features providing detailed information about usage and renewals.

The work involved in dealing with licenses and their related negotiations and renewals have, in a growing number of institutions, resulted in creating new staff positions.[4] New procedures in cataloging departments facilitate the inclusion of Web addresses for digital resources in catalog records for integrated systems. This inclusion of Web addresses is for many institutions a policy-driven attempt to continue to rely on the online catalog as the central mechanism for locating library resources. At a time of both new and increasing demands on existing library staff, the profession continues to debate the benefit of this work. Such debate is due at least in part to a growing awareness of the evolution of research or information seeking practices on the part of library constituents.

The World Wide Web's increasing ubiquity and the availability of browsers such as Google have created new approaches to resource discovery that lessen the online catalog's centrality as the sole or primary research resource. Many students or scholars now rely substantially on Web-based resources and have a growing familiarity with and preference for search engines and Web-based directories like Yahoo (http://www.clir.org/pubs/issues/issues27.html #national). The shift in search behavior combined with the increase in electronic resources being acquired by libraries is prompting libraries to offer a single or consolidated interface to facilitate resource discovery and access. Vendors of integrated library systems are introducing such functionality in their new products. Two of these are MetaLib (http://www.exlibris-usa.com/metalib/index.html) from Ex Libris and ENCompass (http://encompass.endinfosys.com/) from Endeavor Information Systems. Other companies such as MuseGlobal are marketing a suite of search products under the trademarked name of MuseSearch, (http://www.museglobal.com/Products/index.html) providing the means to search across an array of resources with a variety of protocols such as HTTP and Z39.50.

Metadata and Dublin Core

Another development related to the increasing number of Web-based digital resources has been the focus on metadata creation by libraries to facilitate discovery, access, management, and administration of such resources. For example, the Dublin Core Metadata Initiative (http://www.dublincore.org/) resulted in international concurrence on the definition of 15 key ele-

ments (referred to as DC or Dublin Core) for describing digital objects in order to enhance discovery. Subsequent activities have focused on developing metadata dealing with technical aspects of digital objects to facilitate their ongoing management. As previously mentioned, libraries' efforts to develop electronic resource management systems have resulted in ongoing discussions concerning the need for a common set of metadata for these systems. By mapping the MARC standard (which Sally McCallum wrote about in the April–June issue) to the Dublin Core, libraries can convert to and from Dublin Core. Moreover, the Library of Congress continues to lead a number of library standards development efforts.

With increasing numbers of Dublin Core records in existence, attention has shifted to finding ways to create an awareness for the growing number of digital resources these records represent, which are often items created and stored by libraries in databases lacking direct Web access. A group of initiatives funded by the Andrew W. Mellon Foundation[5] in 2001 are utilizing the metadata harvesting protocol of the Open Archives Initiative (http://www.openarchives.org/) in one such attempt. In 1999, the Open Archives Initiative evolved from efforts to enhance communication about research findings for the purpose of advancing scholarly communication and publishing. At that time, an archive of electronic materials on physics was maintained at Los Alamos National Laboratory. A simple protocol based on the Dublin Core as the metadata set was developed to facilitate discovery of the resources in the archive.

The metadata harvesting protocol extends the initial protocol by allowing for the inclusion of community-specific metadata sets along with the Dublin Core for purposes of discovery. Institutions serve as data providers by making the metadata created about their digital resources available for a process known as harvesting. Service providers (harvesters) who have collected the metadata provide a search interface to enable users' discovery of and access to the harvested resources. The protocol initiatives under way thus far range from the University of Illinois at Urbana-Champaign's cultural heritage harvester to a recent project undertaken by Indiana University, Johns Hopkins University, and the University of California at Los Angeles to build a harvester for sheet music.

Other resources

As noted, libraries continue to acquire an increasing number and type of networked electronic resources in a mix of indexes, databases, data sets, and full text. The path between a citation discovered within a database or index to a copy of the cited work can be convoluted. Often researchers may have to conduct subsequent, refined searches to determine if the institution has access to a resource in which the cited work exists. Eventually they may succeed, but frequently such searches result in a request to an interlibrary loan department for a copy of the article or a document delivery request for a resource that is available online. The OpenURL framework developed by Herbert Van de Sompel and his colleagues at the University of Ghent in the late 1990s has established a means of moving among citations contained within the ever-growing collections of online materials in the form of services known as reference or citation linking (see OpenURL articles written by Van de Sompel for *D-Lib Magazine* at http://www.dlib.org/). Modules such as Ex Libris' SFX and Endeavor's LinkFinderPlus offer this service in either standalone form or as part of an integrated system.

