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ABSTRACT

A central feature of the High Performance Computing Act of 1991 is the establishment of a National Research and Education Network (NREN). The level of access that teachers and teacher educators will need to benefit from the NREN and the types of network resources that are most useful for educators are explored, along with design issues that are crucial for implementing networking in the schools. Some of the factors that must be considered have been identified from the experience of the Unified Network for Informatics in Teacher Education (UNITE) networking project implemented in Kansas. The following desirable features are suggested by the UNITE experience: (1) realistic management of expectations; (2) establishing local links to wide-area networks; (3) wide-area network services, such as the INTERNET; (4) wide-area network interfaces for teacher education; (5) dynamic resources that are published for the community; and (6) attention to social and administrative considerations. Three figures illustrate the discussion. (Contains 14 references.) (SLD)

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Wide-Area Network Resources for Teacher Education

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Imagine leading a classroom discussion and being able to immediately display any text, instructional software, or video resource that fit the direction of an evolving debate. Later your students engage in an inquiry activity supported by information that they gather from immense network data bases on such topics as population demographics, employment statistics and longitudinal national weather records. Finally, you consult your personalized electronic newspaper and send an E-mail question to the author of an article that describes an alternative data base inquiry activity. Such scenarios may soon be actualized through recent advances in computers and the improving climate toward establishing wide-area national networks.

On December 9, 1991, the president authorized the High Performance Computing (HPC) Act. For 1992, legislature appropriated nearly $600 million to eight agencies (DARPA, NSF, DOE, NASA, EPA, NIST, NOAA and Education) in support of HPC. If fully appropriated, federal funding for HPC from FY 92 to FY 96 will approach 3 billion dollars. A central function of HPC is to establish the necessary policy and resources for implementing a National Research and Education Network (NREN). Among other goals NREN will seek "...to expand the number of researchers, educators, and students with training in high-performance computing and access to high-performance computing resources; and to promote the further development of an information infrastructure of data bases, services, access mechanisms and research facilities ..." (Public Law 102-194; section 3,1).

NREN will greatly improve the volume and speed with which the rapidly growing pools of electronic–based information are delivered. By 1996, NREN will be capable of transmitting at least a billion bits (gigabits) per second (Gore, 1991), thereby opening a new gateway to a vast array of electronic-based information resources. What level of access do teachers and teacher educators need to benefit from this electronic superhighway? What kinds of network resources are most useful for educators? What design issues are crucial for the successful implementation of networking in schools?

The UNITE system

This paper discusses factors to consider when developing wide-area network resources for educators. Some of the recommendations come from experience and research compiled over a two year period in association with the Unified Network for Informatics in Teacher Education (UNITE) networking project that was initiated through a grant from the Apple Corporation. UNITE is a prototype for linking educators who are geographically separated but share common goals for advancing teacher education. UNITE targets four constituencies concerned with teacher education: student interns, classroom teachers, administrators and teacher educators. These constituencies exchange ideas through electronic mail and community published resources on instructional software, lesson plans, field trips, mentor profiles and research abstracts. The UNITE stations are located in the school's library or staff development area. A school-based liaison team, consisting of an administrator, a teacher, a librarian/computer specialist and if available, a teacher education intern, monitors use of the stations. Student involvement with UNITE centers on cross-school discovery activities intended to extend data collection and analysis across content, grade levels and schools.

In September 1989, dedicated UNITE stations consisting of a Macintosh SE, modem and printer, were established in six secondary, five middle and five elementary schools representing six eastern Kansas school districts. The schools connect to the hub computer at the University of Kansas for updating the mail and resource files. The transmission speed is slow (1200 baud). However, the system is capable of emulating the immediacy of faster transmission speeds by making transfers at night and using the local hard drives for storing files. The disadvantage of this method of distribution is that the quantity of immediately available resources is limited to the size of the local hard drives. Also, as a prototype that has seen many changes to accommodate user preferences, reliability has suffered and we are considering "freezing" the system in a more dependable configuration. The following recommendations are for extending navigational aids, such as UNITE, to take advantages of the growing quantity resources available through wide-area networks.

Expectation Management

Introduction of educational innovation requires a delicate balance between enthusiasm and realistic goals. On the one hand, administrative support is needed to launch innovative projects but too much enthusiasm can breed unrealistic expectations. Obtaining this balance can be especially challenging, given the administrative procedures for allocating projects within local educational agencies and because there are unique reward systems for school of education faculty, practicing teachers and school administrators.

