Using a network menu and the UMLS Information Sources Map to facilitate access to online reference materials

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As computer technology advances, clinicians and biomedical researchers are becoming more dependent upon information from online databases and information systems. By using specially configured computer workstations and high-speed computer networks, it is now possible to access this information in a rapid and straightforward manner. To empower users by providing these capabilities, the authors are assembling a variety of network workstations to be located throughout Yale–New Haven Medical Center. At the heart of the workstation is NetMenu, a program designed to help users connect to a number of important online information systems, including a hospital order entry and results reporting system, a drug reference, bibliographic retrieval systems, and educational programs. In addition, as part of the National Library of Medicine's Unified Medical Language System℠ (UMLS®) project, the authors have developed a local prototype of the UMLS Information Sources Map (ISM) and a companion query assistant program to complement the NetMenu in helping users select and connect automatically to information services relevant to a particular question. The ISM query assistant draws from a listing of many online information sources accessible via local and international networks.

INTRODUCTION

Since the introduction of MEDLINE® in 1971, online information sources have become increasingly valuable to biomedical researchers and practitioners. In many areas, the availability of these resources has increased the quality of work to such an extent that access to online information is considered vital. In clinical medicine, literature review guided by an online bibliographic search is becoming part of a component in the recognized standard of clinical care. In addition to MEDLINE, hundreds of computer-based information sources and online databases may be accessed from a variety of local and international computer networks. Traditionally, health care professionals have accessed these networks using isolated computer terminals and relatively slow telephone-based connections. As a result of technological advances in the 1980s, online information is increasingly available to sophisticated users with computer workstations and high-speed network connections. This paper describes the approach taken at the Yale–

New Haven Medical Center to facilitate widespread access to a diversity of online information sources, through the combined use of workstations, high-speed computer networks, and a local prototype of the Information Sources Map (ISM) being developed in conjunction with the Unified Medical Language System® (UMLS®) project of the National Library of Medicine (NLM). Experimentation with the prototype ISM at Yale is contributing to the development and enhancement of the Information Sources Map, distributed as part of the UMLS Knowledge Sources [1–2].

In the past, access to online information has been extremely variable within the medical center. Isolated computer terminals often are dedicated to specific information sources. For example, it is not uncommon to find two or three computer terminals arranged side by side in offices, hospital wards, and libraries; each terminal might provide access to a single information service, such as a hospital order entry system, clinical laboratory database, or a bibliographic retrieval system. In fact, within the medical center, terminals are dedicated to at least six different library-based systems, four clinical systems, and myriad administrative systems. In some cases, information may be printed out, but there is usually no way to transfer data from a system accessed on one terminal to another system accessed on another terminal, other than reentering the data manually. For some workers, such as admission clerks, a dedicated terminal is adequate. Other workers, such as clinicians, may need to interact with several different systems while caring for a patient. In these situations, dedicated terminals are restrictive and decrease productivity.

It is possible to use a general-purpose desktop computer to access a variety of information sources that may be connected to different networks. To do so, however, the user must have some level of sophistication with regard to the operation of the computer and the connection to the information services. Accessing a specific service requires that the user know which communications program to execute (e.g., Crosstalk Mark 4); how to use this communications program to perform functions such as printing, saving data in files, and exiting; how to navigate through the international computer networks to access a specific service; how to set the configuration of the local terminal emulator to match the specifications of the remote computer; and how to initiate a session by entering the requisite sign-on codes.

Once the connection with an information service is established, the user also must be fluent in the query language and vocabulary used by the remote computer. Although some information services are entirely menu driven, others offer greater access through use of a customized query language. In most cases, the query language is unique to a particular information service or group of services. The complexity of some languages has kept many health care professionals from interacting directly with online information services; instead, many have relied upon highly trained information specialists or librarians to function as search intermediaries.

In recent years, two approaches have been taken toward reducing the barrier posed by complex and diverse query languages. In an effort to standardize languages, information experts and vendors are developing the National Information Standards Organization (NISO) Z39.50 protocol [3]. Although many vendors have endorsed this protocol, few have committed to full compliance in the immediate future. As an alternative to a formal query language, programs such as GRATEFUL MED® (National Library of Medicine, Bethesda, Maryland) have been developed to facilitate end-user searching through the use of search templates and graphical user interfaces. Even so, users still must learn the details and idiosyncrasies of interacting with the various online information sources.

