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Indiana WETnet: A Virtual Water Resource

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INTRODUCTION

WETnet is a concept. A concept developed to help enhance and improve communication and information sharing amongst water resources professionals in the state of Indiana. We believe that by improving communication Indiana will be better able to understand and manage its water environment.

The Indiana Water Resources Research Center (IWRRC) here at Purdue University has been working on developing the WETnet concept for several years. The hope is that the IWRRC's relationship with the water community and our research and academic expertise with engineering information systems and digital internetworking will facilitate the development of the WETnet concept.

A World-Wide Web WETnet prototype server has been developed to demonstrate some of the possibilities of the concept. The WETnet server can be found at URL - http://ingis.acn.purdue.edu:9999/wetnet.html. This paper and other materials related to this work can be found there.

THE WETNET CONCEPT

The WETnet concept exists at the intersection of three familiar areas of interest as depicted in FIGURE 1. The concept is analogous to replacing the hardware and software domain with, say, transportation and lodging, and the intersection would then be a conference. That is to say that when you get a group of people who share a common interest to meet, discuss, and share their ideas then we generally call this a conference. The WETnet concept is similar except instead of traveling across roads and air routes and meeting in hotels and conference rooms, they are meeting, talking, and sharing their common content of interest in the virtual world of software built upon the infrastructure of telecommunications lines and computers. This virtual world is popularly referred to as cyberspace (Benedikt 1991).

Cyberspace is being built and populated at an incredible rate. Statistics on the growth rates change almost daily and projections for the future are nearly unfathomable. Just as humankind set out to explore and develop its physical world centuries ago, we are now exploring and developing a new digital world. As Nicholas Negroponte, Founding Director of MIT's Media Lab, says its all about "the difference between bits and atoms", that is that the economy in the future is going to be based on information, and bits are the DNA of information (Negroponte 1995). The atom-based physical products of today's and yesterday's agricultural and industrial economies will become secondary quantities. WETnet is about developing some digital real estate for people and organizations concerned about their water environment.

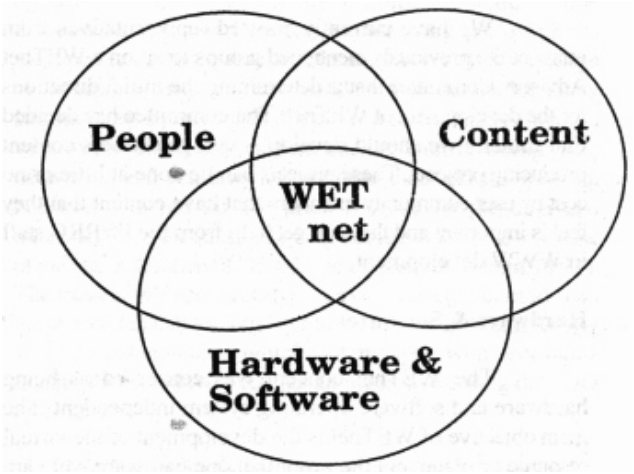

FIGURE 1

People

Water-related environmental modeling and decision making encompasses a very large domain of diverse interested parties. At one level there is the state government legislators and agencies managing and setting policy for the state's water environment. At another there are educators endeavoring to teach environmental awareness, modeling, and management techniques ranging from K-12 environmental science to advanced university level courses. Related to these educators are the researchers who are collecting data, building models, and testing theories to push the envelope of our knowledge about water. Yet another group we might call water professionals who are the individuals whose daily professional activities in some way are related to water (e.g., scientists, engineers, managers, etc. in the private sector). In the final analysis one could say that everyone is in one way or another interested in water ranging from all of us who drink it to those of us who make their living from it.

The "People" portion of the WETnet concept are the most important part of the system. We could develop

the most sophisticated network of hardware and software and develop what we might think is very important content for people to see, and it might all be for naught if we don't have a user community who want to use and see it.

The user community will motivate content development based on their needs. They will determine what sort of hardware and software is needed for access. They will design the digital tools, software, that is needed to make WETnet a more hospitable world. The development of a viable and interested WETnet community of users is the single most important task in the construction of WETnet. They will be the foundation for the formation of a virtual community of concerned and interested individuals as described by Howard Rheingold in his popular book "The Virtual Community" (Rheingold 1993).

We have currently enlisted representatives from many of the previously mentioned groups to sit on a WETnet Advisory Committee that is determining the initial directions for the development of WETnet. The committee has decided that initially we should develop small, grass-roots content producing projects. These projects can be done at little or no cost by user community members that have content that they feel is important and they can get help from the IWRRC staff in WWW development.

Hardware & Software

The WETnet concept was conceived as being hardware and software operating system independent. The main objective of WETnet is the development of the virtual resource or place, not the proof that one hardware/software platform is better suited for digital communing than another. In fact, it is the goal of the project to let anyone with any type of digital platform travel through the WETnet. This goal has already been realized with the explosive growth over the past year of Internet service providers and private and public domain software for every conceivable hardware platform making Internet connectivity both common and economic (Estrada 1993).

