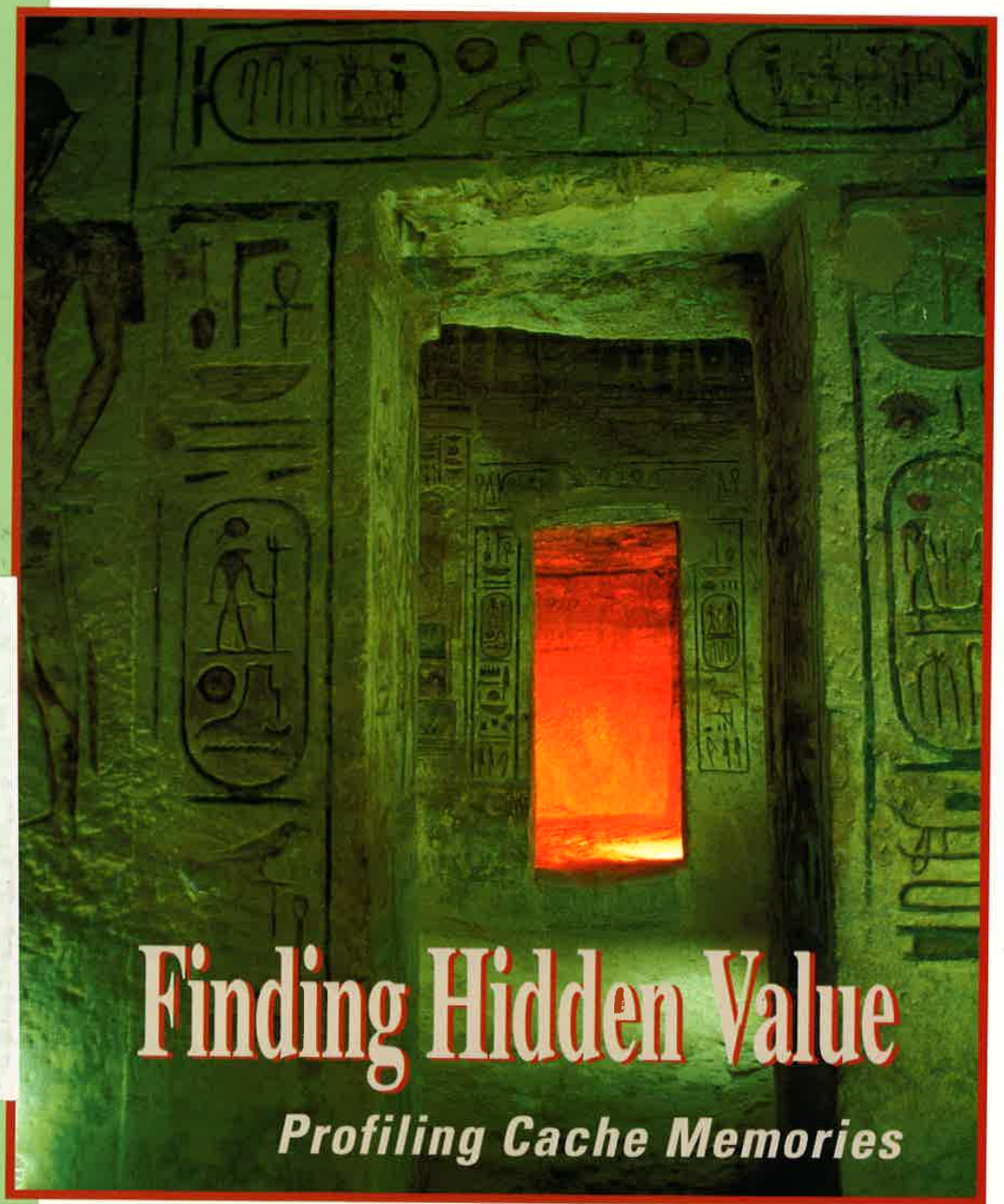
OCTOBER 1994

COMPUTER

Innovative technology for computer professionals



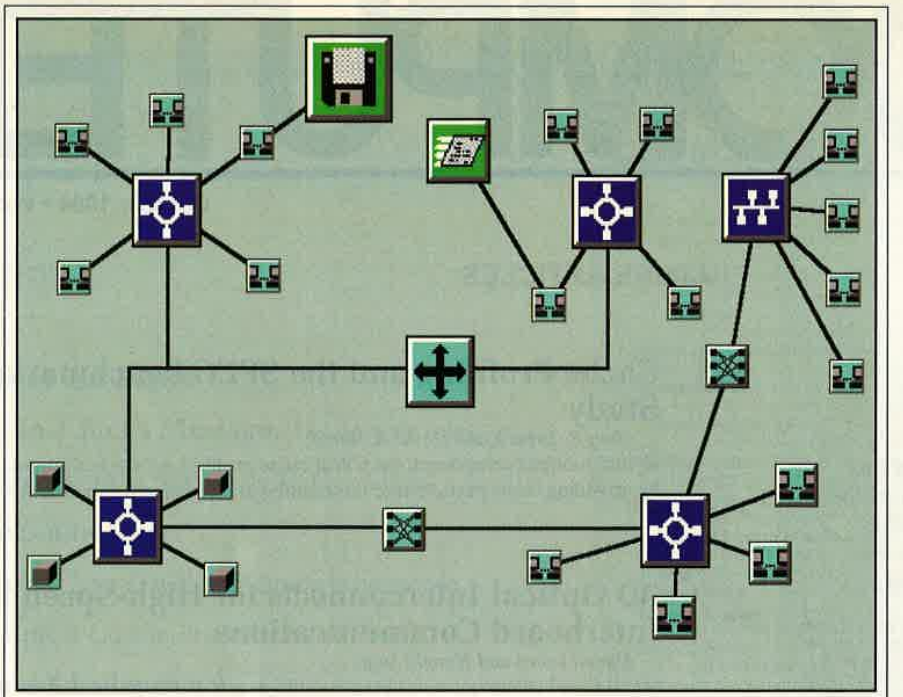
Finding Hidden Value

Profiling Cache Memories

Also: 3D Optical Interconnects • Displaying 3D Images • Mosaic and WWW • Porting Ada • Software Control • New Department, Computer Law • Special Book Offer, See Back Cover

Join the Computer 100. See p. 6.

IEEE COMPUTER SOCIETY
THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.



A typical application. **You** show a picture of **your** model with **your** icons — your graphical, animated results are easier to understand.

After you've tried new MODSIM II, other object-oriented languages will seem primitive

Free trial and, if you act now, free training

MODSIM II is a modern high-level, object-oriented programming and simulation language with these important benefits:

- **Simulation.** All the features you need to do simulation and automatically collect statistics are built-in.
- **Object-oriented.** The powerful mechanisms that help you develop reusable, easily maintainable code.
- **Your program is portable.** Your programs are easier to read, and are portable.
- **Symbolic debugger.** Error detection simplified through steptracing, multiple breakpoints, and data viewing.
- **Graphics and animation.** You easily lay out your graphical user interface. You can draw icons and place them on a palette with no programming.

Free trial offer

The free trial contains everything you need to try MODSIM II on your computer. You receive everything you need for a complete evaluation.

For a limited time we also include free training.

Computers with MODSIM II

MODSIM II® runs on all popular workstations as well as PC's with Windows or OS/2. Your investment is preserved when you change computers, or operating systems.

MODSIM II is already in use at hundreds of installations throughout the world.

For immediate information