In an effort to overcome or at least reduce the constraints of online information access, the authors and others are pursuing the ideal of a network workstation [4–5]. A network workstation would provide easy access to a variety of online information services. Workstations would be available throughout the medical center and would not require users to be familiar with the details of operating the machine, establishing a connection, or conversing in a query language. Furthermore, this system would be capable of maintaining and displaying multiple simultaneous sessions with diverse information sources. For example, clinicians would be able to enter drug orders for a patient by using an order entry system while looking up dosage recommendations using an online drug reference. In addition, information could be exchanged among these various online systems in either a user-guided or automatic fashion.

Initial work toward this ideal began a few years ago with development of a prototype known as NetMenu [6]. Developed on a Macintosh computer with HyperCard software, the prototype offered the user a window into a world that emphasized information services rather than technological hurdles. Information services appeared as if they were personal computer programs and thus could be integrated with other familiar programs and utilities running on the desktop computer. The prototype was limited by several factors, including the performance of HyperCard and the inability to support other platforms such as the PC. Nevertheless, the prototype was valuable in illustrating the concept of providing naive users with transparent access to network-based information services. Surprisingly, computer and networking professionals were as impressed and inspired by NetMenu as were clinicians and biomedical researchers.

THE NETWORK WORKSTATION

Based upon the success of this prototype, in the fall of 1991 the authors began to develop a network workstation that would be practical for widespread deployment throughout the medical center. Like the prototype system, the new workstation was designed to provide clinicians and researchers with easy access to a growing number of network-based information services vital to their daily activities. The following discussion of the workstation highlights some of the problems encountered in its design and the role of NetMenu in addressing many of these problems.

In comparison to the initial prototype, the network workstation project posed additional challenges related to the medical center's diverse collection of information services, host computers, network communications protocols, and workstation hardware. As at many other medical centers, the School of Medicine and the Yale–New Haven Hospital are distinguished as separate legal and administrative entities. The medical school has large numbers of Macintosh computers as well as PCs, while the hospital has a standardized system of IBM PS/2 personal computers. Similarly, Ethernet and Local Talk dominate the school's local area networks, while Token Ring is the principal connection between hospital workstations and departmental computers. In regard to communications protocols, TCP/IP and AppleTalk are used widely in the medical school, while IBM NETBIOS, Novell IPX, and 802.2 are used on the hospital networks. Both institutions manage an assortment of host computers running a variety of operating systems, including IBM MVS, DEC VMS, and UNIX.

The information services provided also are highly diverse, not only in content but in terms of confidentiality, access restrictions, user interface, mode of connection, and relative importance to specific user groups. For example, the hospital's new physician order entry and results reporting system, referred to locally as CCSS (TDS Health Care Systems, Atlanta, Georgia), is important to practicing clinicians because it provides confidential patient information. CCSS restricts access on the basis of location and user identity, and it can be accessed only through the use of proprietary commercial software. A computer-based version of Current Contents, on the other hand, may be particularly valuable to researchers, imposes few access restrictions, and may be accessed using a variety of software products on different platforms [7].

THE NETMENU PROGRAM

To support users in this heterogeneous and ever-changing environment, the network workstation relies heavily on commercial networking and communications products. A new version of the NetMenu program coordinates the use of these commercial products to help the user choose pertinent information sources and connect to these sources expeditiously. To enable workers to interact easily with network workstations located throughout the hospital and university, the user interface has a similar look and feel, regardless of whether the platform is a Macintosh or PC. By using XVT (XVT Software, Boulder, Colorado), a cross-platform programming toolkit, the authors have built NetMenu as a graphical user interface application that runs on both the Macintosh and PC with Microsoft Windows [8]. In addition, with few modifications, the same source code can execute in character mode on a UNIX machine and a PC without Windows. The UNIX platform, operating in character mode, eventually may support dial-in access to the campus network from remote sites, providing the functionality of workstations connected directly to the network. Using XVT, one programmer completed the first phase of the NetMenu project in less than six months, a relatively short time for software development.

When not in active use, a network workstation may display the familiar network logo and a menu of specific services or categories of services (Figure 1). This top-level menu may list the information services used most frequently from that particular workstation (e.g., miniMEDLINE: Georgetown University, Washington, D.C.). The menu also lists the categories of services, such as "Library" and "Clinical Assistance." To see the specific services within each category, the user clicks the mouse over the category's name or icon, and a second-level menu appears on the screen. In this way, the NetMenu can provide access to a large number of services that are grouped in a logical fashion. From either the top-level or second-level menus,

Figure 1
NetMenu, top-level menu of information services and categories of services