We do think that the WETnet concept should be implemented within the framework of the Internet. What this simply means is that if you want to participate and contribute to WETnet you must have a hardware/software platform that supports TCP/IP and at minimum have dial-up capabilities to an existing Internet host. TCP/IP was developed for initial construction of the Internet and continues to be its communications protocol (Comer 1991). Not implementing WETnet on the Internet would mean giving up all of the existing content and accessibility that exists with today's global network of interconnected computers and people. Using the Internet also makes available all of the public domain software tools that have been and are being developed for computer-mediated communications worldwide. This means that WETnet could make use of WWW httpd servers and browsers such as Mosaic, Wide Area Information Server (WAIS) databases, Gopher, FTP, Telnet, and many more current and future software applications found on the Internet.

The "Hardware & Software" component of the WETnet concept is the least critical and easiest to accommodate. It is already being taken care of for us with the past and current Internet development and standards and the future development of the Information Superhighway or the National Information Infrastructure (CPMES 1995).

As WETnet matures and grows as a system the user community will start to request new functionalities and tools. Just as the telephone and FAX machine were innovative and hard to comprehend technologies in their infancies, the WETnet concept of computer-mediated communications is new and it is difficult for us now to fully comprehend its possibilities. This is where the fertile ground lies for interesting research topics. Once a diverse and large user community is in place and comfortable with this new way of communicating, reading, and learning, what kinds of new tools will be required to fully exploit and expand our capabilities? There are many interesting possibilities here for learning about, managing, and modeling our water environment that can only be explored once we have moved into this new virtual world.

Content

The water-related content types that can be put on or developed for WETnet are nearly limitless. The prototype server we have developed demonstrates many possibilities, but what the IWRRC prototype development team thought was important content is not the issue. The important issue related to content is again directly related to the user community. Content must be important enough to a WETnet user that he or she wants to develop and maintain it on the WETnet. The WETnet content must be distributed. The WETnet concept is not to build a large, centralized repository of data and information for water resources, but instead to be a gateway to a distributed network of environmental information maintained by the actual producers or representative agents. We think that for information as diverse and voluminous as to be labeled water-related a centralized repository is destined for failure because it would require funding proportionate to the amount of information stored which would be a non-decreasing function over time.

There are of course many issues related to maintaining a distributed information system and database, but it is not our intention to cover them all in this paper. Suffice it to say that there are many excellent models of successful distributed systems out there right now with the domain administered Internet being the parent of them all. The major point we wish to make is that for initial WETnet development content must grow from a grass-roots level with passionate users publishing their work and interests for others to see. This effort should be coordinated with the development of the WETnet gateway that serves as a starting point for users to explore the web of water-related information. A prototype of such a gateway is what the IWRRC has produced for review by the water-related community of Indiana.

INDIANA WETNET PROTOTYPE

To demonstrate the WETnet concept a prototype World-Wide Web (WWW) server was built. The prototype Indiana WETnet server can be found at URL - http://ingis.acn.purdue.edu:9999/wetnet.html. In the true sense of prototyping we fully intend to have this current server replaced by the WETnet server once the prototype has proven its point, that the WETnet concept can and will work. It is important to realize the difference between the WETnet concept and the prototype WETnet server. This WWW server is just one possible way to implement the concept. This WWW server need not live on, but we feel that the concept should.

The WWW was chosen for the development of the WETnet prototype because it contains most of the base level internetworking functionalities the WETnet concept needs and because it is the single fastest growing tool or form of traffic on the Internet today allowing for wide and easy accessibility. The best introduction to the WWW is found by simply getting connected and start "surfing" the Web. There are also an incredible number of new and recent books on the Internet and WWW, the interested reader should consult "The Whole Internet User's Guide and Catalog" (Krol 1994) which still provides the best Internet introduction and the new "The World-Wide Web Unleashed" (December and Randall 1994) which provides a good overview and introduction to the Web.

The domain of water resources is large and diverse. There are any number of different ways one could stand above the topic of water and attempt to categorize or organize it into logical subtopics or areas. The WETnet server top level or home page provides one such way of looking at the topic of water. Figure 2 is the WETnet home page viewed with NCSA's Mosaic WWW browser in X-Windows (Dougherty, Koman and Ferguson 1994). Figure 2 We have intentionally left the home page simple and short so that any user can quickly grasp the nature and scope of this resource as if it were an overview page for a presentation or a single sheet course syllabus on the topic of water resources in the state of Indiana.

The construction of the prototype was actually a small experiment in distributed development in that each home page bullet item was designed and built by a different person. In a design sense we tried to maintain a consistent look and feel by providing common headers and footers for each page and navigational and informational icons. This also helps to delineate the boundaries of the WETnet prototype. When a user comes upon a page that does not have the same look and feel then she has actually left the WETnet prototype and wandered off into some related area of the Web pointed to by WETnet.