Call Hal Duncan at (619) 457-9681, Fax (619) 457-1184. In Europe, call Peter Holt, In The Netherlands, on 31 43 670780, Fax 31 43 670200. In the UK, call Nigel McNamara on 0276 671 671, Fax 0276 670 677.

Rush information on MODSIM II.

☐ **Yes, I want to learn the reasons for the growing popularity of MODSIM II.**

Special offer — return the coupon today and we will include a free course enrollment worth $750.

Name _____

Organization _____

Address _____

City _____ State _____ Zip _____

Telephone _____ Fax _____

Computer _____ O/S _____

☐ Send details on your University offer.

Return to:
CACI Products Company
3333 North Torrey Pines Court
La Jolla, California 92037
Call (619) 457-9681 Fax (619) 457-1184

In Europe:
CACI Products Division
MECC Business Center
G. Martino Laan 85, 8th Floor
6229GS Maastricht, The Netherlands
Call 31 43 670780 Fax 31 43 670200

In the UK:
CACI Products Division
Coliseum Business Centre
Watchmoor Park, Riverside Way
Camberley, Surrey GU15 3YL, UK
Call +44 (0)1276 671 671 Fax +44 (0)1276 670 677

Mie comp

CACI Products Company

COMPUTER

October 1994 • Vol. 27, No. 10

FEATURE ARTICLES

COMPUTING PRACTICES

COMPUTING MILIEUX

Membership Magazine of the the IEEE Computer Society

Circulation: *Computer* (ISSN 0018-9162) is published monthly by the IEEE Computer Society. IEEE Headquarters, 345 East 47th St., New York, NY 10017-2394; IEEE Computer Society Publications Office, 10662 Los Vaqueros Circle, PO Box 3014, Los Alamitos, CA 90720-1264, phone, (714) 821-8380; IEEE Computer Society Headquarters, 1730 Massachusetts Ave. NW, Washington, DC 20036-1903. Annual subscription included in society member dues. Nonmember subscription rates: available upon request. Single copy prices: members $10.00; nonmembers $20.00. This magazine is also available in microfiche form.

Postmaster: Send undelivered copies and address changes to *Computer*, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08855. Second class postage is paid at New York, New York, and at additional mailing offices. Canadian GST #125634188. Printed in USA.