During the initial administrative orientation, presenters explained that the UNITE resource catalogs begin as "empty" vessels to be filled over time by the constituents. Even with this explanation, messages conveyed to some teachers suggested that a complete compendium of resources would be available shortly. When introducing innovation, developers should consider a separate session for administrators that explicitly deals with the importance of expectation management. Network representatives may also wish to stipulate that the participating schools must demonstrate an intact support system for computer maintenance and training before establishing wide-area services.

Establishing Local Links to Wide-Area Networks

Each of the 17 participating K-12 schools has a single UNITE station. We used the approach of distributing stations across several schools, as opposed to more stations in fewer schools, in order to gain feedback from a variety of grade levels in urban, suburban and rural settings. As the project progressed, an increasing number of teachers expressed the need for network connections from classrooms. These teachers explained that classroom network access would allow them to use the network more frequently and offer more opportunities for student involvement.

Many advances in connecting computers have emerged since the beginning of the UNITE project and networking cost have decreased significantly. Currently, the best first step in introducing wide-area networking may be to establish a reliable Local Area Network (LAN) with computers in classrooms. The computers, connections and the networking software used in forming a LAN vary considerably. Generally the LAN should support printer sharing, electronic mail, access to a central server and be capable of exchanging files at a rate of at least 10 million bits per second.

There are several advantages in establishing a school-wide LAN before introducing wide-area networking services. A LAN is a good platform for familiarizing users with the computers, network services and the training provided by local networking administrator. If the local support is not sufficient to maintain a reliable LAN, it will not support extensive use of wide-area services. After establishing a reliable LAN, you can attach a network "bridge" to allow all users on the LAN to access to wide-area network services.

Wide-Area Network Services

Many of the regional networks, that center on universities, government, and large businesses, are now connected to form the Internet (the precursor to the proposed higher speed NREN). Users of the Internet can exchange mail, make use of the higher processing capabilities of super computers and access resources servers across the Internet. The number of servers on the Internet is growing exponentially. These servers allow users to gain access to any information represented in a digital format including: text of newspapers and online journals, instructional software, terrain maps based on satellite imagery, and more recently, full motion digital video that is compressed in digital formats such as QuickTime™. Some of the fastest growing servers are those that adopt the file transfer protocol developed by The University of

Minnesota's "Gopher©" group, another file transfer system developed at Dartmouth called "Fetch©" and the text searching system for accessing information from the DowQuest™ developed by Thinking Machines Corporation called "WAIStation©." Because some of these developers openly encourage other to establish additional servers that use their protocol, the number of servers and thus the overall amount of information available through the Internet is likely to continue to grow at an exponential rate.

The standard for routing information on the Internet is the Transmission Control Protocol/Internet Protocol (TCPIP). Each computer using TCPIP must have a unique IP number for routing information requested from servers back to that computer. Thus, to connect a LAN to the Internet the school's network administrator will need to acquire a network bridge, a high speed data line to the Internet (preferably one that transmits at least 56 thousand bits peer second -- 56Kbps), and a series of unique IP numbers that anticipate growth across the school or district.

Designing Wide-Area Networks Interfaces for Teacher Education

Even with the vast amount information available through wide-area networks, it will be important that teachers and teacher educators immediately recognize the usefulness of available resources. Teachers need a navigational aid that assists them in integrating resources into their curricula. The resource navigation component of UNITE (Figure 1) serves this purpose through a framework for accessing and contributing to the catalogs of dynamic resources. Currently, the navigator has 16 content hierarchies (Language Arts, Math, Science...), with several hierarchies having over 100 sub-categories. Each content hierarchy is further expanded by cross-referencing with the primary support categories of administration, courseware, research and teaching. The navigator's links to instructional support are shown as icons representing the resource catalogs for: Field Trips, Lesson Plans, Courseware Descriptions and Research Abstracts.

Besides assisting teachers in integrating resources, we assumed that the resource navigation system must be easy for teachers to use. Others have noted the need for developing intuitive intefaces in public school computing networks (Bull et. al., 1993). However, a design that one group of educators finds intuitive may be difficult for another group. For this reason, we adopted a rapid prototyping (Tripp & Bichelmeyer, 1990, Carrol, 1990) approach to development that involved educators from several constituencies in evaluating designs (Aust & Klayder, 1991).

