The Z39.50 Information Retrieval Standard

Part I: A Strategic View of Its Past, Present and Future

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Introduction

The Z39.50 standard for information retrieval is important from a number of perspectives. While still not widely known within the computer networking community, it is a mature standard that represents the culmination of two decades of thinking and debate about how information retrieval functions can be modeled, standardized, and implemented in a distributed systems environment. And - importantly -- it has been tested through substantial deployment experience.

Z39.50 is one of the few examples we have to date of a protocol that actually goes beyond codifying mechanism and moves into the area of standardizing shared semantic knowledge. The extent to which this should be a goal of the protocol has been an ongoing source of controversy and tension within the developer community, and differing views on this issue can be seen both in the standard itself and the way that it is used in practice. Given the growing emphasis on issues such as "semantic interoperability" as part of the research agenda for digital libraries (see Clifford A. Lynch and Hector Garcia-Molina. Interoperability, **Scaling, and the Digital Libraries Research Agenda, Report on the May 18-19, 1995 IITA Libraries Workshop**, <http://www-diglib.stanford.edu/diglib/pub/reports/iita-dlw/main.html>), the insights gained by the Z39.50 community into the complex interactions among various definitions of semantics and interoperability are particularly relevant.

The development process for the Z39.50 standard is also of interest in its own right. Its history, dating back to the 1970s, spans a period that saw the eclipse of formal standards-making agencies by groups such as the Internet Engineering Task Force (IETF) and informal standards development consortia. Moreover, in order to achieve meaningful implementation, Z39.50 had to move beyond its origins in the OSI debacle of the 1980s. Z39.50 has also been, to some extent, a victim of its own success -- or at least promise. Recent versions of the standard are highly extensible, and the consensus process of standards development has made it hospitable to an ever-growing set of new communities and requirements. As this process of extension has proceeded, it has become ever less clear what the appropriate scope and boundaries of the protocol should be, and what expectations one should have of practical interoperability among implementations of the standard. Z39.50 thus offers an excellent case study of the problems involved in managing the evolution of a standard over time. It may well offer useful lessons for the future of other standards such as HTTP and HTML, which seem to be facing some of the same issues.

This paper, which will appear in two parts, starting with this issue of **D-Lib**, looks at several strategic issues surrounding Z39.50. After a relatively brief overview of the function and history of the protocol, I will examine some of the competing visions of the protocol's role, with emphasis on issues of interoperability and the incorporation of semantics. The second installment of the paper will look at questions related to the management of the standard and the standards development process, with emphasis on the scope of the protocol and how that relates back again to interoperability questions. The paper concludes with a discussion of the adoption and deployment of the standard, its relationship to other standards, and some speculations on future directions for the protocol.

This paper is not intended to be a tutorial on the details of how current or past versions of Z39.50 work. These technical details are covered not only in the standard itself (which can admittedly be rather difficult reading) but also in an array of tutorial and review papers (see <http://lcweb.loc.gov/z3950/agency> for bibliographies and pointers to on-line information on Z39.50). Instead, the paper's focus is on how and why Z39.50 developed the way it did, and the conceptual debates that have influenced its evolution and use. While a detailed technical knowledge of the operation of Z39.50 is certainly helpful, it should not be necessary in order to follow most of the material here.

Some disclaimers are in order. I have been actively involved in the development of Z39.50 since the early 1980s and have been a participant -- and on occasion, even an instigator -- of some of the activities described here. This paper is an attempt to make a critical assessment of the current state of Z39.50 and a review of its development with the full benefit of hindsight. It recounts a number of debates that occurred within the developer community over the past years. In many of these, I advocated specific positions or approaches, sometimes successfully and sometimes unsuccessfully. What is presented here is one person's perspective - mine --, which is sometimes at odds with the current consensus with the developer community; I've tried to represent opposing views fairly, and to differentiate my opinions from fact or consensus. However, others will undoubtedly disagree with many of the comments here.

What is Z39.50?

Z39.50 -- properly "Information Retrieval (Z39.50); Application Service Definition and Protocol Specification, ANSI/NISO Z39.50-1995" -- is a protocol which specifies data structures and interchange rules that allow a client machine (called an "origin" in the standard) to search databases on a server machine (called a "target" in the standard) and retrieve records that are identified as a result of such a search.

The rather forbidding name "Z39.50" comes from the fact that the National Information Standards Organization (NISO), the American National Standards Institute (ANSI)-accredited standards development organization serving libraries, publishing and information services, was once the Z39 committee of ANSI. NISO standards are numbered sequentially and Z39.50 is the fiftieth standard developed by NISO. The current version of Z39.50 was adopted in 1995, thus superseding earlier versions adopted in 1992 and 1988. It is sometimes referred to as Z39.50 Version 3.

Z39.50 had its roots in the OSI efforts of the 1980s. Within the OSI model, it is an application layer protocol. But at this point the only lower-layer service that it requires is a reliable full-duplex byte stream transport such as TCP. A TCP port number for Z39.50 is registered, and there is a Request for Comment (RFC) that specifies how to use Z39.50 over TCP (see Clifford A. Lynch. "Using the Z39.50 Information Retrieval Protocol in the Internet Environment," Request for Comments: 1729 [December 1994] <http://www.internic.net/rfc/rfc1729.txt>).. Abstract Syntax Notation One (ASN.1) is used to specify the contents of the protocol data units that are passed between client and server, and the Basic Encoding Rules (BER) are used to serialize the ASN.1 structures.

The protocol is stateful and connection-oriented. The protocol defines interactions between two machines only. While some groups are now developing "broadcast search" applications that permit a client to search multiple servers in parallel, these are applications that are built on top of Z39.50 and use multiple concurrent Z39.50 connections to multiple machines. Z39.50 does not specify an applications program interface (API) to the services of the protocol on either the client or the server. It deals only with the interactions between the client and server machines. In addition, Z39.50 does not address any of the issues involved in user interfaces that the client may present or any of the issues involved in database management at the server.

The basic architectural model that Z39.50 uses is as follows: A server houses one or more databases containing records. Associated with each database are a set of access points (indices) that can be used for searching. This is a much more abstract view of a database than one finds with SQL, for example. Relatively arbitrary server-specific decisions about how to segment logical data into relations and how to name the columns in the relations are hidden; one deals only with logical entities based on the kind of information that is stored in the database, not the details of specific database implementations.

One of the basic Z39.50 functions allows the client to transmit a search to the server (a SEARCH request). A search produces a set of records, called a "result set", that are maintained on the server; the result of a search is a report of the number of records comprising the result set. The standard is silent as to whether the result set is materialized or maintained as a set of record pointers, and as to how the result set may interact with database updates that may be taking place at the server. Result sets can be combined or further restricted by subsequent searches. Note that this is substantially different from SQL servers, which do not employ result sets.