DEPARTMENTS

In the next issue: Associative processing and processors

On CS On-Line: See p. 93 for a list of items now available on the Computer Society's infoserver.

Cover image: The tomb of Ramses II; Stock Imagery © 1993, G. Adams
Cover design: Chris Patterson

COMPUTING PRACTICES

Back in the late 1970s, I was predicting that a more user-friendly operating system would quickly supplant Unix. But I hadn't reckoned on MIT's X Windows. More recently, I suggested that the Internet was passé, soon to be overshadowed by advances in multimedia office environments. Oops, wrong again. Mosaic is to Internet what X Windows was to Unix.

Our first article, "Mosaic, HTML, and the World-Wide Web," by Ronald Vetter, Chris Spell, and Charles Ward, provides an introduction to the Mosaic browser, a GUI for this net-based hypertext system. If you're a net user not (yet) familiar with Mosaic, this article will get you started. If you're already a Mosaic user, you'll still appreciate this overview.

Our second article effectively embodies the original intent of this column. Months ago we ran an article describing an Ada tool for analyzing system dependencies. Joseph Skazinski wrote me to say that while he found the article interesting, it didn't fully describe the difficulties of porting Ada. I asked for examples, and he sent a short draft detailing his experiences. After some editorial give and take, I'm pleased to present his "Porting Ada: A Report From the Field." It's a nuts-and-bolts article about porting a large military application across several platforms. Even if you're not working in Ada, I think you'll find some of Joseph's suggestions useful.

Oh, and thanks to all of you who have written to me about the last two issues. Your feedback will ensure that Computing Practices stays in touch with the working engineer. As usual, feel free to contact me about what you liked and didn't like here in Practices.

— Paul Oman

Mosaic and the World-Wide Web

Ronald J. Vetter
North Dakota State University

Chris Spell and Charles Ward
University of North Carolina at Wilmington

The World-Wide Web, one of the newest information services on the Internet, uses hypertext links to other textual documents or files.[1] With this method, users can click on a highlighted word or words in the text to provide additional information about the selected word(s). Users can also access graphic pictures, images, audio clips, or even full-motion video through hypermedia, an extension of hypertext.

The World-Wide Web project was started by CERN (European Center for Nuclear Research) in an attempt to build a distributed hypermedia system.[2] Users access WWW through a "browser program" that can read and fetch documents locally as well as from sites around the world via the Internet. Browsers access files using FTP, NNTP, Gopher, and several other Internet-based protocols (see the glossary of terms). Browser clients can also search remote documents and databases if the associated server at that site has built-in search capabilities.

Browsers can be line-oriented (to work with traditional terminals) or graphics-oriented (to work with more modern graphics display terminals). One of the most popular graphics-oriented browsers is Mosaic, which was developed at the National Center for Supercomputing Applications (NCSA) as a way to graphically navigate the WWW. The first version of NCSA's Web browser, a WWW client for Unix with X Windows called XMosaic, was made available to the Internet community in 1993. Due primarily to its easy-to-use graphical user interface (GUI), XMosaic soon became the most popular interface to the Web.[3]

Mosaic is a system for wide-area distributed asynchronous collaboration and hypermedia-based information discovery and retrieval. Mosaic browsers are currently available for Unix workstations running X Windows, PCs running Microsoft Windows, and Macintosh computers. Mosaic can access data in WWW servers, Wide Area Information Servers (WAIS), Gopher servers, Archie servers, and several others. Figure 1 shows an example Mosaic screen (the home page) from the University of North Carolina at Wilmington.

Many commercial and government organizations and universities are migrating to Mosaic because of its many useful features and capabilities.[2,3] It has a consistent mouse-driven graphical interface and can display electronic data in a variety of fonts and styles. Mosaic reads SGML (Standard Generalized Markup Language) and

0018-9162/94/ $4.00 © 1994 IEEE

Glossary of terms

Archie — A system that allows searching of indexes of files available on public servers by anonymous FTP on the Internet.

CERN —European Center for Nuclear Research.

FTP — File Transfer Protocol.

GIF — Graphics Interchange Format.

Gopher — A distributed information service that makes available hierarchical collections of information across the Internet. Both the server and client software are available as public domain software from the University of Minnesota.

HTML — HyperText Markup Language.

HTML+ —HTML extension that supports new features.

HTTP — HyperText Transfer Protocol, the native WWW protocol.

ISO — International Standards Organization.

Mosaic — A system for wide-area distributed asynchronous collaboration and hypermedia-based information discovery and retrieval. Mosaic browsers are high-level graphical user interfaces (GUIs) currently available for Unix workstations running X Windows, PCs running Microsoft Windows, and the Apple Macintosh.

NCSA — National Center for Supercomputer Applications.

NNTP — Network News Transfer Protocol.