The current design emerged over a two year period and included five version upgrades. After each version release, users sent recommendations to the "Catalog Critics" special interest group on the electronic mail system. As the users worked with each prototype they began to comment on design issues and common preferences soon emerged. User recommendations resulted in changes to the icon design and placement, consistency, feature names and a general simplification of the interface. Without this rapid prototyping approach the design of the resource navigator would have been considerably different and likely less useful to educators.

The recently developed navigation systems by the Gopher© (Figure 2) and Fetch© (Figure 3) groups also provide insights for developing effective wide-area network navigation systems. Gopher and Fetch are both more open development environments than the UNITE resource navigator. They allow the server's systems operator to establish the content hierarchy those best suits local needs. Clearly, this strategy has been successful in terms of causing a proliferation of servers across the Internet. However, as the number of open content hierarchy servers expands, the number of "wayfinding" problems that cause users to become lost in hyperspace will likely increase as well (Kerr, 1986; Kinzie et. al., 1990).

A standard for organizing teacher education resources on wide-are networks is needed. The content structure of this standard should accommodate a variety of curricula so that teachers will easily understand how the resources are integrated with their existing teaching strategies. Other categories to consider for this standard include: media format, length, appropriate grade level, prerequisite skills, geographic stipulators, publisher, and support categories such as classroom use or professional development.

Community Published Dynamic Resources

The UNITE catalogs of instructional resources are dynamic because any user on the system can expand or modify them through a contribution and review process. Each catalog is essentially a distinct data-base consisting of tailored fields such as subject descriptor, grade level, equipment requirements and publisher. These catalog fields provide necessary indexing information for conducting multiple key word searches. In some cases, resource described in the catalogs can be previewed directly. For example, after reading a description in the courseware catalog, users can immediately preview instructional shareware packages.

The development of the dynamic resources follows recommendations for teacher collaboration and empowerment (Goodlad, 1990; Grady, 1988; McDonald, 1989; Maeroff, 1988). Instead of imposing top-down "expertise," contribution tools encourage educators from all constituencies to participate in both contributing and reviewing resources. Any user can contribute a suggestion by first selecting the "Add a New Resource" or the "Modify an Existing Resource" option. Users follow a step-by-step procedure as they are guided through the contribution process. When a contribution arrives at the hub, a message is sent to all reviewers explaining that a resource is available for review. Reviewers are extended throughout the system and may include representatives from all constituencies.

Once a resource is requested by a reviewer, it is unavailable to other reviewers until released. This avoids conflicting reviews. During the review process the reviewer and author often communicate through electronic mail to exchange suggestions or resolve concerns. Once approved, a new or modified resource becomes available across the network for use and/or further modification. Names of the original author and reviewer as well as the names of any other contributors or reviewers are listed with each resource entry.

An evaluation of resource usage patterns and observations of UNITE users revealed several insights concerning the use of computer based resources by educators. First, many users expect vast amounts of information under each resource category and if their favorite category is low in resources they lose interest quickly. Also, different constituencies prefer different resource categories. For example, teacher education majors prefer catalogs of lesson plans whereas practicing teachers prefer resources of a timely nature or regional specialty. Some of the most often used and best received resources are those developed for local use, such as data bases of field trips. Searching mechanism for large scale database should include indexes (e.g., by county) for tailoring searches to regional interests.

Regarding community publishing, users who publish on networks become vested and are more likely to continue network use. In a vote during one UNITE project, teachers unanimously preferred a peer review, as opposed to an administrator controlled, process for monitoring publication on the system. We also found that the teacher education constituency most likely to freely contribute resources are teacher education students. Most teachers, on the other hand, will expect some form of compensation for contributing resource entries. This compensation may be in the form of monetary reward, release time, course credit or additional access to networking resources.

Social and Administrative Considerations

Many of the initial social and administrative barriers to electronic networks may be overcome by providing direct and immediate access for all teachers. After conducting a naturalistic study (Guba, 1981) on the implementation of UNITE, Bichelmeyer (1992) concluded that the integration of technology in schools is often constrained by a Teacher Needs Hierarchy. This hierarchy's contingency schedule is similar to Maslow's Human Needs Hierarchy where level one must be reached before level two is reached and so on. She proposed the following steps in the Teacher Needs Hierarchy: (1) Time and Accessibility, (2) Dependability, (3) Vesting, (4) Control, (5) Integration.