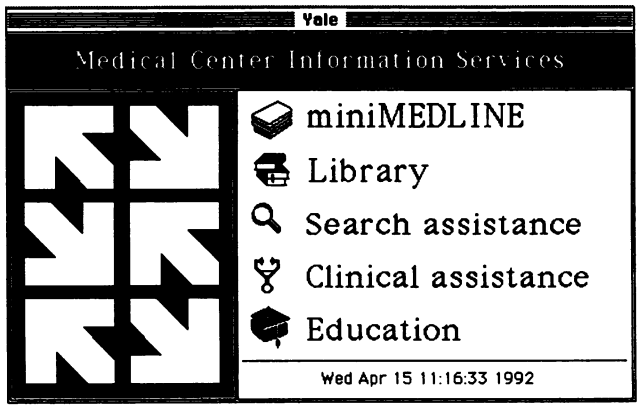
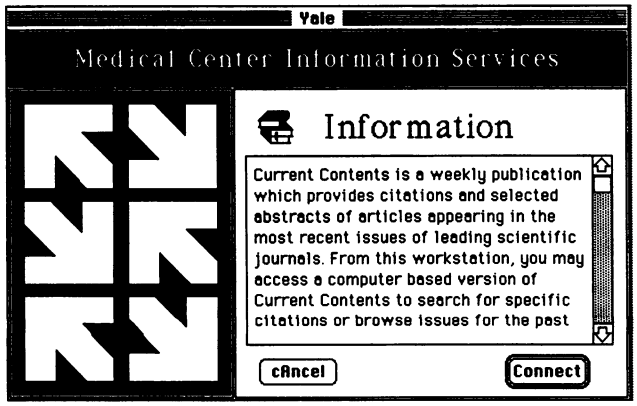


Figure 2
NetMenu, descriptive information about Current Contents—an information service listed in the library category



the user may proceed in two ways once the desired information service is found.

If the service appears in the top-level menu (e.g., miniMEDLINE), the user may click the mouse once or twice over the name or icon representing the service. A single click will call up a scrolling text box containing descriptive information about the particular service (Figure 2). To establish a connection and begin an interactive session, the user may click on the "Connect" button; pressing the "Cancel" button returns the user to the top-level menu. Alternatively, double clicking on the name of a service in the top-level menu immediately begins automatic connection to the service display of the descriptive information.

If the service appears in a second-level menu, the connection process can be activated by double clicking on the service name. Alternatively, a single click over the name will highlight that service within the list. The user then may press the "Info" or "Connect" buttons, either to view descriptive information or to activate the automatic connection process respectively.

The content of a particular NetMenu display is determined when the program is executed, based upon a configuration file maintained by the workstation administrator. In this way, a workstation can offer a different selection of services depending on its location, the specific services accessible from that location, and the most likely users. For example, in patient care areas of the hospital, a workstation initially displays a menu listing that includes the hospital information system (CCSS), miniMEDLINE, a drug reference program, and a category of services labeled consultation programs.

At present the NetMenu configuration file exists as an ASCII text file, which is maintained manually using a word processing program. Using a standard format and keywords, a workstation administrator specifies the arrangement of service or category names and icons in the top-level menu; the names of information services listed in the second-level menu; the names of script files to activate the automatic connection process; and descriptive information about each service. To simplify maintenance of the configuration file, the authors are developing a HyperCard program that will enable administrators to add, delete, and re-arrange the names of services based upon a master catalog of information services, such as the ISM. The "configurator" program then will automatically generate a new configuration file.

CONNECTING TO AN INFORMATION SERVICE

To initiate a connection to an information service, the NetMenu program either launches or transfers control to a commercial communications application (e.g., Dynacomm Asynch, Future Soft Engineering, Houston, Texas), typically stored on the workstation as part of the overall system. This application executes a predefined script to log on to the requested information service. In some cases, the script may prompt the user to enter specific sign-on codes required by the information service. Each script is designed to operate with a specific communications application and may be precompiled for storage and retrieval from a network file server.

Naturally, there are significant tradeoffs involved in the decision to use commercial communications applications versus building specialized communications programs. In making this decision, the authors considered a number of important issues concerning flexibility to customize the user interface; capability to control or limit the user's actions; the exchange of information between NetMenu, ISM applications, and networked information sources; the need to support many diverse network protocols; the complexity of network communications programming; and the costs of short-term implementation and long-term support.

The second issue, listed above, concerns maintaining rigid control over what actions users may perform on a network workstation. On many public machines, the author would like to prevent users from altering the workstation's configuration by changing communications parameters, or by resizing, closing, or moving windows around the desktop. Although such actions may increase the versatility of a workstation in the hands of sophisticated users, these actions may render a workstation entirely useless to unsophisticated users. It was therefore important for the network workstation to control or limit the user's actions.