PPP — Point-to-Point Protocol, which allows a computer to use the TCP/IP protocols with a standard telephone line and a high-speed modem. PPP is replacing SLIP (see below) as a standard.

SGML — Standard Generalized Markup Language.

SLIP — Serial Line Internet Protocol, which allows a computer to use TCP/IP (Internet) protocols with a standard telephone line and a high-speed modem.

TCP/IP — Transmission Control Protocol/Internet Protocol.

Telnet — Lets users connect to any remote system on which the user has an account.

URL — Uniform Resource Locator.

HTML (HyperText Markup Language) text, enabling information to be presented in an attractive way. Mosaic also supports a wide variety of basic forms elements, such as fields, check boxes, and radio buttons, as well as characters from different languages (as defined by the ISO 8859 standard), including French, German, and Hawaiian. Finally, Mosaic supports graphics of up to 256 colors (in GIF or X bitmap format) as well as digital audio and video.

Users can extend Mosaic's functionality by creating custom servers and by letting other applications control its display remotely. Screen contents can be broadcast to a network of users running multiplatform groupware, such as NCSA's Collage, using NCSA's Data Transfer Mechanism (DTM). Mosaic users can traverse hypermedia links to provide basic network services (for example, FTP, Gopher, Telnet, NNTP, and WAIS) and store those links in "hotlists" for quick reference. And with the additional features available in HTML+, Mosaic users can "check out" Web documents for revision or for local or remote annotation.

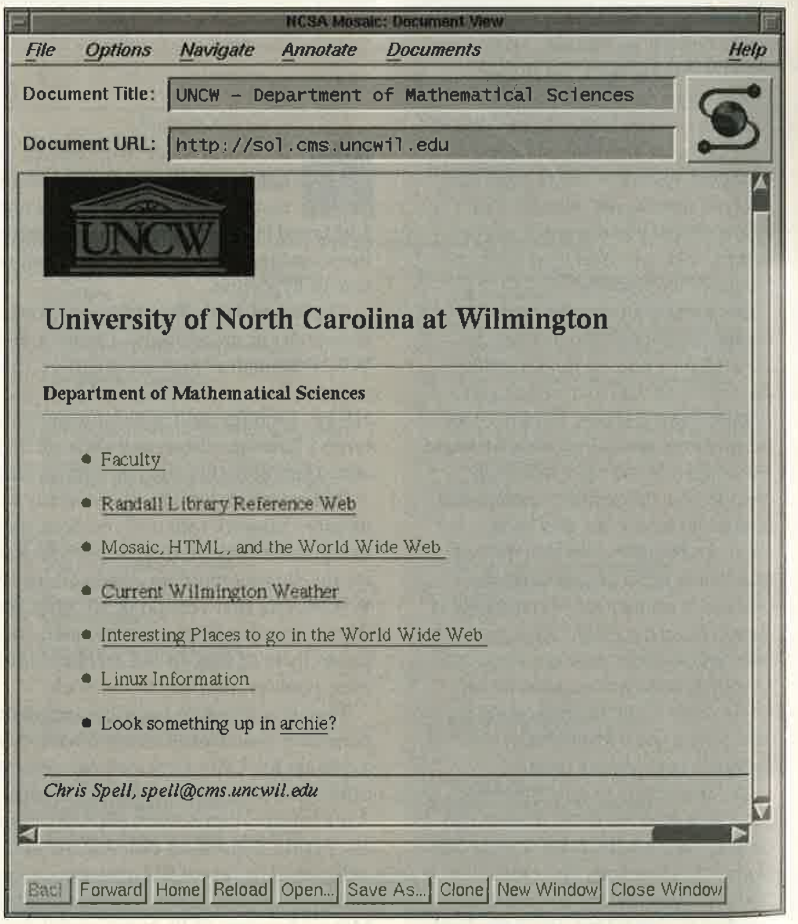


Figure 1. Sample Mosaic screen for the home page of the University of North Carolina at Wilmington.

HTML and HTML+

The Web uses HTML for creating and recognizing hypermedia documents.[3] This is a simple markup system, related

to the Standard Generalized Markup Language (SGML), used to format hypertext documents. (On the Web, these documents usually carry the ".html" suffix.) HTML code describes how textual elements (like paragraphs, lists, numbered and bulleted lists, descriptive lists, and quoted paragraphs) will be displayed. The current HTML standard supports basic hypermedia document creation and layout, but this capability is still very limited. The HTML+ extension supports interactive forms, defined "hotspots" (hyperlinks) in images, formatted tables, and more versatile document layout, formatting options, and styles.

Writing HTML documents. Most HTML documents are written using a standard text editor — for example, *vi* in a Unix environment — in a plain text format. Although HTML code is a tedious language to write, some authoring tools can now convert plain text to HTML automatically.