Records from the result set can be subsequently retrieved by the client using PRESENT requests. The PRESENT request offers elaborate options for controlling the contents and format of the records that are returned. The PRESENT request indicates specifically which records from the result set are to be retrieved. There are facilities for managing buffer space in the presence of very large records and also for transferring very large numbers of records from server to client without the need for repeated PRESENT requests and responses (and hence many round-trip interactions between client and server).

Z39.50 also contains functions for search management. For example, a server can provide progress reports for an active search, or can ask the client for authorization to continue a resource intensive search; a client can abort an active search. The report for search completion can also return supplementary information such as how many records matched individual component terms in a search.

Z39.50 contains facilities for managing result sets, for sorting result sets, for browsing the values of access points associated with a database, for opening and closing connections, and also a general mechanism called "extended services", which is essentially an asynchronous remote procedure call mechanism that the client can use to invoke services on the server, optionally making reference to the contents of a result set as a parameter. Extended services (which will be discussed in more detail later) were originally intended as a means of saving result sets across sessions, queuing them for print or electronic mail processing at the server, or for registering and managing queries that would be executed periodically on the server.

The protocol also defines the following:

- A query language for specifying searches, which in turn builds upon registered definitions for attribute sets that specify the names of access points;
- Various record syntaxes that can be used for transferring records from the server to the client, including both some application domain specific syntaxes like MARC for bibliographic data and a massively complex, very general purpose syntax called Generalized Record Syntax One (GRS-1);
- A language for describing how to construct records that are to be transferred from a result set back to the client; and
- A facility called EXPLAIN which allows clients to obtain a wide range of information from a server about what databases are available, what access points are

supported in each database, and the like. EXPLAIN is modeled as a special-purpose database which is searched using standard Z39.50 queries; the standard specifies the detailed structure of the records that can be retrieved from this database. EXPLAIN is intended to permit the development of clients that to at least some extent are dynamically self-configuring as they encounter various servers.

Z39.50 makes extensive use of registries for various types of objects, such as attribute sets used in queries and record syntaxes used in present requests. These are referred to via object identifiers which are used as parameters in the various protocol requests and responses that move between client and server. Some initial object identifiers are assigned by the standard; assignment of object identifiers on an ongoing basis is handled by the Z39.50 maintenance agency.

A Timeline of Z39.50 Standardization and Deployment

Z39.50 has its roots in efforts dating back to the 1970s to allow standardized means of cross-database searching among a handful of (rather homogeneous) major bibliographic databases hosted by organizations such as the Library of Congress, the Online Computer Library Center (OCLC), and the Research Libraries Information Network. At the time, the primary application was to support shared cataloging using a logical national bibliographic database constructed from this small number of bibliographic utilities rather than to offer end users a common view of large numbers of autonomously managed databases. This program was called the Linked Systems Project. Initially, the participants both wrote protocol specification and worked on implementation; however, by the early 1980s the focus of the Project had shifted to almost exclusively to implementation, and the work on the specifications had been moved into a formal standards development effort under the auspices of the National Information Standards Organization (NISO). (See Clifford A. Lynch and Cecilia M. Preston. "Internet Access to Information Resources," Annual Review of Information Science and Technology (ARIST) Volume 25 (New York, NY: Elsevier, 1990), pp. 263-312. for more details on the early history of Z39.50)

NISO committee D was established in 1979. It operated under the normal rules for traditional standards making bodies: as a small, closed committee of appointed experts who worked very much in isolation from the broader community until the final product of the committee went to ballot, and with a relatively weak connection between the protocol developers and those who would actually implement the resulting standard. After an unsuccessful ballot in 1984, the committee was finally successful in balloting "American National Standard Z39.50, Information Retrieval Service Definition and Protocol Specifications for Library Applications" in 1987; the standard was published in 1988. This document is probably best described, in hindsight, as an unimplementable abomination which should never have been adopted in the form it was. Rooted firmly but somewhat inarticulately within the OSI framework that was evidently mandatory for formal standards making bodies at the time, the context of the 1988 standard was, as its title suggests, information retrieval from bibliographic databases. To the best of my knowledge, outside of the Linked Systems Project context the only "implementation" of Z39.50-1988 was Brewster Kahle's work on the Wide Area Information Server (WAIS) project. The role of Z39.50-1988 in WAIS might best be describe as "inspirational" rather than that of a standard. WAIS never interoperated with anything except WAIS, and freely deviated from Z39.50 both in intent and specifics in the interests of producing a working system. It's a tribute to Kahle and his colleagues that they managed to produce anything useful based on Z39.500-1988.

By the end of the 1980s the community's view of goals for Z39.50 were beginning to change. Indeed, the community interested in using the standard had grown much larger and more diverse than the handful of institutions involved in the linked systems project. The concern was now with end user access to bibliographic and abstracting and indexing databases, and even more general classes of databases. The world now was being viewed as containing many clients and servers -- not just a handful of major bibliographic utilities -- in part because of the deployment of local on-line catalogs into libraries during the 1980s, and in part as a result of the implementation of access to abstracting and indexing databases for the general library patron community rather than specialist searchers. The rapid growth of network-accessible computers also motivated this changing perspective. The typical application envisioned for Z39.50 at that time was to permit the implementation of a user interface, running either on a timeshared mainframe or a personal workstation (sometimes called a "scholar's workstation"), which provided uniform, consistent access to a range of networked servers hosting content resources.

There were also a messy set of standards issues emerging in the international arena. Parallel to NISO's committee D, an international committee, ISO Technical Committee 46 Subcommittee 4, had been working on a protocol called Search and Retrieve (SR), which was almost identical to Z39.50 except that it used ASN.1/BER as a protocol data unit encoding and omitted a few functions. It was defined by a pair of independently edited documents distinct from the work done in NISO. The international work was standardized in 1991 as ISO 10162/10163. The feeling in the USA was that it was essential that the next version of the US protocol not only be implementable and responsive to the evolving needs of the potential implementor community but that it also be at least compatible with the ISO work, though there was a sense that the requirements of the US community went beyond the functions available in the ISO version.

During 1989-1991, a major shift occurred in the way that Z39.50 protocol development was being handled in the US. The Library of Congress was appointed as the maintenance agency for the standard by NISO; this provided a focal point for the drafting of a revised standard. One of the early assignments of the maintenance agency was to harmonize USA developments with the ISO work. Ray Denenberg of the Library of Congress took on the role of editor for the revised USA standard. Committee D was disbanded, or faded away; functionally it was replaced by a self-selected unofficial group called the Z39.50 Implementorís group (ZIG) convened and chaired by Mark Hinnenbusch of the Florida State Center for Library Automation.