As Cuban (1986) documented, the initial enthusiasm for technological innovation often subsides rapidly if measures are not taken to manage expectations and renew interests. Much of the local enthusiasm is often associated with individual advocates whose status or popularity influences success. When these individuals leave a site the enthusiasm for "their" innovation often leaves with them. This is especially true when incoming technology mentors seek to make their mark by adopting and advocacy that differs from the predecessor. Advocates should attempt to extend enthusiasm so that all participants have ownership in the innovation -- an approach that may require significant restructuring of school's reward system.

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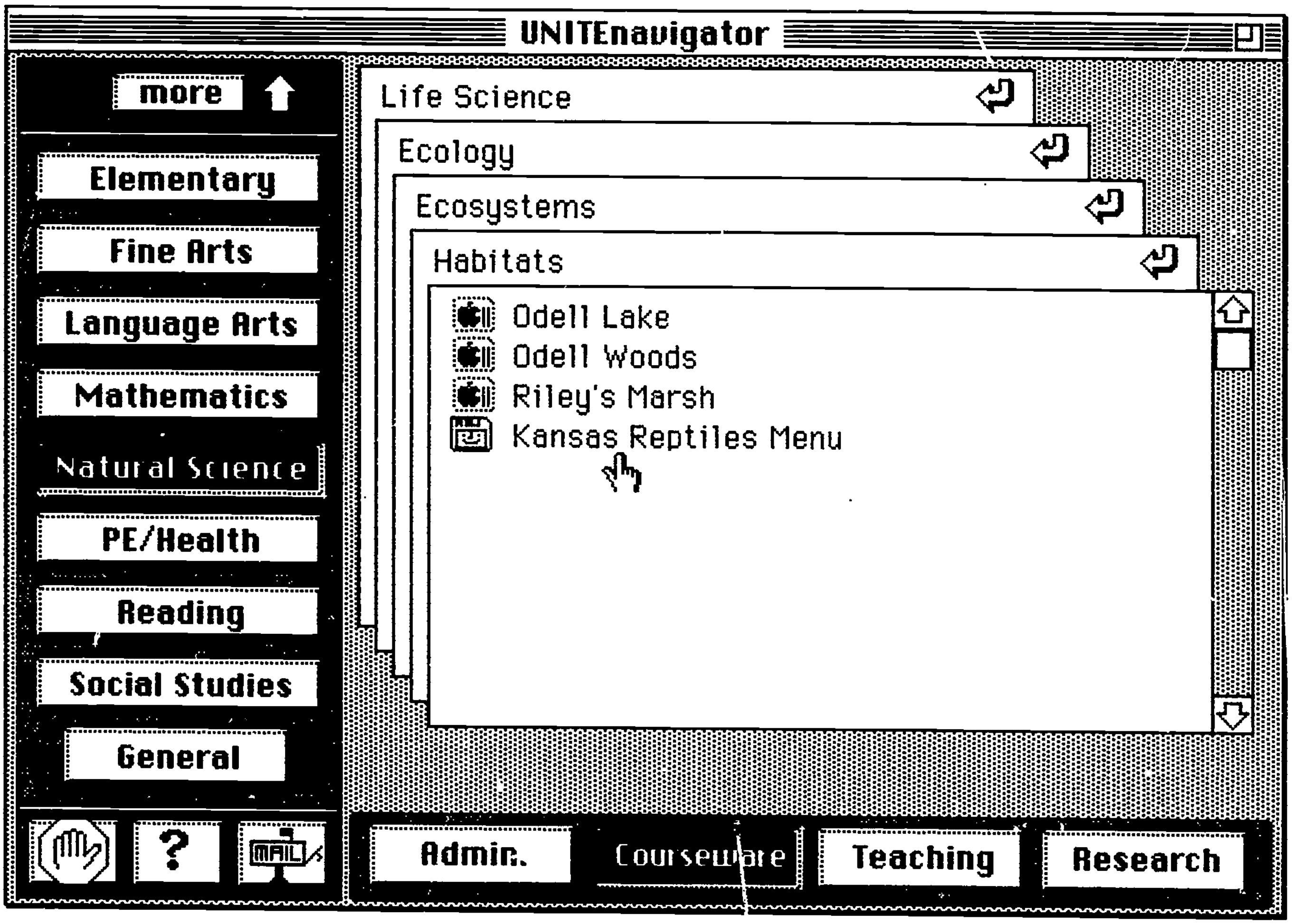
Figure 1