One way to learn how to write HTML documents is to look at how others have created their documents. You can do this by using the "source" button (available on most Mosaic browsers) to view the HTML code for a document or page you find particularly interesting. Most HTML statements are fairly straightforward. For example, Figure 2 shows the HTML code for the Mosaic screen image depicted in Figure 1. The code corresponds closely to the final graphic document. If you intend to write HTML code, we recommend that you read the on-line Mosaic document "A beginner's guide to HTML," which is available on the Web (see sidebar on HTML editors and converters).

```
<TITLE>UNCW - Department of Mathematical Sciences</TITLE>
<img src="/icons/uncwlogo_half.gif">
<H1>
University of North Carolina at Wilmington
</H1>

<hr> <b>
Department of Mathematical Sciences</b>
<hr> <ul>

<p> <li>
<a href="faculty.html">
Faculty
</a>

<p> <li>
<a href="/randall/ref.html">
Randall Library Reference Web
</a>

<p> <li>
<a href="mosaicpaper.html">
Mosaic, HTML, and the World Wide Web
</a>

<p> <li>
<a href="ncweather.html">
Current Wilmington Weather
</a>

<p> <li>
<a href="OtherLinks.html">
Interesting Places to go in the World Wide Web
</a>

<p> <li>
<a href="/linux/linux.html"> Linux Information
</a>

<p> <li>
Look something up in <A HREF="/cgi-bin/archie">archie</A>? <P>
<p> <li> <p> </ul> <p>

---

<address>
Chris Spell, spell@cms.uncwil.edu
</address>
```

Figure 2. HTML code for the Mosaic screen shown in Figure 1.

HTML editors. HTML documents can be created with WYSIWYG (what you see is what you get) editors or with editors that simply assist you by allowing you to select the desired markup tags from a menu. HTML editors are easier to use and interactively display the resulting HTML document on-screen. For example, current versions of the Emacs editor have an "HTML mode" to assist users with writing statements. There is also an editor for Microsoft Windows called HTML Assistant. For X users, tkWWW supports WYSIWYG HTML editing; and since it is a browser, you can try out links immediately after creating them. HotMetal is a professional HTML Plus editor for X and Microsoft Windows. For Macintosh users, the BBEdit HTML extensions allow the BBEdit and BBEdit Lite text editors to conveniently edit HTML documents.

Navigating the Web

Information currently accessible through the Web includes information served through Telnet, Gopher, WAIS, FTP, Usenet news, Archie, and anything in the form of Unix man pages or hypermedia documents. Mosaic lets users effectively navigate the Web and access the

wide variety of information databases associated with these existing Internet resources.

Uniform Resource Locators. A Uniform Resource Locator (URL) refers to the format used by WWW documents to locate other files and is currently a draft standard for specifying an object or resource on the Internet. A URL gives the type of resource being accessed (for example, Gopher or WAIS) and the path of the file. The format used is: *scheme://host.domain[:port]/path/filename.*

The first part of the URL, the scheme, specifies the access method. Several keywords can be specified for the scheme:

- FTP — retrieves a file on your local system or on an anonymous FTP server,
- HTTP — retrieves a file on a WWW server (the native WWW protocol),
- Gopher — retrieves a file on a Gopher server,
- WAIS — retrieves a file on a WAIS server,
- News — reads the latest Usenet news, or
- Telnet — uses the telnet protocol to connect to some site.

The part of the URL after the colon is interpreted with regard to the specific access method. In general, two slashes after the colon indicate a machine name or, optionally, a port. (For additional information, see "A Beginner's Guide to URLs," http://www.ncsa.uiuc.edu/demoweb/url-primer.html.) The last part of the URL describes the location-specific path and filename of the desired document. Some example URLs are:

- ftp://ftp.uu.net/info/README
- ftp://ftp.uu.net/usenet
- http://info.cern.ch:80/default.html
- news: alt.hypertext
- telnet://dra.com

HTML editors and converters

BBEdit HTML — A Macintosh editor for HTML documents obtained by accessing http://www.uji.es/bbedit-html-extensions.html. You can also obtain the extensions package by anonymous FTP from sumex-aim.stanford.edu in file /info-mac/text/bbedit-html-ext-b4.hqx.

Emacs editor — Current version Emacs have an HTML mode to assist users with writing HTML statements (ftp://ftp.ncsa.uiuc.edu/Web/elisp/html-mode.el).

HTML — An introductory reference, "A Beginner's Guide to HTML," is available at http://www.ncsa.uiuc.edu/General/Internet/WWW/HTMLPrimer.html. The HTML primer is available at http://www.vuw.ac.nz/who/Nathan.Torkington/ideas/www-html.html.

HTML Assistant — A Microsoft Windows editor with features to assist in the creation of HTML documents can be obtained by anonymous FTP from ftp.cs.dal.ca:/htmlasst.