Initially, perhaps 15 organizations were represented on the ZIG, but the meetings were widely advertised and open to all interested parties. The group grew in size rapidly. For the first time, a public electronic mail list was also put in place to facilitate discussion of the revision of the standard, again opening up the process to a much larger range of interests. The process was much more akin to the kinds of standards development efforts one finds in the IETF, though the work was reconnected with the traditional process at the end through a formal ballot to the NISO membership.

The net effect of all of these events was that by 1991, a second version of Z39.50 had been prepared and put out for ballot. This became Z39.50 version 2 or Z39.50-1992. Unlike its 1988 predecessor, Z39.50-1992 had heavy input from a substantial number of people actually building implementations in various environments. It was a compatible superset of the ISO 10162/10163 work that had been done internationally. While still heavily driven by applications involving bibliographic and abstracting and indexing databases, influences such as the work of the WAIS project on full text databases, emerging SGML projects, and similar applications had broadened the sphere of applications and the version 2 standard was actually useable with a very broad range of datatypes, though it did not necessarily have all the flexibility one might want for dealing with them.

Perhaps the greatest problem with the 1992 version of Z39.50 was its continued explicit positioning of the protocol within the OSI framework. Worse, Z39.50-1992 wants to actually make use of certain relatively esoteric presentation layer services (which turned out not to be part of most of the available OSI protocol stack implementations). This was a major barrier to deployment. By 1992, it was already clear to most implementors that OSI had failed, but this was not yet a politically acceptable statement within international standards bodies or certain US government and library circles. There was at least one OSI-based implementation of Z39.50-1992, which was developed but never really much exercised because there was nobody to talk to -- and no way of talking to anyone. In order to move Z39.50 from theory to practice it was necessary to move it into the TCP/IP based environment of the Internet, despite the political controversy that this would entail.

In 1992-1993, a program called the Z39.50 Interoperability Testbed was launched under the sponsorship of the Coalition for Networked Information (CNI). The purpose of this project was to facilitate the development of a large number of interoperable implementations of Z39.50 which ran over TCP/IP and were accessible through the Internet. This effort was a substantial success, and led to a number of demonstrable Z39.50 clients and servers which could be seen to communicate with each other at trade shows like the American Library Association's exhibits. This was a very novel experience for vendors and librarian-purchasers alike: they could actually put vendor claims of standards conformance to the test by trying to get a vendor's system to communicate with other vendor or university implementations. The vast majority of the implementors that participated in the testbed were library automation systems vendors offering access to bibliographic or abstracting and indexing databases, although universities and bibliographic database access providers also played major roles. In part as a result of the efforts of the interoperability testbed, Z39.50 gained a great deal of credibility in the library automation community and rapidly became part of the specifications most libraries used in the procurement of new library automation systems, thus further encouraging implementations. (The Z39.50 maintenance agency maintains a list of implementors; readers are invited to browse this to get a sense of the range of current implementations of the protocol).

While Z39.50-1992 moved into widespread implementation, the ZIG began work in 1991 on Z39.50 version 3. Version 3 was much more ambitious than version 2. While version 2 built upon the functions of the 1988 version and the ISO work, Version 3 included everything that anyone participating in the implementor's group wanted. It was a consensus document in the sense that all proposed requirements were accommodated. By this time, however, the implementor's group was much larger and more diverse, including major information services providers like Lexis/Nexis, Dialog, and Chemical Abstracts, as well as the traditional constituencies. These new participants brought with them a vast range of new requirements and sometimes a fundamentally different view of the role of standards and interoperability. The resulting version 3 product, balloted in 1995, contained a number of important incremental changes like segmentation (important for high performance on fast networks), sorting, and access point browsing; it also introduced the EXPLAIN database. But version 3 also introduced very complex features like extended services and the generalized record syntax, which were major departures from previous protocol versions, and which were to raise more fundamental questions about the appropriate scope of the Z39.50 protocol and about the nature of interoperability one might expect from conformant implementations. These are discussed later from several different perspectives.

Version 3 was much larger than version 2, weighing in at about 160 pages (as opposed to about 40 for the earlier version). Yet the comparison is a little misleading; in version 2 very little was optional, while the vast majority of the new functionality and changes in version 3 were optional. The actual set of changes necessary to move from a version 2 implementation to a minimal conformant version 3 implementation are not very large, with much of the work for a server being to politely decline to perform various optional functions. An additional reason for the bulk and apparent complexity of version 3 was that it, in fact, included version 2. Version 3 was designed as a superset of version 2, which incorporated the ability to fall back to the older version 2 specification if the parties involved did not support version 3 for the sake of backwards compatibility with the existing base of implementations. This seemed like a good idea at the time. But in hindsight, it is not clear that the amount of confusion and complexity it created in the standard was really worthwhile.

Version 3 of the standard explicitly recognized the TCP/IP Internet environment in an appendix but also contained carefully crafted language which still permitted Z39.50 to be viewed as an OSI protocol by those who wished to do so. This, again, is confusing to today's reader, but was probably politically expedient at the time the standard was balloted.

Since the adoption of version 3 in the USA in 1995, developments have been proceeding in a number of directions. The independent international text of ISO 10162/10163 has been superseded by the international adoption of the NISO Z39.50-1995 text, meaning that there is now only one standards document to work with, rather than multiple documents describing what is hopefully the same protocol. International participation in the Z39.50 Implementor's group has grown substantially, with a particularly heavy representation from Europe but also now growing interest from Australia; the ZIG has been meeting abroad once a year for the past few years. Thus, in a real sense, the whole international Z39.50 community is directly involved in ongoing development of the standard, although through the peculiar mechanism of an unofficial advisory group to the maintenance agency for a US standard. Presumably future versions of the standard will be balloted within NISO, and perhaps within ISO internationally as well, although they are not being developed within the normal standards development processes for these organizations. With the growth of international participation, there has been an increased focus on issues such as support of multiple character sets and languages.

Various groups have been developing Z39.50 profiles. The maintenance agency keeps a list of these, but the process by which they are approved and subsequently maintained remains somewhat unclear. Profiles are basically customizations of the standard to particular communities of implementors with common applications requirements. A profile may include a whole range of agreements: for example, agreements to use or not to use specific optional version 3 features; agreements on particular attribute sets and record syntaxes to be used (including perhaps the definition and registry of new attribute sets and/or record syntaxes to support the community in question); and even agreements on what extended services will be used (including, again, definitions of new extended services that the profileís community may want to use). Often it is doubtful how much meaningful interoperability will be possible between one Z39.50 implementation that is built according to a given profile and another which is not aware of the specific profile. Examples of profile work include GILS, the Government Information Locator System; the Museum Interchange Profile being developed by the Computer Interchange of Museum Information (CIMI) group; the Digital Collections profile under development by the Library of Congress; the (revised) WAIS profile; profiles for applications involving remote sensing and geospatial data, and a cataloging profile under development by the National Library of Australia.