The WWW contains an enormous amount of diverse and dynamic information. There are roughly two types of WWW resources one generally encounters on the Web: 1) an original piece of topical content, or 2) an attempt to organize existing original pieces of topical content via organized lists of hyperlinks commonly referred to as jumpstations. There is a place for each of these types of resources, but there is some well founded recent discussion about there being far too much construction of lists as opposed to the creation of original content. These discussions are based on some interesting philosophical ideas pertaining to the data or information versus knowledge or wisdom question. The quandary can be inadequately summarized by saying that there are some learned people who would claim that modern society with its computers, networks, and centuries of recorded data and information has come to put far too great a value on the data and information for the sake of having access to it at the expense of the actual creation of knowledge or wisdom (Heim 1993). The Indiana WETnet prototype server was constructed with this in mind in that for WETnet to be of real and long lasting value it must contain original content along with serving its organizational gateway role as an index to existing data and information.

The following sections correspond to the bullet list water resources topology presented on the WETnet home page in Figure 2. The Figure's referred to in the following sections can be found in the Appendix.

Introduction and What's New

This first bullet item hyperlink takes you to the page depicted in Figure 3. This section is relatively self explanatory in that it serves two purposes: 1) it is the first place a new user should come to learn about the WETnet,

and 2) the What's New section was designed to be used by the experienced user who needs a quick index of things that may have changed or been added since his last visit.

Related to the What's New page is the Boiling Points page that is found in Figure 4 and is accessible from the home page as the last hyperlink in Figure 2. The Boiling Points page serves as an index into the parts of WETnet that are currently very popular based on the number of people accessing them.

Subject Tree and Search Engines

These two areas of WETnet provide different ways to achieve the same goal. The top level page for the water resources subject tree and search engines is shown in Figure 7. Both these tools allow a user to find information on the WETnet quickly or to browse topically or based on keywords.

The idea behind the subject tree is that the domain of water resources covers a large amount of data and information and touches many different disciplines and this leads to confusion for neophytes and different perceived topologies of the area based on background. For example when asked to build a hierarchical outline on the topic of water a hydrologist might say the top level should be broken down into atmospheric, surface, and ground water subdivisions, whereas a water resources systems analyst might say that one is either dealing with water quantity or water quality. There is more than one subject tree or way to logically organize the topic of water based on one's background and objective for creating the logical subdivisions. The WETnet server should contain every possible subject tree on the topic of water that we can conceive. Each one will simply be a different view of the same underlying information, just as there are many textbooks on the same subject.

The subject tree will allow a user to browse the WETnet by following a hierarchically organized structure to the information, whereas the search engines will allow a user to provide a keyword of interest that will be used to search indexed databases of varying scope. The search will return a list of hyperlinks to every document or area of WETnet that has material related to that keyword.

A user may explore the WETnet in three basic modes: 1) traditional Web browsing by following the hyperlinks down through areas, across to different areas, or out of WETnet completely, 2) by entering a subject tree to topically browse and learn about the overall domain of water, or 3) search for all items of interest based on a particular keyword or combination of keywords. In hypermedia terms the WETnet allows for both directed and undirected browsing. The arrow, home, and help icons found in every page's header or footer also provide navigational aid.

Data

For most water resources professionals data is the first thing that comes to mind when they are introduced to the WETnet concept. They ask questions such as: I have just started a new project, what data is available for my area of concern?, I have just completed a project, how do I make my data available to others?, I can't get my data to work with this model or software?, Has anyone digitized the state's watershed boundaries? For the purpose of building the prototype server we have limited our data scope to digital spatial data.

We chose to use spatial data for the prototype because of how important and popular it is right now in environmental management and modeling. The spatial data described right now in the prototype are the data that researchers at Purdue have been developing and accumulating for years for their own research and educational needs. There are many other repositories for spatial data across the state of Indiana and we do not propose to move and/or make copies of all of them here at Purdue. Instead we hope to put in place a distributed, domain-based model; that is each person or domain would maintain their own data, make it Internet accessible, and the WETnet server would act an indexed database with pointers to the databases distributed across the state.

The third hyperlinked bullet on the home page is for water resources data and takes you to Figure 8. Figure 8 presents one of the three possible ways the user may embark on a search for spatial data, by graphically pointing and clicking on the area of interest. If the user clicks on the state of Indiana in Figure 8, a new page will be returned showing the user Indiana with the county boundaries displayed and "clickable". To find spatial data of interest the user may: 1) graphically point and click her way down to the area of concern, 2) select from a textual listing of spatially referenced items (e.g., states, counties, cities) or from a content-based listing (e.g., wetlands, soils, landuse), or 3) provide a spatial or content-based keyword to a search procedure that will return a hyperlink listing of all data sets found that are related to that keyword (e.g., all data sets for Marion county, all wetlands coverages for the state).

Once the user has located the data sets of interest they may either graphically view them as postscript or GIF image dumps from GRASS (URL - http://www.cecer.army.mil/grass/GRASS.main.html) or ARC/INFO (URL - http://www.esri.com/), view a metadata description of the raw data, or determine if the data is available for download. The download capability gets rather complicated with copyrights and accountability issues and is beyond the

scope of this paper. We merely wished to demonstrate through this prototype that a user could search for, view, do some simple GIS manipulations to, and get spatial data over the WWW.