HTML+ — To learn more about HTML+, you can examine the ASCII text of a draft specification for it at ftp://ds.internic.net/internet-drafts/draft-raggett-www-html-00.txt.; or a PostScript version of the same at ftp://ds.internic.net/internet-drafts/draft-raggett-www-html-00.ps

LaTex2HTML — Converts LaTex documents to HTML (http://cbl.leeds.ac.uk/nikos/tex2html/doc/latex2html.html).

Mail2HTML — Converts electronic mailboxes to HTML documents (ftp://info.cern.ch/pub/www/dev).

NCSA's list of filters and editors — This document mentions several editors, including two for Microsoft Windows (http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/faq-software.html#editors).

RTF2HTML — Converts Rich Text Format (RTF) to HTML (file://oac.hsc.uth.tmc.edu/public/unix/WWW).

HyperText Transfer Protocol. HTTP is the protocol employed between the server and client.[4] It requires only a reliable connection-oriented transport service, typically TCP/IP. The client establishes a connection with the server and sends a request containing the word GET, a space, and the partial URL of the node to be retrieved, terminated by the carriage return and line feed characters. The server responds with the node contents, which consist of HTML text documents. The end of the contents is signaled by the server closing the connection.

Ways to spin a Web. Creating a Web can be as simple as pointing a hyperlink from an existing Web document to your existing data. Making it public involves running the FTP or HTTP daemon. Any file available by anonymous FTP can be immediately linked into the Web. This method requires only a small start-up effort and allows contributions to be made network accessible via the Internet in a very short period of time.

You can also create a Web by writing your own HTML code and pointing it to databases of interest. Data may come from local archives or be stored elsewhere on the Internet. This requires familiarity with the HTML language and the information resources currently available on the Internet. Existing files (for example, a LaTex document) can be converted to HTML automatically by using a set of special software tools.[5]

When creating Web documents for public access, we have found the following guidelines to be useful.

- Remember that most users accessing information over the Internet are browsing and are therefore unwilling to wait long for a document to appear on their screen. You should use graphics only to catch the reader's attention. Keep the size of images on the home page small; they should be used as simple icons that show what the object points to. Wait until the user selects the icon to incorporate high-quality (and large) images into your documents. This will let users access the home page quickly and will ease server and network load. Although each image takes time to process and slows the display, using a particular image multiple times in a

document causes very little performance degradation compared to using it once.

• Documents transmitted over a network will not display as quickly as documents will locally, where you typically develop them. Before making any document public, be sure to test the document's remote access time to ensure that it is reasonable.

• Always provide an estimate of the number of bytes that will be sent when a user selects a given "hotword" (especially for high-resolution images and digital audio and video). This helps users decide whether to select a given hotword.

• Do not mix a large number of different fonts, colors, and so forth on a single display screen. Use good graphic arts design principles. This is especially important if the screens will be used for educational purposes and projected onto an overhead screen.[6] For example, certain colors that look good together on screen and are easily distinguishable may not be so distinguishable when sent through a projection panel and displayed with an overhead projector. We have provided some guidelines to help developers of multimedia presentations avoid some of the common problems associated with the projection of these materials.[6]

• Do not say "Click Here." It is redundant and only clutters the screen. Hotwords are normally a different color or font, so it is obvious (especially to frequent users) that "clicking here" will cause a hyperlink to be traversed.

• Put a reference (for example, an electronic mail address) at the bottom of every page telling whom to contact about the document. This can be accomplished by using the HTML Address Tag construct.

• Do not make your pages too long. Rather, create a hierarchical set of menus that group items into meaningful categories. That way only those items of interest will have to be selected.

How does the WWW compare to Gopher and WAIS?

While all three of these information presentation systems are client-server based, they differ in terms of their data models. In Gopher, data is either a menu, a document, an index, or a Telnet connection. In WAIS, everything is an index, and everything that is returned from the index is a document. In WWW, everything is a hypertext document, which may be searchable if it contains text. This means that WWW can represent Gopher and WAIS data models as well as provide extra functionality. Only WWW has hyperlinks.

Although text is supported by all three systems, WWW provides facilities for displaying "richer" text (for example, headings, lists, and emphasized text) in a standardized way. Image, audio, and video data are all supported by external viewers (for example, MPEGplay). There is little direct support for application-specific data in any of the three systems, and all use different methods for expressing type and encoding. Also, all three systems have little support for controlling the presentation of nontext data. For example, backdrops and synchronization in time are not supported, and buttons are only supported in a limited way. (See Adie[2] for a more comprehensive evaluation.)