The introduction of and growth in networked resources (both licensed and locally created)—just one example resulting from and driving the use of technology—clearly illustrates the extent of the impacts on libraries. An analysis of the increased distance-education opportunities or a more detailed look at changes in scholarly communication would reveal a similar range of impacts.

Looking ahead

The articles in these two *Annals*' special issues on the history of library automation have illustrated the transformative effects of the introduction and development of computer technology into libraries through the 1970s and 1980s. As we have attempted to show through the focus on effects of networked electronic resources, a similarly broad look at the 20 to 25 most recent years would serve to further underscore the extent of this transformation. One hesitates to make predictions, but certainly there are inklings of what the library might look like—or perhaps more importantly what library services might look like—in 2025.

Current development efforts of consolidated search interfaces might be extended through the addition of layered services to record searches for reexecution on a defined time frame. Rather than a series of notification services defined individually within product-specific interfaces as done currently, the consolidated search interface would handle this. As Davis and Meyer discuss in their book *Blur: The Speed of Change in the Connected Economy*, this approach

demonstrates an awareness that people buy products and services because they have needs that these things, together, help to fill. Bundling more product or service into the original offer is a way to meet more of that need.[6]

Ensuring access to resources and search histories provides another opportunity to leverage technology. One might imagine authentication developments resulting in the invention of a pocket-sized device enabling a person to authenticate against a central registry or directory from any compliant workstation to gain access to resources and up-to-date search histories. The device itself could combine the features of the relatively new, small-profile USB memory devices or "keys" with embedded public-key certification to this end.

While we consider the benefits of new approaches to existing services, we are mindful of the current technology's limitations with respect to presenting relevant search results in the face of the voluminous new material added to the Web. As the Griffiths and King article in this issue briefly mentioned, more work is needed to determine the relevance of search engine results. In an effort to show relationships between search results, one area of development focuses on providing visual mapping of result sets. Northern Light was a precursor to this approach, sorting search results into categorized subfolders. Newer efforts replicate this approach in a directory-like hierarchy or move beyond it into various forms of visual representations of how search results cluster. The National Library of Medicine is using Antarcti.ca's Visual Net (http://antarcti.ca/ and http://pubmed.antarcti.ca/start) as an interface to PubMed, the publicly accessible database of medical information the NLM maintains. Visual Net uses visual elements to represent broad categories that can be further drilled down into visually revealing significant additional details manifested as dots, rings, and arrows indicating language, currency, a work's previous review status, and much more.

Although it is impossible to predict confidently the specifics of future library computing applications, we can be confident of the continuing efforts of librarians and technologists to develop and apply the latest technologies in seeking to extend their services to constituents.

References and notes

1. C.A. Lynch, "From Automation to Transformation: Forty Years of Libraries and Information Technology in Higher Education," *EDUCAUSE Rev.*, vol. 35, no. 1, Jan./Feb. 2000.
2. D. Reynolds, *Library Automation: Issues and Applications*, R.R. Bowker, New York, 1985, p. 6.
3. T.D. Jewell, *Selection and Presentation of Commercially Available Electronic Resources: Issues and Practices*, Council on Library and Information Resources, Washington, D.C., 2001; http://www.clir.org/pubs/abstract/pub99abst.html.
4. M.A. Drake, "Technological Innovation and Organizational Change," *J. Library Administration*, Apr. 1993, pp. 39-53, and "Technological Innovation and Organizational Change Revisited," *J. Library Administration*, Jan. 2000, pp. 53-59.
5. As illustrated in Deanna Marcum's article on the CLR, an organization receiving significant funding from the Ford Foundation, in recent years the Andrew W. Mellon Foundation has played a critical role in funding activities advancing scholarly communications.
6. S. Davis and C. Meyer, *Blur: The Speed of Change in the Connected Economy*, Warner Books, New York, 1999, p. 24.

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