Projects

A user may enter the WETnet wanting to know what water-related projects have been done in a particular location, involve a particular person, or have been based on a particular topic such as groundwater quality or wetlands management. The Indiana Water Projects bullet on the home page takes you to Figure 9. The water resources projects top level page provides the interface for browsing or searching a database of projects based on any of the above criteria. This area of WETnet is closely related to the data area, but provides a different organizational view of the underlying data and information.

The water projects area contains an indexed database of pointers to distributed project summaries and descriptions administered by the originators of the information. A user might find textual abstracts, published papers, hyperlinks to the data used, descriptions of results, hyperlinks to the professionals involved, hyperlinks to the models used in the models area, and other project-related data and information. There is also a mechanism provided that allows a WETnet user to register his or her project with the database on-line.

Professionals

Figure 10 shows the top level interface to the database of Indiana Water Professionals. This area of WETnet is relatively self-explanatory in that it provides the user with all of the standard functionalities they would expect from a database of professionals. The interesting possibilities in this area of WETnet are related to the additional features hypermedia offers you. For each professional there could exist any multimedia type information, hyperlinks to their own personal WWW pages, hyperlinks to all other areas of the WETnet that the professional is involved with, and other functionalities described in the future directions hyperlink on the Figure 10 page.

Education

One of the most powerful ways to use hypermedia and the WWW is for the creation of educational materials for diverse audiences (Nielsen 1993). The idea here is that the fundamental information or knowledge we possess about any given area is an atomic collection of observations, facts, and assumptions that we collectively agree on. What differs is the way these atomic elements are presented based on the presenter's background or expertise and their perceived audience. With WETnet and distributed hypermedia we could collect these atomic modules or pointers to them and use them to build water-related educational resources for different audiences and purposes such that one module could be re-used in different resources.

Figure 11 is the top level page in the WETnet prototype for the collection and organization of educational modules. We are far from realizing the above vision of the creation of these atomic general purpose modules, but there are good models of such paradigms out there such as object oriented modeling and programming. There are also a growing collection of self-contained university and K-12 level educational resources out on the WWW that will serve as an excellent starting point building such resources.

A third audience that should not be neglected is the general public or non-school affiliated individuals who are interested in becoming educated or informed on a specific area of interest. The WETnet prototype has an example of a resource for such a target audience. Figure 6 presents the Water Doctor, a hypertext-based resource for an individual to consult if they have questions about their drinking water which is the most common general query type of telephone call we get at the IWRRC. The water doctor empowers the user with the ability to try to self-diagnose their water problem, look up water testing options for their area, and generally browse water quality information. This information starts out with a very general overview and allows the user to follow links to more complex descriptions if they desire. There are many other resources that could be created for aiding an inquisitive citizenry.

Models

The models section of WETnet represented by Figure 12 is the most ambitious or advanced resource. The idea is to provide the user with a model base, not unlike the database in the data area, that is essentially a collection of models indexed with sample data, source code, executable binaries, and documentation. The user can either search for models based on keywords or browse the model base starting with a topology of water models. Once a model of interest is located the user would have a number of different options available ranging from downloading the actual source code or binary for their architecture to running a demonstration version of the model on the server it is located on and viewing its progress and results on their screen. This is what we refer to as the foundation for distributed modeling.

The possibilities for distributed modeling are exciting. One of the difficulties involved with developing and testing a new model is getting enough data to test the models responses to realistic inputs. If the model is made available through WETnet to everyone who might have a use for it and have data they are interested in using, then they can run it on a remote server with their data and view the results. They do not have to worry about getting the model to run on their machine and the model developer doesn't have to worry about collecting enormous amounts of data. People can then start discussing the model's effectiveness for their area with other users across the state or country in a WETnet discussion area. Model developers could start working together across institutional boundaries building more robust models that draw on their individual areas of expertise. We have called this collaborative modeling and it to has many interesting possibilities that are beyond the scope of this paper and are speculative at this point.

Agencies

One of the most daunting tasks for any citizen is trying to understand the structure and purpose to the local, state, and federal government agencies that exist to serve

citizens. Water is such a critical part of life that a rather large number of government agencies have made some facet of water management or planning part of their jurisdiction. The agencies area of WETnet shown in Figure 13 is an attempt to organize in one place a comprehensive overview of every government agency that has anything to do with water.

The Indiana Water Agencies area of WETnet was designed to serve several purposes. One, it is an educational or informational tool for students and citizens to use to better understand and evaluate their government. At minimum it would contain locational and contact information. Two, it could be used by each government agency as a marketing tool to let the citizens know the vital role they play in managing and protecting their environment. Third, the agencies area could serve as a sort of redundancy checker or cross agency communication channel. Agency personnel could us this section of WETnet to see what other agencies are doing across the state and share resources where appropriate.

Other Servers

The other servers area of WETnet shown in Figure 5 is a simple jumpstation to other servers around the world that are considered to be of interest to a user of the WETnet. The list is organized into groups such as water resources, federal government, state government, and other server types. This list should always be evolving as resources are born and die across the Web. It could also contain brief synopses of each hyperlink to help users decide whether to follow the link or not. This is where the WETnet user would come to truly surf the WWW of information.