Limitations. Perhaps the greatest limitation of current distributed hypermedia systems is that there is no simple way to find out what information has changed, what information is new, or even what information is out there on the Internet. Mosaic users commonly complain about difficulties finding resources on a particular topic or subject. Unless the user has extensive knowledge of the Internet, it is hard to locate resources of interest on the WWW. A related problem is remembering where resources were found when trying to access them again (hotlists are useful, but it is better to annotate the location and description of the resource on a notepad or set of index cards so that it can later be recalled). Another problem is that there are simply too many links,

Getting started: How to access the Web[1]

To access the Web, you first need an account on a machine that is connected to the Internet. All WWW features can be accessed with client/browser software from this machine. To obtain a browser for your machine, refer to the discussion below. Many of the browsers discussed here require that you have SLIP, PPP, or other TCP/IP networking to your computer. SLIP or PPP can be accomplished over phone lines, but only with the active cooperation of your network provider or educational institution. If you only have normal dial-up access, your best option is to run a browser on the system you call directly or from a system that can be connected to.

Browsers accessible via Telnet. Several browsers are available over the Internet through Telnet. An up-to-date list of these is available on the Web as http://info.cern.ch/hypertext/WWW/FAQ/Bootstrap.html. For example,

- **Info.cern.ch** — No password is required. This is in Switzerland, so continental US users might be better off using a closer browser.
- **ukanaix.cc.ukans.edu** — A full-screen browser "Lynx" that requires VT100 terminal emulation. Log in as www.
- **www.njit.edu** — A full-screen browser in New Jersey Institute of Technology. Log in as www.
- **vms.huji.ac.il** — A dual-language Hebrew/English database at Hebrew University of Jerusalem in Israel, with links to the rest of the world. Log in as www.
- **sun.uakom.cs** — A machine in Slovakia. Log in as www.
- **fserv.kfki.hu** — A machine in Hungary. Log in as www.

Continued on overleaf

Table A. Mosaic browsers.

Operating system	Program	FTP Availability	Comment
Windows	Cello	ftp.law.cornell.edu:/pub/LII/cello	
	Mosaic for Windows	ftp.ncsa.uiuc.edu:/PC/Mosaic	
Macintosh	Mosaic for Macintosh	ftp.ncsa.uiuc.edu:/Mac/Mosaic	
	Samba	info.cern.ch:/pub/www/bin/mac	
Amiga	AMosaic	max.physics.sunysb.edu:/pub/amosaic	
NextStep	OmniWeb	ftp.omnigroup.com:/pub/software; for information, http://www.omnigroup.com/	The browsers listed here are native NextStep applications. Next systems can also run X-based browsers using one of the widely used X-server products for the Next.
	CERN's Browser-Editor	info.cern.ch:/pub/www/src	Allows WYSIWYG hypertext editing. Requires NextStep 3.0.
X/Dec-Windows	Mosaic for X	ftp.ncsa.uiuc.edu:/Web	Unix browser using X11/ Motif; compiled for several popular platforms.
	Mosaic for VMS	ftp.ncsa.uiuc.edu:/Mosaic	NCSA Browser using X11/DecWindows/Motif.
	tkWWW Browser/	harbor.ecn.purdue.edu:/pub/tcl/extensions/tkwww (followed by an extension dependent on the current version)	Editor for X11 supports WSYIWYG HTML editing.
	Viola for X (Beta)	ftp.ora.com:/pub/www/viola	Viola has two versions for Unix/X: one using Motif, one using Xlib (no Motif). Handles HTML+ forms and tables. Has extensions for multiple columning and collapsible/expandable lists. Client-side document included.
	Chimera	ftp.cs.unlv.edu:/pub/chimera	Unix/X Browser using Athena (doesn't require Motif).
Text-mode Unix and VMS browsers	Line Mode Browser	info.cern.ch:/pub/www/src	This program gives WWW access to anyone with a dumb terminal. A general-purpose information retrieval tool.
	Lynx full-screen	ftp2.cc.ukans.edu:/pub/WWW/lynx	This hypertext browser for VT100 terminals uses full browser screen, arrow keys, highlighting, etc.
	perlWWW	archive.cis.ohio-state.edu:/pub/w3browser	A tty-based browser written in Perl.
	VMS client	vms.huji.ac.il:www/vms_client	A full-screen client based on VMS's SMG screen management routines.

Obtaining your own browser. The preferred method of accessing the Web is to run a browser yourself. Browsers are available for many platforms, both in source and executable forms. Table A lists some available browsers (a more extensive listing can be found at http://info.cern.ch/hypertext/WWW/Clients.html).

Setting up your own server. Browsers can obtain data from programs supplied by information providers. These programs can either be WWW servers that understand the HyperText Transfer Protocol, "gateway" programs that convert an existing information format to hypertext, or a non-HTTP server that WWW browsers can access — anonymous FTP or Gopher, for example. To learn more about WWW servers, you can consult a WWW server primer available at http://www.vuw.ac.nz/who/Nathan.Torkington/ideas/www-servers.html. Table B lists some servers currently available for Unix, Macintosh, Microsoft Windows, and VMS systems. (For more information on writing servers and gateways in general, see http://info.cern.ch/hypertext/WWW/Daemon/Overview.html.)