Custom-built software is one approach that could be taken in addressing many of these important is-

sues. Although a customized application might be expensive to build initially, the long-term costs might be lower if the program was distributed widely and the project was financed centrally.

On the other hand, communications programming is complex—even programming for a single platform and single protocol. To support a heterogeneous environment, communications applications had to feature multiplatform and multiprotocol support. Fortunately, an increasing number of commercial communications products are available for the Macintosh and PC that meet many of Yale's specifications. These products are extremely powerful in terms of offering multiprotocol support, rich scripting languages, facilities for exchanging data with other applications, and facilities to customize and limit the user interface.

On the PC/Windows platform, the authors chose Dynacomm Asynch (Future Soft Engineering, Houston, Texas) as the communications application. In addition to featuring an extremely rich scripting language, Dynacomm Asynch supports a variety of dial-up and network connections using network modems, NETBIOS, and TCP/IP, to mention just a few. A Dynacomm product featuring the same scripting language is also available for the Macintosh. However, the current version does not support direct network communications, so PacerTerm (Pacer Software, La Jolla, California) had been selected as the principle communications application for the Macintosh. A major upgrade to the Macintosh Dynacomm product is reportedly in progress. When this upgrade becomes available, PacerTerm may be replaced with Dynacomm, thereby simplifying the creation and maintenance of scripts, and standardizing the user interface for both platforms.

In addition to automating the sign-on process to an information service, scripts are being used to enhance and even to replace the traditional character-based user interface offered by many host systems. For example, by adding a menu bar to the user interface of the Micromedex drug reference (Micromedex, Denver, Colorado) mounted on a main-frame computer, the user's task of navigating through this complex and multifaceted reference is simplified. The scripting language also is used to add "buttons" to the user interface, allowing easy execution of common functions, such as printing a few screens. To enhance sessions with miniMEDLINE, a button may be added to allow users to order reprints of referenced articles. The script could send an electronic mail message to the library, requesting that a reprint be prepared and mailed to the user. A similar feature, enabling users to order reprints, is available through other bibliographic retrieval systems, including LOANSOME DOC℠ service provided through GRATEFUL MED.

For a variety of practical reasons, the system also must support PC network workstations that do not run Windows. For this DOS platform, Crosstalk Mark 4 (DCA, Alpharetta, Georgia) was chosen based on its scripting language and broad multiprotocol support. Obviously, this platform limits capabilities for enhancing the user interface and facilitating data exchange between information services. To limit the user's actions, memory resident programs have been built that remap keys and key combinations, effectively disabling access to specific functions of the communications program. One possible enhancement would be the use of a task-switching or multitasking program. For a variety of technical and practical reasons, development activities are restricted to functions required to simplify workstation operation by the most inexperienced users.

In the present environment, workstations use two protocols to manage communications with information services. In the School of Medicine, computers generally communicate with TCP/IP. Macintosh workstations use MacTCP (Apple Computer, Cupertino, California), while PCs running DOS use PC/TCP (FTP Software, Wakefield, Massachusetts). Within Yale-New Haven Hospital, most workstations are connected to an IBM Token Ring network. Workstations establish connections using either 802.2 or NETBIOS, depending upon the requested information service. To minimize the software requirements of each workstation, NETBIOS is used first to establish a connection to an IBM Asynchronous Communications Server (LANACS), which in turn connects to information services through a network modem or directly using the TCP/IP protocol.

In some cases, an information service might be an application that executes on the network workstation itself and is stored locally or on a network file server. The user begins operation of the application by selecting its name and pressing the "Connect" button in NetMenu. Examples of local applications that may be launched by NetMenu include Hypercard-based teaching programs for the Macintosh and CD-ROM retrieval programs that could access a network CD-ROM server.

THE INFORMATION SOURCES MAP

Although the NetMenu program is capable of listing a large number of information services on second-level menus, the authors favor restricting these lists to services that are especially important to users and are accessed frequently. Other than displaying descriptive information about sources, NetMenu does not assist users in selecting sources pertinent to answering a specific question. In an effort to provide this kind of assistance to biomedical professionals, the authors are implementing and refining a local

prototype of an information sources map to assist NLM in determining the appropriate structure and content of the UMLS Information Sources Map.