The UNITE Resource Navigator

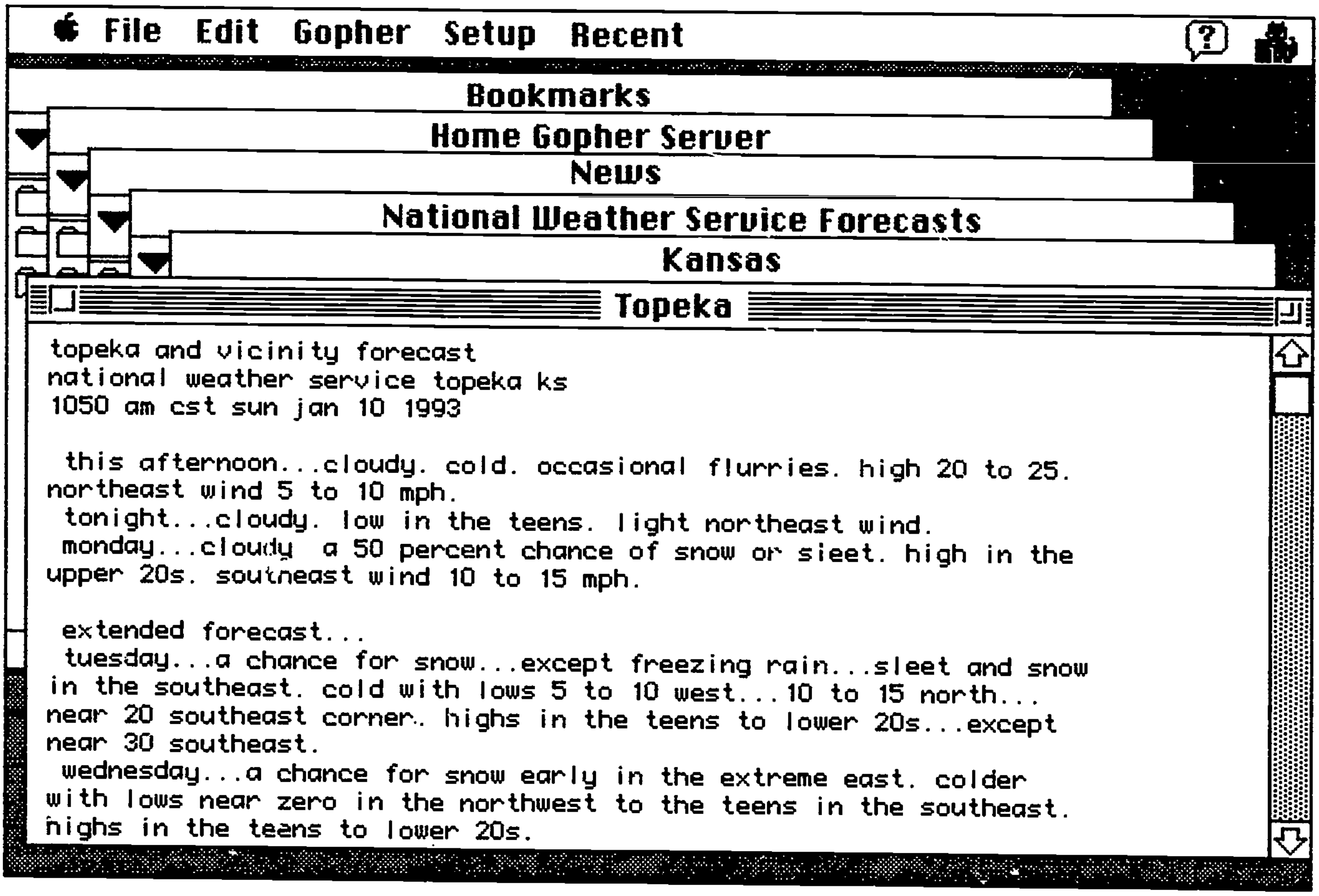


Content categories appear vertically along the left margin of the screen. The four support categories, Administration, Courseware, Teaching and Research appear horizontally along the bottom of the resource navigator. In this view the user began by selecting the support category for Courseware followed by the main content category Natural Science and then the sub-categories of Life Science, Ecology, Ecosystems and Habitats.

In this view the user is about to selected the software *Kansas Reptiles Menu* listed under the Courseware support for the selected content hierarchy. The dark icon in front of the listing indicates that the user will be able to directly preview this software on the UNITE system.