SUMMARY AND THE FUTURE OF WETNET

The WETnet concept exists at the intersection of interested individuals, water-related content, and the hardware and software that makes up the global network of computers known as the Internet. We believe that if these three areas are brought together as a WETnet that Indiana will be able to better understand and manage its water environment.

We created the WETnet prototype WWW server to demonstrate this concept and do initial development work. We hope you will visit the prototype server and provide us feedback through the on-line forms or e-mail.

The future of the WETnet concept rests with the user community. We believe that for WETnet to be a success that the content must be developed and maintained by interested users. We hope to help educate potential users on developing content. Once the WETnet community is in place and they are publishing and consuming information, then we can start building advanced tools for things such as collaborative modeling, development of atomic hypermedia modules for education, and other resources that are inconceivable until we move into this new virtual world. As Nicholas Negroponte says, "Computing is not about computers any more. It is about living." (Negroponte 1995).

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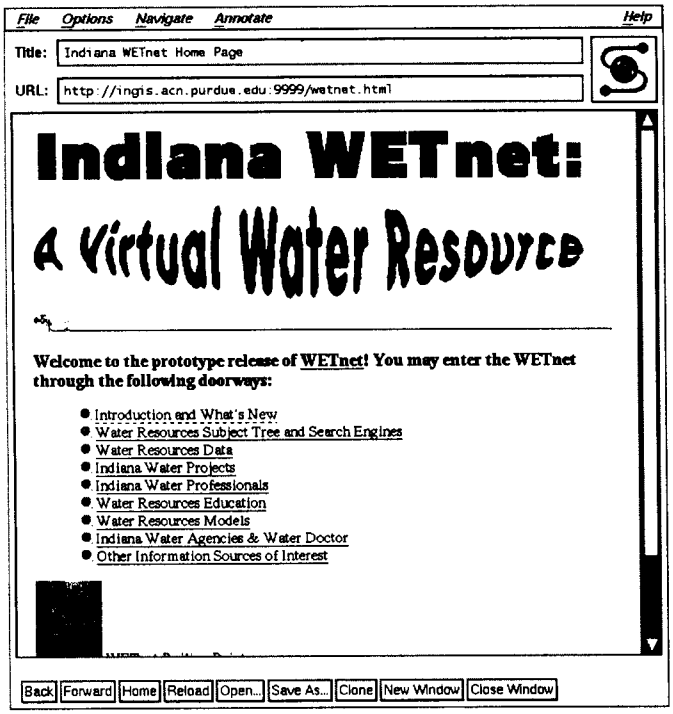
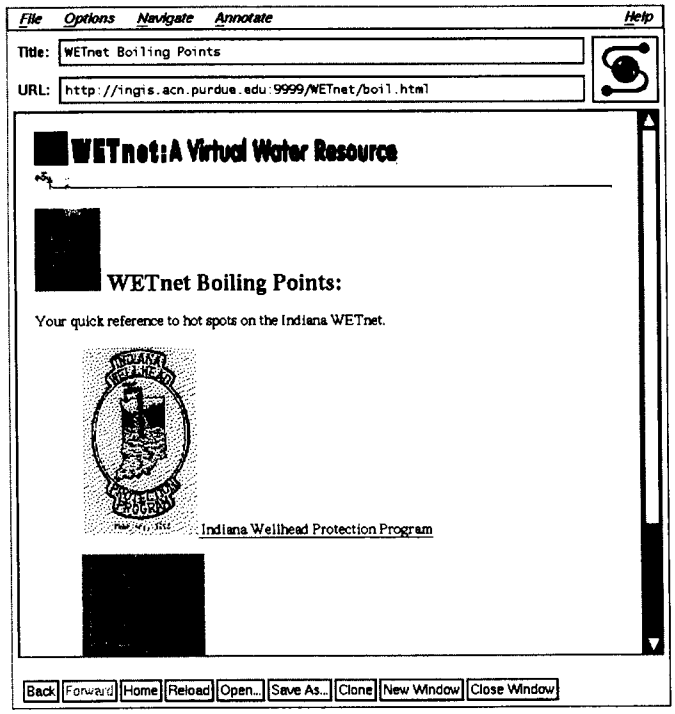


Figure 2



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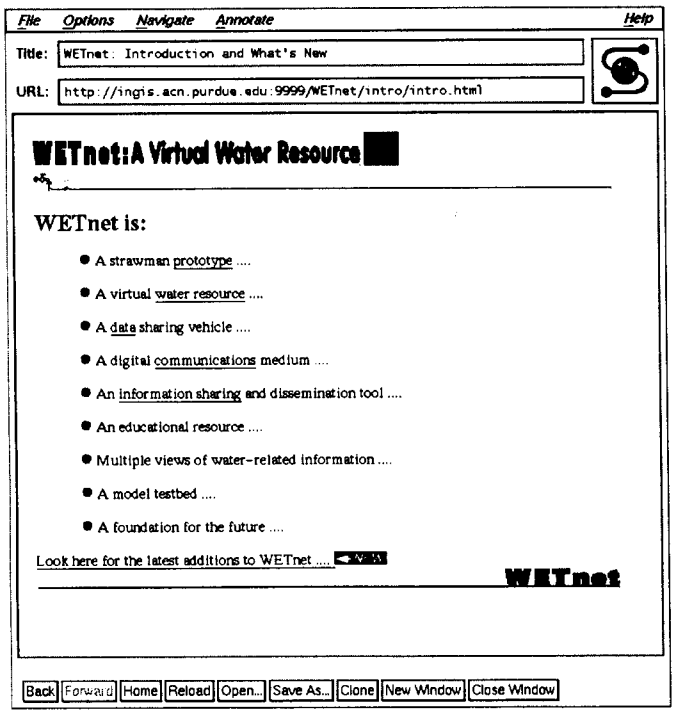