The ISM is a directory of information services. Application programs will read the ISM to help the user determine what sources are available and which ones might be most relevant to a particular question. In addition, once an information source is selected, the application program may help establish an automatic connection to the source. To provide these functions, the ISM will contain a variety of information about each information source, including the name, the provider or owner, a text description, content type (e.g., bibliographic citations), targeted audience, network communication scripts to allow automatic connections, data input templates to facilitate the exchange of data between sources, and information to be used in determining the relevance of the source to a user query.

One major focus of UMLS has been the construction of the Metathesaurus to facilitate the translation of medical terms from one vocabulary to another [9]. Ultimately, the Metathesaurus may be very useful in automating the transition between information sources that use different vocabularies, such as ICD-9 and MeSH®. To complement the Metathesaurus, a Semantic Network has been constructed to represent the "relationships among the broad categories or semantic types to which all concepts in the Metathesaurus are assigned" [10]. A third UMLS knowledge base being developed is the ISM, or a directory of information services [11]. Application programs will read the ISM to help the user determine what sources are available, and which might be most relevant to a particular question. In addition, once an information source is selected, the application program may help make an automatic connection to the source. To provide this functionality, the ISM will contain a variety of different information about each information source, including the name; the provider or owner; a text description; content type (e.g., bibliographic citations); a variety of descriptions of its subject coverage; targeted audience; network communication scripts to allow automatic connections; data input templates to facilitate the exchange of data between different sources; and information to be used in determining the relevance of the source to a user query.

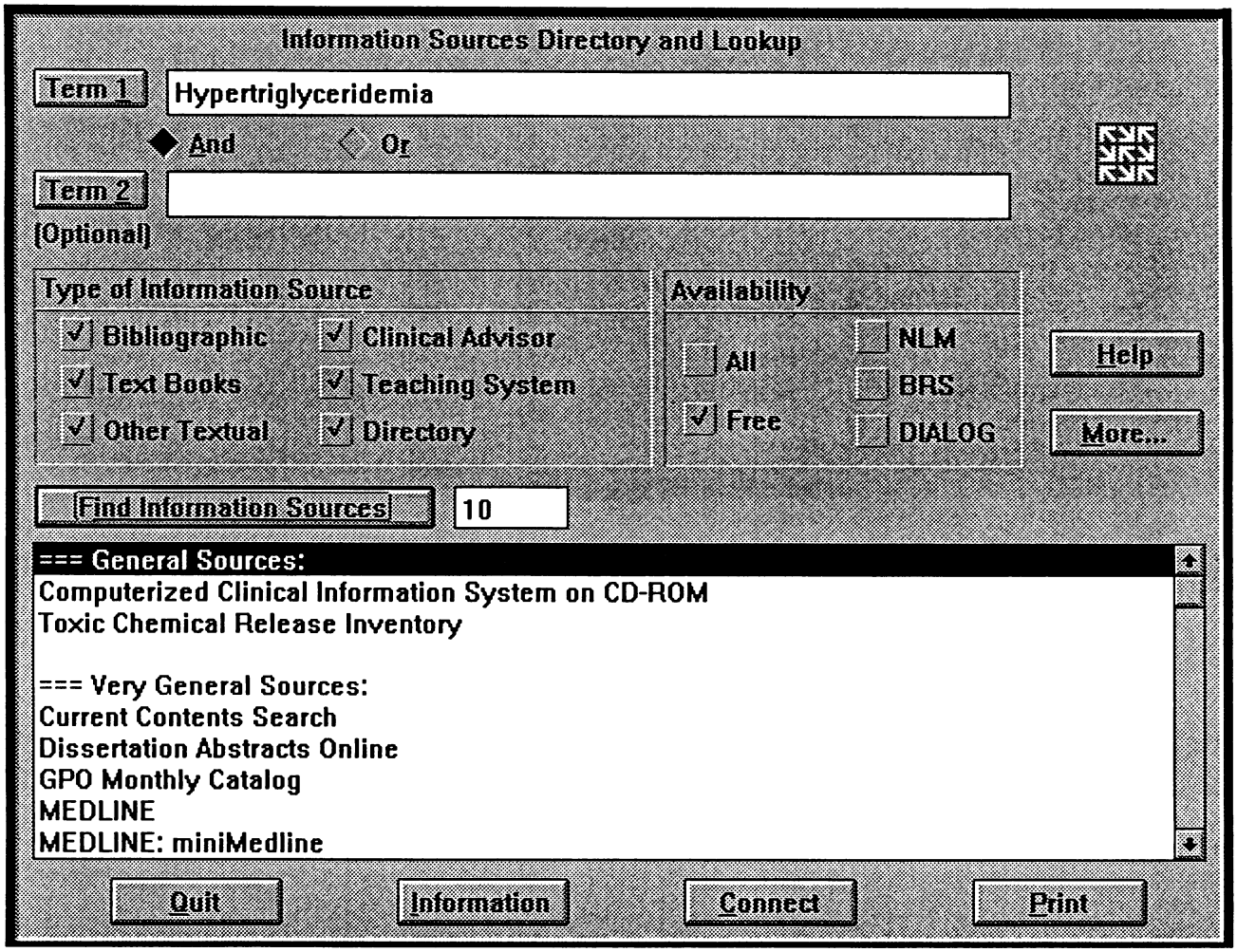
To explore what type of information would be most useful in the UMLS ISM, the authors initially built a prototype containing 112 information sources currently available through local and national networks. Most sources were chosen as representative examples from a directory of online databases and can be divided into five broad categories: clinical medicine, drug information, biomedical research, environment, and agriculture [12]. The actual entries in the prototype ISM are quite diverse in scope, depth, and degree of relevance to biomedicine. The primary focus was on commercially accessible online databases, but a number of other types of information sources were included, such as clinical consultation and medical teaching programs.