In some sense, the development of profiles signifies the fragmentation of the Z39.50 implementor community into more specialized and potentially insular sub-communities. To a degree, I believe that it is also a response to the interoperability problems raised by the vast number of optional or incompletely specified features in version 3 of the standard. Finally, one can also view profile development within the Z39.50 community as a response to the lack of other well-defined processes for establishing standards for attribute sets and record interchange syntaxes to support various semantic classes of information resources (such as museum information); these are developed as Z39.50 profiles rather than separate parallel standards that are used in conjunction with Z39.50.

There is work underway on linkages between Z39.50 and various other standards activities. URLs have been defined for Z39.50 database queries, for example. There is an active effort to incorporate SQL as an alternative query language with Z39.50 search requests, although a complete definition of the requirements, limitations, and expected benefits of such an integration remain somewhat unclear. People are beginning to think about how Z39.50 and CORBA might inter-relate.

And, of course, there is discussion about the possible development of version 4 of the standard, about what principles might guide the development of such a version, and what requirements might shape it. At present no consensus exists on such guidelines, and there is no firm commitment or timetable for a new version of the standard. There does seem to be a general feeling that it will be important to simplify and streamline future versions of the standard; that it is important to more rigorously separate semantic definitions that are specific to certain classes of databases, such as attribute sets and record syntaxes, from general protocol mechanisms that are relevant of all databases; and that the elaborate backwards compatibility requirements that characterized the transition from Z39.50-1992 to Z39.50-1995 may not be necessary in future.

The Role of Content Semantics in Z39.50

Z39.50 becomes linked to the semantics of the databases being searched in two primary areas: the attribute sets used to describe the access points being searched, and the record syntax (and related record composition control parameters in PRESENT) that are used to actually transfer records back from server to client. As indicated earlier, because these semantics are typically at the level of logical (intellectual) constructs for classes of databases, Z39.50 offers a much higher degree of abstraction than traditional database management system technology.

In many of the early applications scenarios for Z39.50, particularly in the bibliographic environment, there was a strong (though usually implicit) assumption that both client and server software really embodied deep and sophisticated understanding of data semantics, of the meaning of attribute sets like BIB-1 (which is used for queries against bibliographic data), and of record syntaxes such as MARC. Put another way, there was an implicit assumption that Z39.50 might be buried rather deeply underneath an application at both client and server: The client's user interface would likely do a good deal of processing to translate a user query into a Z39.50 query using the BIB-1 attribute set. Similarly, a substantial amount of work reformatting records received from the server for presentation to the end user would be required. At the server side, elaborate processing might be done in order to translate a Z39.50 query into one or more database queries, perhaps even post-processing the results of the database queries in order to fully implement the semantics of the Z39.50 query in cases where it did not map directly into the capabilities of the server's database system.

Here, attributes from the commonly known attribute set and fields within the commonly understood record transfer syntaxes are operating at a semantic level, independent of the implementation of a database on a given server. One speaks of intellectual ideas like author names and dates of publication, rather than of particular field or column names specific to a given implementation. Automatic configuration, in this environment, basically means that the client and server make reference to attribute sets and record syntaxes that are already mutually understood at a semantic level, and then characterize the specific capabilities of the server, where necessary, in terms of this common understanding of semantics.

By the time of version 3, an alternative model was gaining support in some quarters. In this view, client and server really understood very little of the semantics of the information being searched and retrieved. The responsibility for this was placed primarily on the human user of the client software. Here, the Z39.50 protocol interactions were a much more directly exposed to the user and shared semantics were only used at a mechanical level, for example to agree on the datatype of a particular data element. Neither the client or the server really understood the meaning of the information that was being searched and retrieved. Automatic configuration was not about adjusting client search strategies and Z39.50 query formulation for the peculiarities of a specific serverís capabilities, but about how to tailor a user interface.

To slightly exaggerate this approach: The client should be able to get from the server a list of supported access points along with textual labels for them which are suitable for display to a human user. Based on this, the client throws a search form up on the screen; the user fills in some of the blanks for some attributes, and the client mechanically translates this back into a Z39.50 query. Records are handled similarly, using some general syntax like GRS-1, where the client gets back a series of data elements and textual tags to display with them (perhaps using EXPLAIN to obtain the textual tags).

Clearly, in such an environment, the client software really cannot add much value. It can't help the user with the mapping of searches expressed at an intellectual level into appropriate Z39.50 queries for specific servers, and it cannot, for example, easily fuse data from multiple sources. In a way, the client is just acting as a programmable user interface which is configured by the server. Put another way, one can think of this latter approach as one in which database semantics are reduced to simple syntax. One simply makes reference to arbitrarily-named access points and record data elements, and as side information, users are provided some hints to help them interpret the actual meaning of these arbitrarily named fields.

Semantics are clearly intimately connected to interoperability. In the first view of semantics, that in which applications are very sensitive to content semantics, it is clear that a client encountering a database that employs an unknown attribute set and/or record syntax will be unable to interoperate meaningfully with the server. To make the client and server interoperate, there are three main approaches:

1. Extend the client to know about the characteristics of the new logical class of information (that is the record syntax and attribute sets);
2. Have the server automatically map the semantics of some attribute set already known to the client to the logical access points relevant for the new class of information, and then map the new information into a familiar record syntax for the client (which, in both cases, is likely to be only an approximate, imprecise and probably incomplete mapping); or
3. Have the client obtain automatic configuration information from the server or a third party which allows similar mappings to be performed at the client -- in essence, use an existing set of semantics that the client knows as a basis for establishing at least approximate semantics for the new class of information.

All of these are hard, and require substantial work on someone's part in order to make a new class of information content broadly accessible to the base of Z39.50 clients. Further, they require community consensus on an understanding of the structure and attributes of various classes of information content. There is an unending list of such classes: bibliographic records, seminar announcements, course schedules, personnel records, gene sequences, descriptions of the properties of chemical compounds. In many cases it is not clear how to define the appropriate community to develop and document such a consensus on how a given class of content is to be structured. Shared semantics within the Z39.50 context presupposes that some basis for defined semantics of a given kind of information object already exists; that it has been codified so that it can be shared. This is not always a realistic assumption, and to some extent the need for it limits the situations in which Z39.50 can deliver its fullest value as a framework for the development of distributed information retrieval applications.