Figure 3

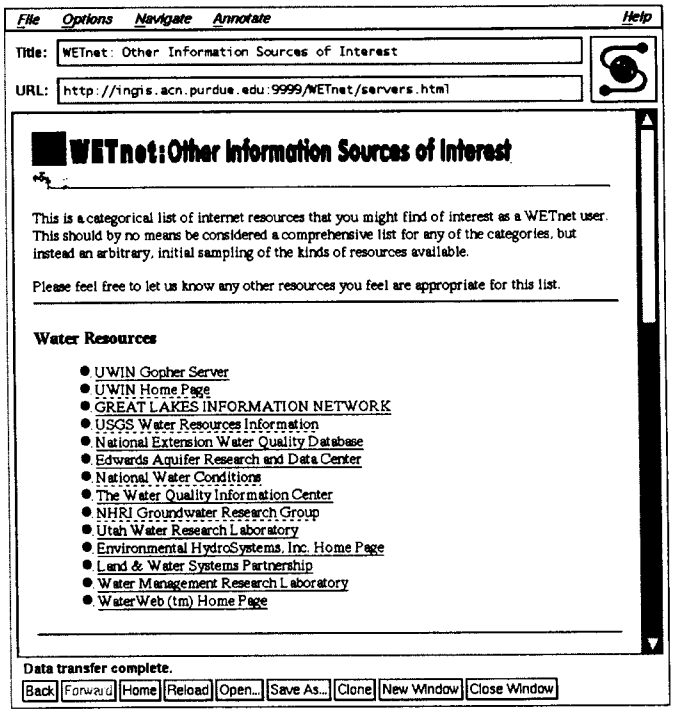

Figure 5

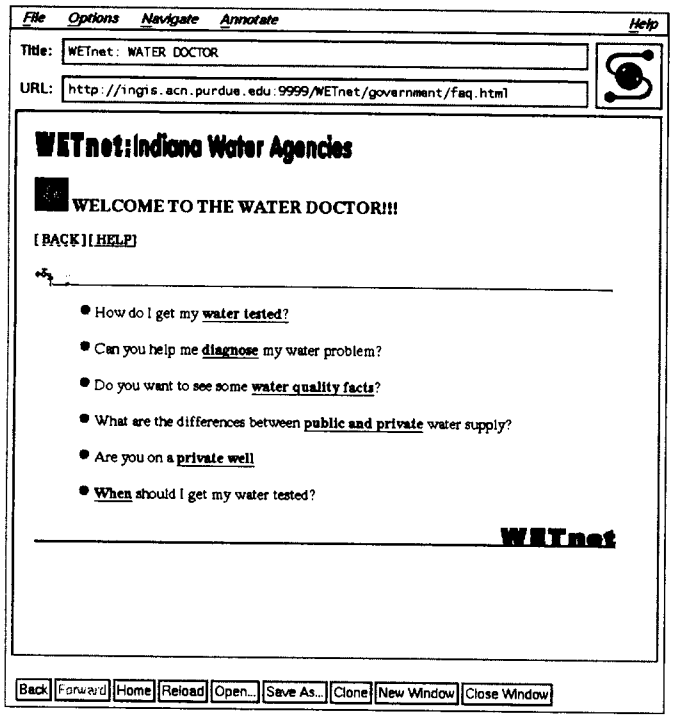

Figure 6

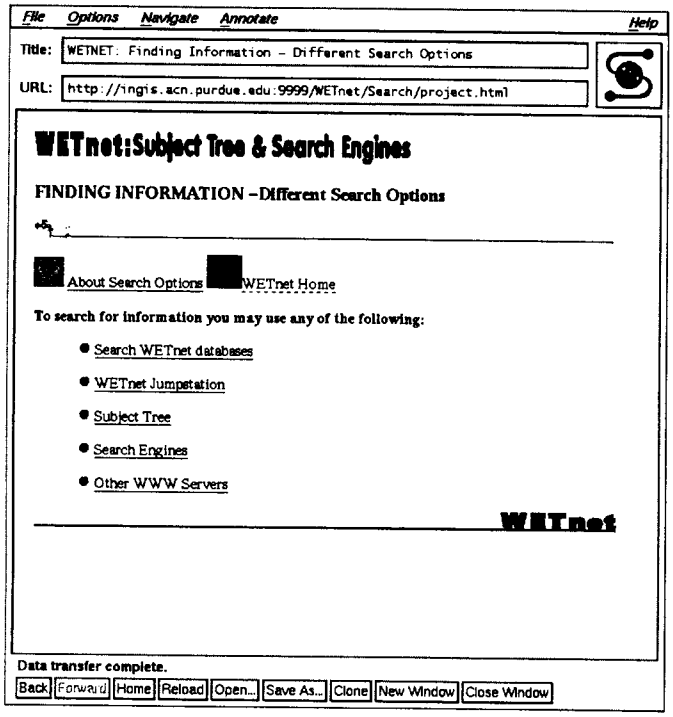