To assess the relevance of an information source to a user query, the various sources were coded from the perspectives of subject content and expected use. Initially, the subject content of each source was described with a series of high-level Medical Subject Heading (MeSH) terms and UMLS semantic types. Based on preliminary testing, however, it was determined that MeSH term indexing affords greater discrimination among information sources possibly relevant to a query [13]. To enhance further the process of selecting sources, several characteristics of the sources were defined, including the likelihood of using the source in particular settings (e.g., patient care, clinical research, basic biomedical research, and health services research); the degree of systematic coverage (e.g., comprehensive or sporadic); the degree of consensus or review to be expected in material retrieved from the source (e.g., NIH expert panel recommendations or letter to the editor); and the type of information offered by the source (e.g., bibliographic citations, patient records, clinical advice, and medical teaching).

For preliminary testing of the prototype ISM, an interactive query assistant program was constructed to run on a Macintosh. The function of the query assistant program was to take, as input, one or two query terms and generate a list of information sources which might be relevant to the question expressed by the query terms. First, the query terms are mapped to corresponding MeSH and semantic types using the Metathesaurus. Second, the user specifies additional characteristics of the sources that might be relevant. The query assistant program then selects sources by comparing the ISM entries for each source with the query, using the subject content index terms and other coded characteristics. A source might be selected if, for example, one of its MeSH or semantic type index terms matches or is the parent of a query's MeSH or semantic type.

Using thirty representative queries compiled from an NLM test set, the authors tested the ability of the ISM coding to discriminate among sources possibly relevant to a query. The codings were useful in partitioning the information sources, allowing a subset of sources to be retrieved for a specific query. Coding of subject content by MeSH terms afforded better selectivity than coding by semantic types, the difference being most pronounced with health services research queries. Finally, the additional characteristics coded in the ISM enabled even further discrimination between sources. The main purpose of this study was to explore issues in coding information sources; other