In the second view, where only mechanical semantics are supported, interoperability is not going to be conditional upon any kind of mutual understanding of semantics, except to the extent that special datatypes (for example, as might be needed for chemical structure searching) are required to fully exploit the search capabilities of the server, or specialized display routines might be needed to interpret the datatypes of some of the data elements in the records coming back (for example, animations). In these cases the client will need methods for handling input and/or display of the new datatypes. So, in one sense, there is much broader interoperability; more clients and servers can communicate without prior arrangement or knowledge. Further, it avoids the need for prior consensus on how the semantics of a given class of information should be structured.

Yet, in another sense the loss of abstraction renders this use of Z39.50 much closer to traditional low-level distributed database applications, with all of the limitations, scaling and maintenance problems that characterize these applications, and misses much of the point that motivated the development of Z39.50. At best, I believe that this should be used as an undesirable fallback applications scenario which is invoked only in cases where it becomes clear that there are no shared semantics to build upon, in order to ensure some minimum level of access to exotic information resources that are outside of a given client's basic design objectives.

It is interesting to note that recently there has been considerable work done in developing a very generic set of data elements called the Dublin Core which could be used both as the basis for an attribute set of access points and in the construction of a record syntax. While these could be used as an intellectual set of semantics that would provide wide interoperability (since they can be mapped to most more elaborately structured information resources), their very generality means that the amount of processing a client can perform based on an understanding of their semantics is very limited. Ultimately, they serve as rough classes to which access point values can be assigned, and as tags that can be used to label corresponding data elements when returned records are displayed to users. Z39.50 provides maximum leverage where there is a shared understanding between client and server of rich and specific information semantics.

This is the first of a two-part story; Part II will appear in the May 1997 issue of this magazine.

Editor's note, 1/11/99. Part II was not published as planned.

Z39.50

The User's Perspective

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Contents

I. Introduction

There is great interest in library communities in designing and implementing digital library systems that conceal the complexities of an information landscape characterized by numerous, disparate information resources. Users often encounter frustration in their efforts to discover relevant sources, negotiate connections, learn resource-specific user interfaces, and search using a variety of inconsistent query languages and semantic conventions. This work is typically done in an isolated section of a much larger sphere of information, and often users are left with the feeling that they have overlooked some important items.

Although librarians, computer scientists, and other professionals are currently conceiving of and designing systems to alleviate some of this complexity for the user, they must remain sensitive to the reality that even the best ideas may inadvertently inhibit, rather than enhance, the user's experience. To create effective digital libraries, an understanding of users' actual work experiences and behavioral tendencies should form the basis of digital library designs. Increasingly, user studies are being conducted as part of digital library projects (Peterson, 1995, Lloyd, 1996). Most recent studies have taken a user-centric, iterative approach in which the major focus is on how users do their work, not just how they respond to a particular interface design or system feature (Van House, 1996).

Consistent with this user-centric approach, Cornell University's Albert R. Mann Library conducted a comprehensive user study to inform the design of the next generation "Gateway" <http://www.mannlib.cornell.edu>, an electronic library system that provides access to over 600 information resources, including bibliographic indexes and catalogs, full-text documents, statistical datasets, and spatial data. Although the Mann study explored a wide range of issues relevant to digital libraries in general -- including discovery of relevant resources, searching, navigation, and general comprehension of the information landscape, -- the current article focuses on a sub-section of the study designed to explore user perspectives on a common user interface for searching bibliographic resources and the ability to search multiple resources simultaneously. The goals of the larger Gateway User Study, its methodology, the findings, and implications are discussed elsewhere (Payette and Rieger, 1997).

II. Gateway User Study: Multi-Database Search and Common User Interface

1. Purpose of the Study

Mann Library considered using the Z39.50 search protocol in the Gateway to enable a common user interface for bibliographic searching, and to give users the option to search several databases simultaneously. A component of the larger user study was devoted to validating Mann Library staff's assumptions on the effective use of Z39.50 for these purposes. The user's perspective is critical for identifying barriers to effective implementation and for setting criteria for evaluating existing Z39.50 clients and servers. The knowledge we obtained from our users in this study will influence our decision to acquire an existing Z39.50 client or develop our own. Also, user feedback will dictate the extent to which we enhance the Gateway to support simultaneous searching of multiple databases.

Nearly twenty-one percent of the Gateway resources are bibliographic databases, such as Agricola, BIOSIS, Medline, Periodical Abstracts, PsycInfo, and Carl. These citation databases contain secondary information and provide users with references to journal articles, book chapters and conference presentations. They contain core information for each citation (such as journal title, article title, year of publication, volume number, article abstract) to assist users in identifying and evaluating primary materials. The Gateway also includes bibliographic utilities including the Cornell University Online Catalog, RLIN and OCLC. Each resource has its own distinct search interfaces such as NOTIS, BRS, Dialog, Carl, RLIN Eureka, OCLC, and Cambridge.

With the rapidly increasing number of bibliographic databases in the Gateway, the Mann Library reference desk staff witnessed users' frustration in dealing with different search interfaces and syntax conventions. Users were unable to carry search statements from one database to another. Except for several InfoShare databases that utilize the NOTIS interface, the other Gateway bibliographic databases do not contain hooks to the Cornell University Online Catalog. Users can benefit from these links since they can eliminate the additional search step of checking the availability of a desired publication in one of the Cornell Libraries.

2. Methodology

The Gateway User Study employed survey research methods including focus groups with Mann Library staff and interviews with a selected group of faculty and students. Using non-probability techniques (purposive and quota sampling methods), we recruited twenty-seven faculty, and sixteen undergraduate and graduate students who currently use the Gateway. Two survey instruments were used in the study: a questionnaire and an interview schedule. We administered the questionnaire to collect profile data on participants prior to meeting them for interviews.

The faculty and student interviews were semi-structured and organized into three sections. The first two sections were designed to gain an understanding of the users' conceptions of digital libraries, the Gateway, and its navigation tools. The final section of the study focused on the desirability of a common user interface and multi-database search. Our intent was to explore users' opinions on implementing bibliographic file features such as cumulative search, common user interface, and links from bibliographic databases to the Cornell University Online Catalog.

3. Interview Questions

The final section of the interview explored solutions to the above highlighted problems. We introduced interviewees to the concepts of multi-database searching and common interface through discussions and demonstrations using prototype interfaces developed to demonstrate a Z39.50-based bibliographic search (see below, Figures 1 and 2). We provided the interviewees with some search examples to help them to understand how a multi-database search could be conducted. Throughout this exercise, we solicited users' comments and reactions to several open ended questions including:

1. Would a common search interface across databases be preferable to a database-specific interface such as BRS or Dialog? If so, why?
2. Would you be willing to sacrifice any functionality for a common interface? For example, with a common user interface you may not be able to limit your search by update code to identify relevant citations that were added during a certain database update. Or, you may not be able to refine your search by subject codes assigned for a certain database such as ERIC Clearinghouse number.
3. What is your most common search strategy when you are searching a bibliographic database? Do you search by keyword, author, title word, other fields? How often do you take advantage of database-specific search features such as Medline subject headings or ABI/Inform's journal codes?
4. What are the critical features for a common interface?
5. What is your general reaction to multi-database searching? Do you find it desirable? Would it significantly improve your bibliographic database search experience?