Figure 7

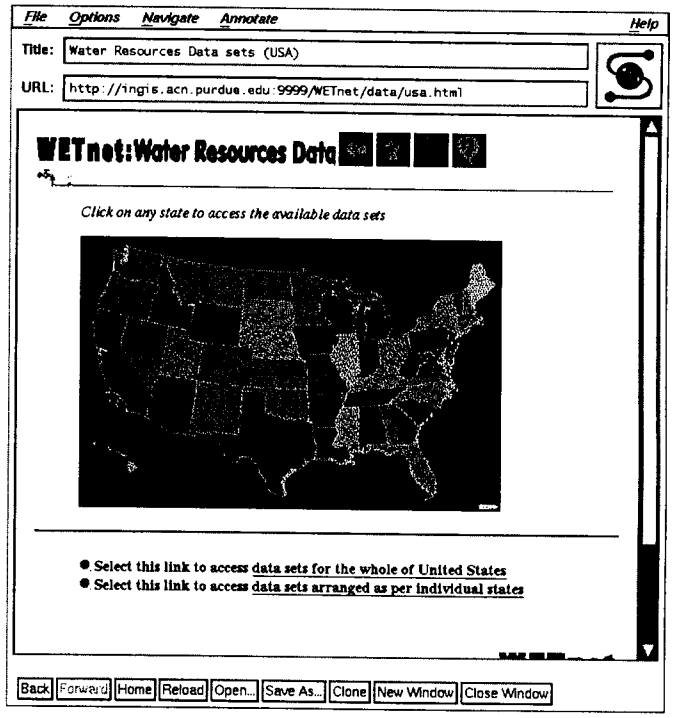

Figure 8

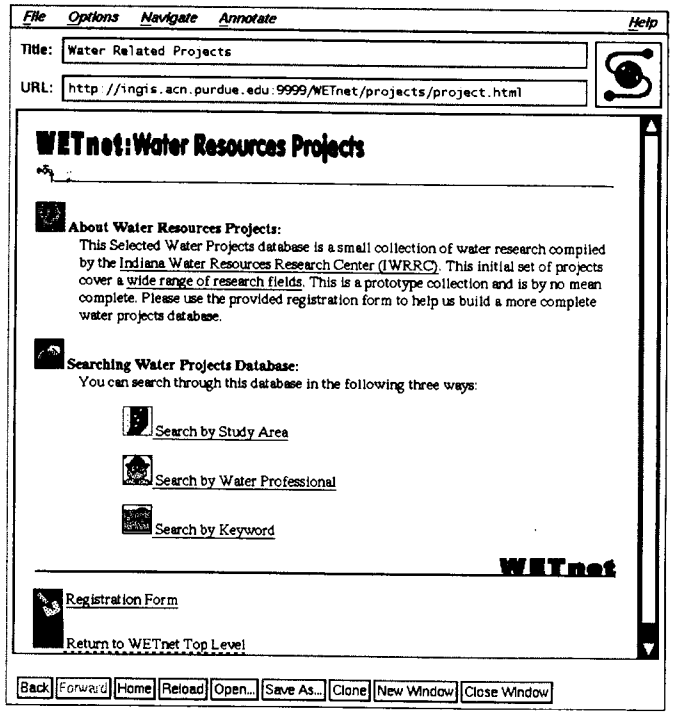

Figure 9

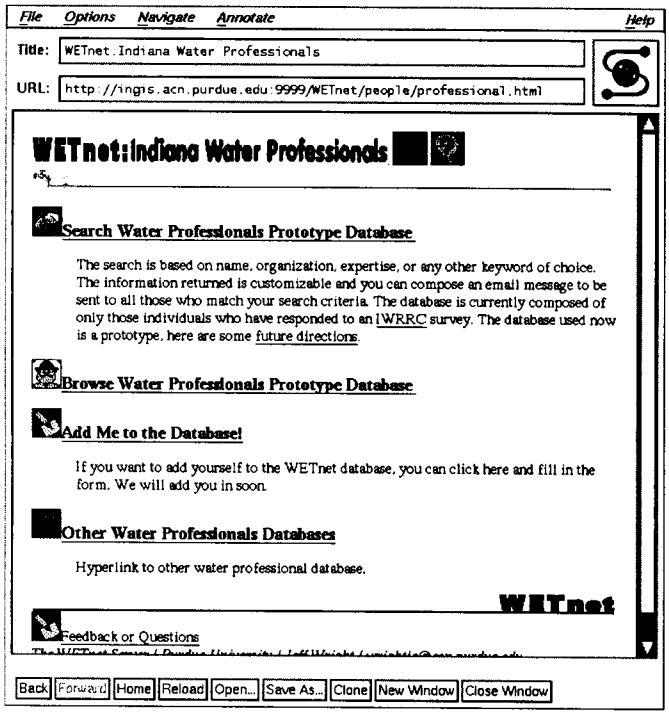

Figure 10