Figure 3
Beginning operation of query assistant

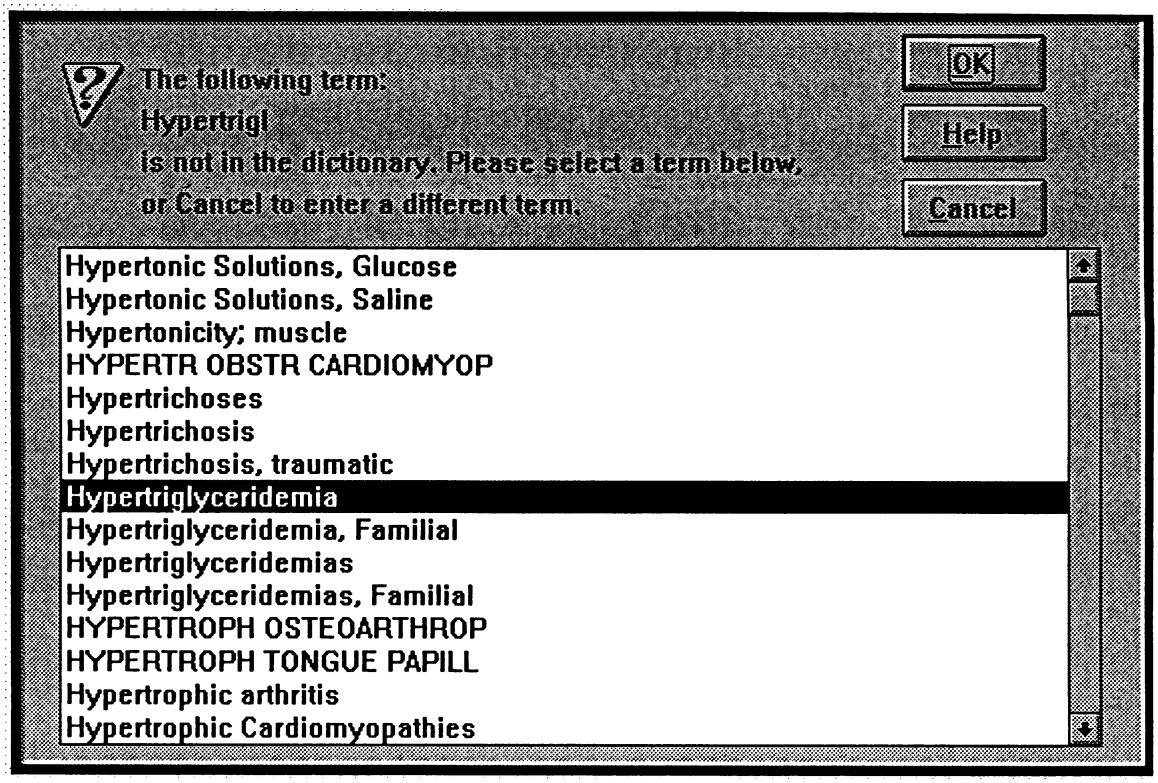


workers have conducted experiments to assess the accuracy of the selection process itself, i.e., the actual relevance of selected sources [14].

Based on this work with a prototype ISM, a new version of the query assistant program was constructed that would be practical for wider deployment and testing within the institution. Unlike the prototype application, which is six megabytes in size, the new query assistant application was developed to function in a client-server model. The client portion of the program simply manages the graphical user interface and operates on a Macintosh or Microsoft Windows platform. In addition, the client program allows automatic connections to sources selected by the user. The client interacts with the server, which resides on a networked UNIX machine. The server program contains the engine to search the ISM and Metathesaurus, in helping users to select relevant information sources. The client portion of the query assistant program was built using the Dynacomm scripting language, which is ported easily between the Macintosh and Microsoft Windows.

To begin operation of the query assistant, the user fills in text entry and check boxes to describe the question at hand and the kinds of information sources the user feels might be helpful (Figure 3). For example, to identify sources that may provide information about both hypertriglyceridemia and heart disease, the user first types "hypertriglyceridemia" in the box labeled "Term 1." When the return key is pressed, the term is transmitted to the ISM server along with a request for the names of sources that

Figure 4
List of alphabetically close terms



might offer information about hypertriglyceridemia. The ISM server then attempts to locate the term in the Metathesaurus. If an exact match is found, then the server uses the term to generate a list of pertinent information sources. The list is displayed in a box in the lower portion of the display.

If there is no exact match to a term in the Metathesaurus (e.g., because of a misspelling or the use of a variant term), the server returns a list of alphabetically close terms, which are displayed in a dialog box (Figure 4). The user may choose from this list the most appropriate substitute term to be used by the server in selecting sources.

To narrow the list of possible information sources, the user may type a second term, e.g., "heart disease," in the text box labeled "Term 2." The default "AND" check box is selected to request the names of sources offering information about both terms. When the return key is pressed this time, both terms are sent to the server. The returned list of information sources may be refined further based upon specific criteria and interests indicated by check boxes in the middle of the screen.

From the list of suggested information sources, the user may select a specific source and initiate an automatic connection by pressing the "Connect" button. To accomplish this, the query assistant requests information from the server on how the source is accessed. Often, a specific source is available through several networks or information vendors (e.g., from the NLM, BRS, or DIALOG), each requiring passwords and the use of different query languages. In these instances, the user is asked to choose from the list of vendors or networks. Finally, the query assistant program requests from the server information for use by a communications script, which is executed to establish a connection.

The authors are currently in the early stages of deploying network workstations and NetMenu within the Yale Medical Library. These versions of NetMenu allow access to a variety of bibliographic systems, including ORBIS (the Yale University Library catalog implemented with NOTIS), mini-MEDLINE, and Current Contents; a search assistant tool, which performs automated Metathesaurus term look-up and expansion to potentially related MeSH

terms; two clinical advice programs (COAG-ADVISOR and HEPATITIS-ADVISOR), running at the Center for Medical Informatics [15]; and several teaching programs, which run locally on the Macintosh workstation. In the near future, the ISM query assistant program will be added to the list of services accessible from NetMenu. In addition, a Microsoft Windows version of NetMenu will be installed soon at the Library of the Department of Epidemiology and Public Health, and a DOS character version as a clinical workstation at a number of locations within Yale-New Haven Hospital. Users who dial into the network from outside the medical center will be able to access network information services by interacting with the DOS character version of NetMenu running on a Chaterbox dial-in system (J&L Information Systems, Chatsworth, California).