6. Is simultaneous database searching (being able to search more than one database simultaneously) preferable to sequential bibliographic database searching (being able to carry the same search statement from one database to the next)?
7. How would you want to identify the multiple database search option in the Gateway interface?
8. How would you want to specify which databases to include in a particular multi-database search?
9. How would you like to group the databases for multi-database searching? Examples include: by subject (agriculture, medicine, education, etc.), by type of information (scholarly vs. popular), by chronological coverage (current information vs. historic information), by holdings (only those journals held by Cornell Libraries vs. all journals).
10. Do you want to run your search against a default set of subject-specific resources (e.g., medicine, agriculture, art) identified by the Gateway developers or do you want to select them by yourself from a list of databases?
11. After you run a search against a number of bibliographic databases, how would you want the findings to be presented? Examples include: have the system compress duplicates, identify the source database for each retrieved citation, sort the findings in chronological order, etc.
12. What are your concerns about implementing multi-database search and common user interface features in the Gateway?

III. Selected Findings

1. Users' Perceived Benefits of Common User Interface

As anticipated, the interviewees, especially the students, were very supportive of incorporating a common interface for searching bibliographic databases. 89% of the faculty and 100% of the students expressed the view that a common user interface would significantly improve their bibliographic database search experiences**.** Some of the benefits the interviewees perceived were:

- The availability of a common interface could enable them to learn a single interface that is applicable to all the bibliographic databases and therefore eliminate the need to master different search interfaces for different databases.
- A common interface could provide a consistent, reliable means of printing and downloading information. Currently, many bibliographic databases available through the Gateway must be accessed using a Telnet or TN3270 client. Therefore, the interface and information capture options (printing and downloading) during a bibliographic search are determined by the telecommunication software (such as Comet, Trumptel, TCP3270) used to connect to the database. For example, TCP3270, unlike Trumptel does not support printing of scrolling text. Therefore when reviewing the findings, users need to either print screen by screen or save the information on a disk/hard drive. This is especially cumbersome for those who are using file management software to organize the findings of their literature search.
- A web-based common user interface, enabled by Z39.50, could allow users to search, view, and capture (print, download, e-mail) citations in a uniform, consistent manner.

It is important to note that only those bibliographic databases that are Z39.50 compliant can take advantage of the common interface. Ideally, a user could enter a query using a search form that operates against multiple resources. When submitted, the query could be encoded into a Z39.50 request for searching and sent to each bibliographic database selected by the user. After the search request is decoded and processed by individual bibliographic database servers, the results (citations) could be sent back and presented to the user as a web document. With a web-based interface, the user could view, print, or save the search results using web-browser features such as Netscape's "Save As", "Print", and "Mail Document."

2. Comparison of Common and Database-Specific Interfaces

Users identified a common user interface that can function across multiple databases as preferable to customized, database-specific interfaces. A majority of the faculty and students interviewed favored a common interface. Only two of the interviewees preferred database specific interfaces that enabled them to fine tune their searches. These faculty members, both biologists, identified themselves as frequent users of the BIOSIS database, which indexes and abstracts journal articles in the area of biology. They said that they often refine their searches by using BIOSIS concept codes as they had very specific research areas.

Only four out of the forty-two interviewees (10%) said that they needed ***both*** database-specific and common interfaces. These users thought a common interface for searching multiple databases would be valuable for identifying those databases that were relevant to their specific search topic. Once they found the best sources, they would search databases individually to take advantage of database-specific search features. For example, one interviewee said that he might conduct a multi-database search to find which databases have the greatest number of citations on public health policy before narrowing down his search to a few databases that are highly relevant to his topic.

3. Users' Search Strategies

Most of the interviewees said that their typical search statements consisted of author's last name and subject-related keywords. They indicated that the ability to conduct these types of searches was their ***critical*** requirement for a common user interface. All the faculty and students interviewed identified keyword searching as their primary search method. Author searching was the second most heavily used method for limiting a search, with all the faculty and 13% of the students reporting it as one of their most frequently used search strategies. Most of the faculty relied on "backward and forward chaining" in conducting their literature reviews; typically, they started this process by searching for publications authored by someone they deemed an authority in the subject of interest.

We observed a significant difference between the faculty's and students' preferred search strategies. While 54% of the faculty sometimes used search techniques such as limiting by subject headings, update codes, publication date or journal title, ***none*** of the students took advantage of these features. Although we were initially concerned that users would be reluctant to sacrifice advanced search features, we found that most faculty and students in this study used very simple keyword searches for most of their research. The majority of those interviewed felt that the value of a common user interface would outweigh the potential loss of database-specific features.

4. Users' Perceived Benefits of Multi-Database Searching

In introducing the concept of multi-database searching to the interviewees, we initiated a discussion of artificial boundaries in the information space. Currently, resources are segregated in individual databases and collections, often bounded by the scope of a publisher's coverage, a library's holdings, or an information provider's specialized collections. We sought to understand users' perception of and sensitivity to these boundaries when conducting searches for their research.

To demonstrate ways in which these boundaries could be traversed, we exposed users to two variations of the multi-database search concept, both of which could be enabled using Z39.50. First, we described the simultaneous search, where the user could access a virtual database that is distributed and accessible via a single user interface with a single query. We indicated that simultaneous multi-database searching could break down the "stove pipe" approach to information by enabling a wide-area, parallel search of disparate databases or collections through a single query from a single interface. We distinguished this from sequential, or serial, multi-database searching which would enable the user to cast the same query against a set of databases, one at a time, by repeating the query in each successive database.

Multi- vs. single-database searching

After introducing the concept of multi-database searching, and exposing users to prototype interfaces, we asked interviewees to consider the value of this type of searching in the process of conducting their research. The majority of the sample responded favorably:

- The faculty was very receptive to the concept of multi-database searching, with 88% considering it a desirable approach to their work and 58% perceiving it as highly desirable.
- Students were very comfortable with the concept of multi-database searching which they perceived to be similar to their experiences with Internet search engines such as Infoseek and Yahoo. Given their high exposure to the Internet, it is not surprising that 100% of the students rated multi-database searching as desirable or highly desirable.
- None of the faculty or students felt that multi-database searching would be "undesirable," however, 11% of the faculty were neutral, indicating that they did not feel it was a priority in their work. These faculty members indicated that they were very satisfied with their few trusted sources of information, and did not feel the need to acquire additional information.