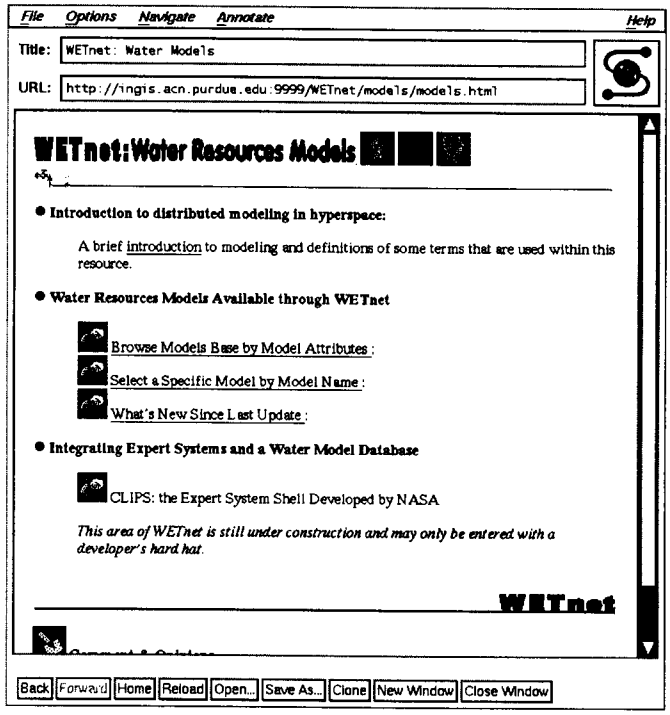

Figure 12

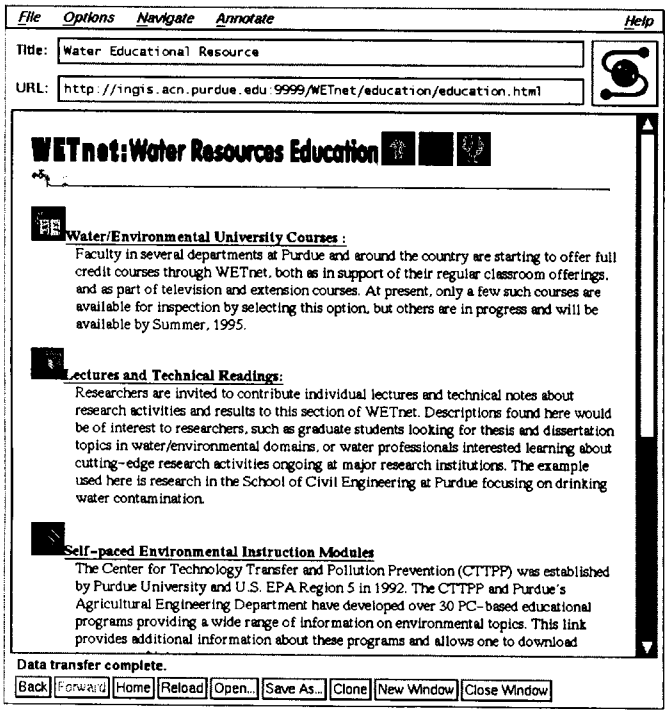

Figure 11

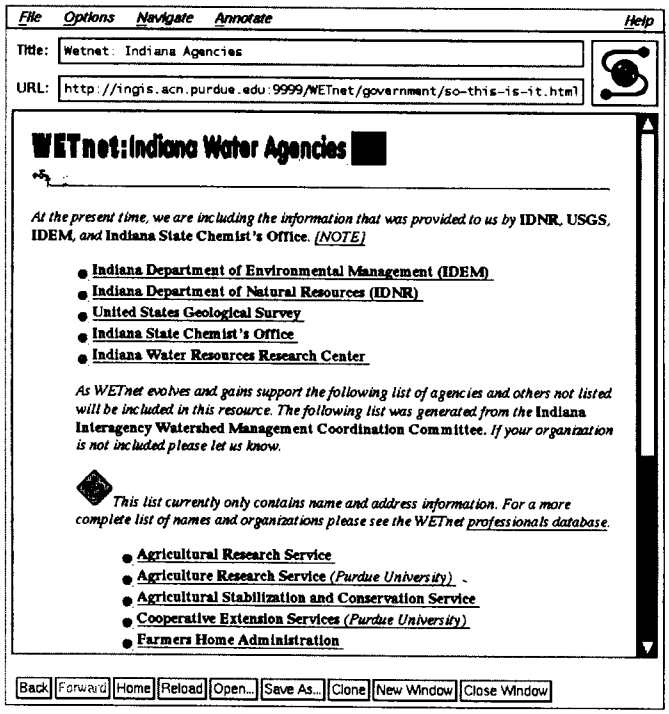

Figure 13