DISCUSSION

The work just described represents the first of many phases in a project to deploy network workstations throughout the medical center. The NetMenu program has been constructed to coordinate a variety of commercial communications products, enabling inexperienced users to select and access a number of important information services in an easy, intuitive fashion. To supplement NetMenu, an ISM query assistant program has been constructed to help users select relevant information sources from a large number of diverse sources accessible through local and international networks. At present, NetMenu serves as an application launcher (e.g., shell) and help facility. In a later phase of the project, the program will be enhanced to help simplify access to information services that require personal identification and passwords. For this purpose, authentication systems such as Kerberos could be incorporated into the NetMenu program to interact directly with other network-based authentication modules [16].

In addition, NetMenu eventually will play a more active role in coordinating the exchange of information between network services and workstation-based applications designed for decision support and the presentation of clinical data. By using the emerging technologies for interprocess communications on popular computer workstations (e.g., publish/subscribe, dynamic data exchange [DDE], and object linkage embedding [OLE]), NetMenu and related programs might help facilitate the desktop integration of medical information. Such integration has been difficult to achieve, due to the architecture of traditional information systems. This situation should change as workstations become more powerful and more accessible to health care professionals.

Over the past several years, there has been considerable interest in facilitating the retrieval of information from an increasing number of online databases. In the commercial sector, Telebase (Malvern, Pennsylvania) offers a service that allows a user to search a number of diverse online databases using a single query expression. The Wide Area Information Server (WAIS) project is another example [17]. Developed by a consortium of four corporations (Dow Jones & Co., Thinking Machines Corp., Apple Computer, and KPMG Peat Marwick), the WAIS project has established a uniform protocol to enable inexperienced users to search a number of free text database servers, accessible via local and national networks. First, the user must choose specific WAIS servers that might contain information or documents relevant to a query. For assistance in choosing these servers, Thinking Machines has created a Directory of Servers with indexed textual descriptions of all known servers.

Compared to the Telebase and WAIS systems, the approach described in this paper differs in a number of respects. Most importantly, NetMenu and the ISM query assistant do not interact directly with online information sources other than the ISM itself. As a result, individual documents or citations are retrieved through further interaction with specific information sources using their respective query languages. The Telebase system uses a "brute force" technique to select relevant information sources. To the author's knowledge, Telebase makes no attempt to narrow the assortment of information sources based upon the specific query. Every source listed in a domain category is searched automatically. By contrast, the ISM query assistant helps the user narrow the selection of sources.

In effect, the query assistant provides a function somewhat analogous to that provided by the WAIS Directory of Servers. Unlike the ISM, the WAIS Directory of Servers does not use standard, consistent information to index databases available on WAIS servers. The ISM query assistant program does not restrict the user to only those information sources that comply with the WAIS communications protocol; instead, a user may connect to many different types of local and remote sources using diverse communications protocols. In addition, NetMenu provides a direct connection to local information sources without the need for an intermediate server. The ISM is also unique in being customized for biomedical information sources by incorporating special codings for subject content and additional characteristics. The WAIS and ISM approaches are complementary, however. The WAIS servers each can be viewed as online information services that may be cataloged in the ISM. By using the WAIS protocol, available in the public domain, the authors eventually may augment the query assistant program so it can interact directly with WAIS servers accessible via the Internet.

CONCLUSION

Two complementary methods have been developed to facilitate the selection of relevant online information services and to provide easy access to these services. The NetMenu program operates on both personal and public network workstations and may be customized for the information sources available from particular locations as well as for the needs of its primary users. On the desktop machine, NetMenu guides users in connecting to common sources of information and could coordinate the exchange of information between these sources.

Whereas NetMenu offers access to an important subset of services, the ISM query assistant helps users select from a comprehensive collection of biomedical information sources. The ISM knowledge base and server reside on a central machine, thus enabling frequent revisions and Internet access by a large number of clients. In the future, as medical libraries become more electronic and less centralized, facilities such as NetMenu and the ISM may become powerful tools to help biomedical professionals navigate through vast stores of information and tasks that may become indispensable in the performance of their daily work.

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