Among the faculty who reacted favorably to the multi-database approach, most felt that the multi-database search would enhance their research by increasing the breadth of information brought to their attention. They acknowledged a sense that they may be missing important information in their more limited searching of a few selected bibliographic databases. Many indicated that they tended to stick with a few known, reliable sources because they felt they could not devote time to seeking out new sources, learning how to use them, and adding additional steps to their existing information gathering process. Many faculty felt that the multi-database search could expand their horizons without requiring them to invest additional time. In short, the users in this study perceived both ***efficiency*** and ***increased access*** as major benefits to multi-database searching.

Simultaneous vs. serial multi-database searching

Faculty were interested in both the simultaneous and serial options for executing a multi-database search. When asked to compare the two, most faculty (52%) wanted to have ***both*** options available to them, and most indicated that they would like to choose the approach based on the situation or the context of the problem they were solving. The students were very clear on their preference, with 93% preferring simultaneous searching. Among the faculty, only 20% said they would prefer the simultaneous search to the sequential. None of the faculty or students preferred the sequential approach exclusively.

5. Users' Concerns with Multi-Database Searching

Slow response time

At first glance, it seemed that the faculty's interest in serial searching of multiple databases was somewhat inconsistent with their interest in efficiency. However, upon further investigation, we concluded that most faculty were interested in this feature as a result of fears related to system performance of a widely cast, parallel search of multiple sources. While finding the simultaneous approach conceptually appealing, a significant number of interviewees worried about slow response time. The users perceived serial searching as a way to control their session, while still offering more efficiency than the traditional method of querying individual resources characterized by distinct interfaces and query syntaxes. For instance, if a user anticipated that a particular query would take a long time to process in a simultaneous search of several databases, she may choose to work incrementally, by casting the search in one database, evaluating the results, and then launching the same search from the same interface against another database, possible refining it slightly to limit the result set.

Information overload

A significant number of faculty (46%) reported a desire to be able to pick and choose databases for inclusion in their multi-database search. This might suggest that users valued the existing partitioning of information into discrete databases (e.g., Biological Abstracts) or collections (e.g. a particular publisher's set of electronic journals). By probing further into the users' interest in the source databases, we were able to ascertain that faculty were not expressing an interest in preserving this model of information organization, but in minimizing information overload and the slow response time they associated with searches cast over numerous databases.

Among the faculty, 46% said they did not want to be overwhelmed with citations, revealing that their primary interest in distinguishing individual databases was to reduce information overload by limiting the search to known and reliable sources. Nonetheless, the faculty expressed comfort with the idea of searching a more abstract information space, as long as they had the ability to control for the following: (1) the general type of information (they wanted to distinguish scholarly from popular material); (2) the time they would have to wait (they assumed searches of large information spaces would take a long time); (3) the quality of the results (they assumed that searches of large information spaces would yield many irrelevant hits). In the absence of these overt controls, users felt it was necessary to control which databases were to be included in a multi-database search.

Irrelevancy in the result set

Although 77% of faculty did not require the identification of the source database for *individual references* in a multi-database result set, many were interested in statistical feedback to help them determine which databases were most fertile and relevant for the problem at hand. For instance, many faculty expressed interest in a brief report of what percentages of their results were obtained from which source databases, instead of reporting sources for each citation in the results. With this information users could opt to focus their efforts in certain databases, exclude databases from their multi-databases search session, or refine their query to expand or limit the search results.

6. User Interface Issues with Multi-Database Searching

Initiating the Multi-Database Search Feature

We asked the faculty and students who expressed an interest in the multi-database search option how this feature should be presented to them in the Gateway. The faculty were aware that, in theory, all databases could be included, but that only some could be made Z39.50 compliant at this time. We exposed the interviewees to several prototype interfaces that took different approaches to initiating the multi-database search feature:

1. ***Scenario 1*:** The user activates a general purpose search screen from a button on the main screen. The user could select a broad subject category, and the screen would expand to unveil the databases associated with the topic (Figure 1). These databases would form default groupings of related databases, as determined by librarians.
2. ***Scenario 2:*** The user selects one or more databases from a checklist of all databases, then, enters a query that will be executed against all of them, simultaneously (Figure 2).
3. ***Scenario 3:*** The user discovers a particular database in the Mann Gateway Catalog, proceeds in the traditional manner to make a single connection to that database, and, then, receives notification from the system that there are related databases that could be searched in tandem with the chosen database. The user could choose to branch to a multi-database search screen, or continue to connect to just the selected database.