Figure 2

The Gopher© Navigational Interface

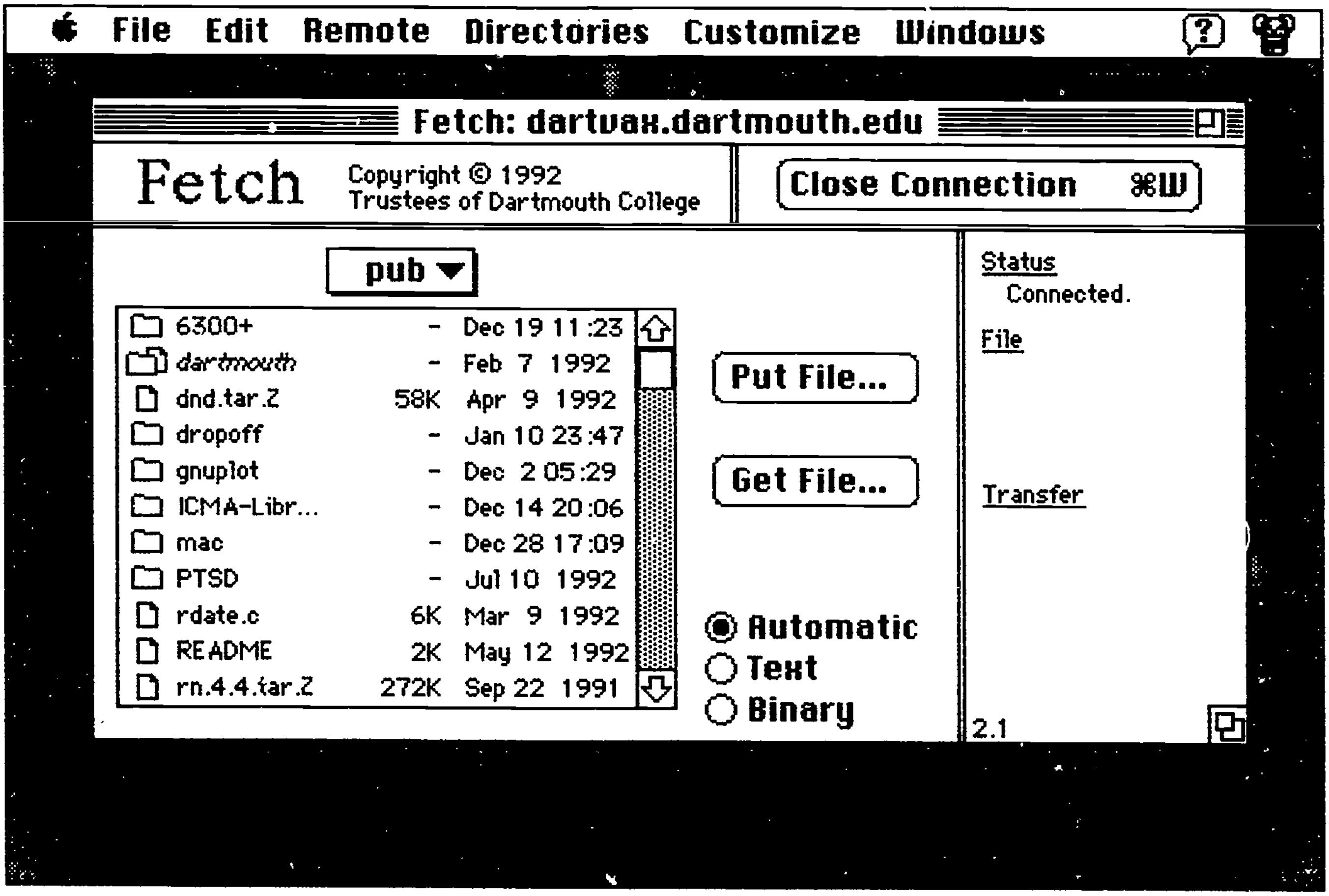


The Gopher© software and protocol were designed by the Gopher team at the University of Minnesota. Gopher is a fast and simple way for searching and distributing files that has gained considerable popularity on the Internet. Each server administrator determines the structure of the content hierarchy on their server. Gopher databases usually use full-text indexes meaning any word in the database is a key word.

In the above depiction the overlapping windows show the path the user took to obtain a regional weather report from the national weather service on the home Gopher server. The National Weather Service data base is updated frequently.

Figure 3

The Fetch© Navigational Interface



The Fetch© system was developed at Dartmouth College. Fetch uses the File Transfer Protocol (FTP) to transfer files on the Internet. The interface is similar to the one used by application programs to locate files on a hard drive.