Figure 1 : Initiating the Multi-Database Search by Subject Categories

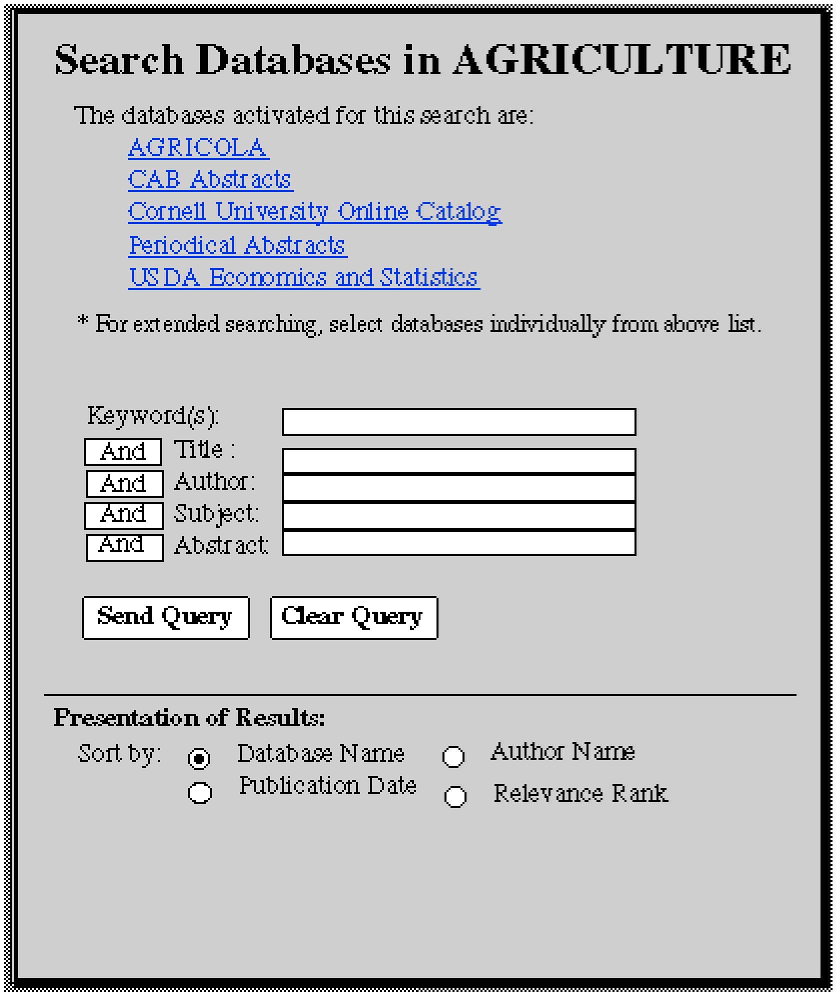
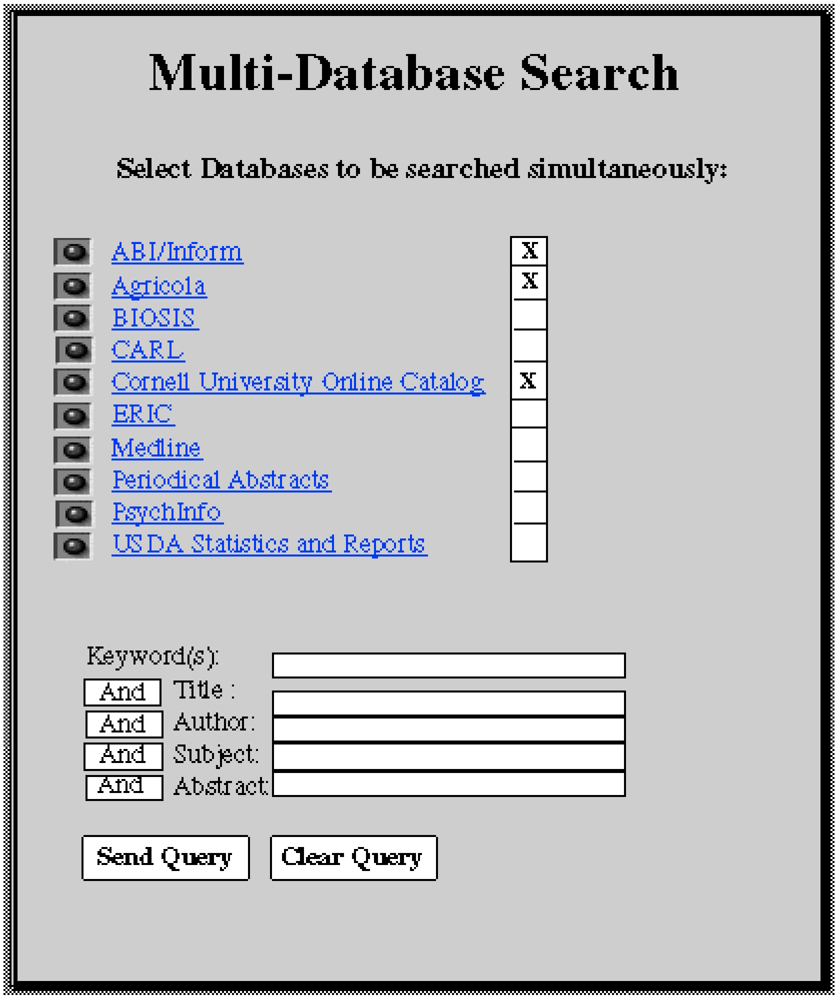


Figure 2 : Initiating the Multi-Database Search by Selecting Databases



In response to these scenarios, 60% of the faculty and 93% of the students were interested in having the system automatically activate the multi-database search feature, and accordingly, were attracted to the first and third scenarios. Generally, these users wanted the multi-database search to be the default search mode, or they wanted the system to automatically make them aware of this option at an appropriate time. Students expressed little interest in the user-activated approach, however, 24% of the faculty reported interest in activating the multi-database search as an option, not as a default. Accordingly, these faculty preferred the third scenario since it let them connect to individual databases in a manner they were accustomed to, but provided the option to extend the search. This group also found scenario two to have some appeal since it gave them total control over which databases would be searched together. The remaining faculty (16%) and one student expressed no preference on the ***means*** of invoking this option in the system. Both the "system activated" group and the "user activated" group expressed an interest in the system helping them know which databases would work best together, either through default groupings of databases by subject, or through a customized recommendation based on some other "behind the scenes" analysis of their query.

Presentation of the search result set

We exposed the faculty and students to a very rudimentary screen design that depicted a result set from a multi-database search. Using paper and pencil, interviewees modified this design while discussing the implications of receiving "hits" from multiple sources. Their first issue centered on the management of duplicate records. Approximately 70% of faculty wanted to receive a merged result set with duplicate responses suppressed, meaning that records that were found in more than one source database would be reported only once. It should be noted that although 46% of faculty wanted the ability to pick which databases were included in a search, 77% did not require knowledge of the source database(s) for individual citations in the result set. As previously mentioned, students expressed minimal interest in choosing databases to be included in a search, and consistent with this, 87% were not interested in having the databases of origin reported with individual hits in the result set.

During our discussions on presentation of result sets, we encountered many users who said it would be beneficial to be able to check the library's holdings for items retrieved from a multi-database search. Many recognized the potential of including the Cornell Online Catalog in the multi-database search scenario and expressed interest in creating a button or a link on the results presentation screen to view holdings information for items encountered in the result set.

Generally, users reported an interest in viewing abstracts, and having the result set sorted in multiple ways, including by chronological publication date, by author, and by relevance to their query. It should be noted that users were interested in relevance ranking, however, they did not address issues of how data should be ranked across multiple databases.

IV. Conclusion

In the current study, we found that users would be very interested in a common user interface for searching disparate bibliographic databases. Most were willing to sacrifice special features and advanced functionality found in native database interfaces in favor of a more generic and simple user interface to support their typical searches. A small percentage of our sample was interested in maintaining "back doors" to native database interfaces if a common interface could not support database specific features such as searching by concept codes and identifiers (e.g. BIOSIS, ERIC), or browsing specialized thesaurus (e.g., Medline).

This study indicates that the implementation of simultaneous multi-database searching should be approached with caution. Although users were very interested in the ability to search multiple databases together, they were already anticipating slow response time and being overwhelmed with information, particularly irrelevant information. More work needs to be done in the area of increasing relevancy of responses from queries executed against multiple, disparate resources. In the interim, users felt that irrelevancy could be minimized by a system that presented default groupings of databases that tend to work well together, or that are related by subject.

To satisfy user requirements for the presentation of results from a multi-database search, a system will have to support merged results sets, compression of duplicates, and cross-database relevance ranking. Since databases will typically reside on different computers, often using different Z39.50 servers, client software will have to manage the integration of records into a single, non-redundant result set. If these capabilities are not available in an existing Z39.50 client, or cannot be effectively developed in a custom-made client, libraries may want to introduce multi-database searching in a limited manner.

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