Creating a public home page. There are several things you can do to publicize your new HTML server or other offering:

- Submit it to the NCSA "What's New Page" at http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/whatsnew.html.
- Post it to the newsgroup comp.infosystems.announce. Please read the newsgroup first to get a feel for the contents. You can also crosspost to comp.infosystems.www.
- Submit it to the maintainers of various catalogs, such as the WWW Virtual Library http://info.cern.ch/hypertext/DataSources/bySubject/Overview.html.

Reference

1. "World-Wide Web Frequently Asked Questions," http://siva.cshl.org/~boutell/www-faq.html, June 1994.

Table B. Mosaic servers.

Operating System	Program	FTP Availability	Comment
Unix	NCSA httpd	ftp.ncsa.uiuc.edu:/Web/ncsa_httpd	
	CERN httpd	info.cern.ch:/pub/www/src.	
	GN Gopher/HTTP server	URL http://hopf.math.nwu.edu	Serves WWW and Gopher clients. A good server for migrating from Gopher to WWW, although lacking the NCSA and CERN servers' script capabilities.
	Plexus	http://bsdi.com/server/doc/plexus.html	Written in the Perl scripting language. Documentation available at the URL.
Macintosh	MacHTTP	http://www.uth.tmc.edu/mac_info/machttp_info.html	
MS Windows and Windows NT servers	HTTPS (Windows NT)	ftp://emwac.ed.ac.uk:/pub/https	A server for Windows NT systems, both Intel- and Alpha-based.
	NCSA httpd (Windows)	ftp.ncsa.uiuc.edu:/Web/ncsa_httpd/contrib/whtp11a6.zip	The NSCA server has most features of the Unix version, including scripts.
	SerWeb	FTP://winftp.cica.indiana.edu:/pub/pc/win3/winsock/serweb03.zip	A simple, effective server for Windows.
VMS Servers	CERN HTTP	http://delonline.cern.ch/disk$user/duns/doc/vms/distribution.html	A port of the CERN server to VMS.
	Region 6 Threaded HTTP Server	http://kcgl1.eng.ohio-state.edu/www/doc/serverinfo.html	A native VMS server that uses DECthreads.

as Hall has pointed out in a recent article.[7] Users of distributed hypermedia systems are often overwhelmed by the large number of possible links and become disoriented when moving between different application packages and information servers.

Steps are being taken to address some of these problems in Mosaic. Several resources now provide information on new and established Mosaic servers by topic. For example,

- The WWW Virtual Library[8] is a good place to find resources on a particular subject, and
- What's New With NCSA Mosaic[9] carries announcements of new servers on the Web.

More recently, several software tools have been developed that create automatic indexes you can search. Two such tools are WebCrawler(http://www.bio-tech.washington.edu/WebQuery.html) and WWW Worm(http://www.cs.colorado.edu/home/mcbryan/WWWW.html). WebCrawler indexes the contents of the documents, whereas WWW Worm builds its index based on page titles and URL contents. Although tools that automatically traverse the Web are useful, tools that recursively search for information may not notice self-referencing links and may begin to return an infinite number of indexes.

Popularity. The WWW is gaining popularity as evidenced by the amount of network traffic (in bytes) across the National Science Foundation's North American Network (NSFNet).[10] In fact, WWW traffic recently surpassed Gopher traffic, according to statistics produced by monitoring traffic on the Internet backbone. (Since WWW browsers can also access Gopher servers, the Gopher traffic may be somewhat inflated.) From January to August 1993, the amount of traffic attributed to Web use multiplied by 414 times, and usage of the server at CERN doubled every four months — twice the rate of Internet expansion.[3] The Web is now ranked eighth of all network services in terms of sheer byte traffic as of May 1994 (Gopher is ranked tenth).

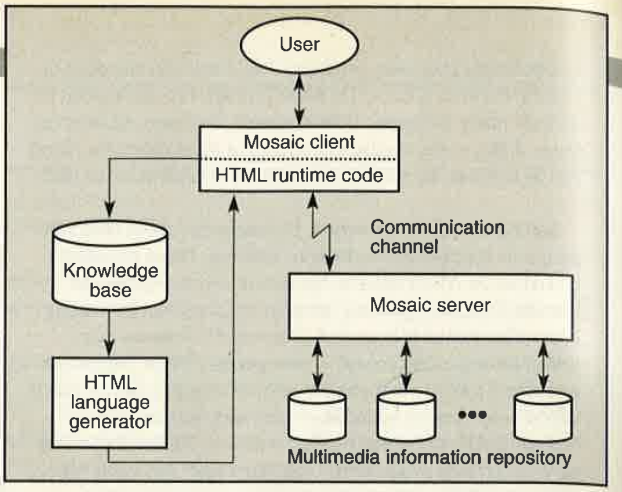


Figure 3. Mosaic extension model. An intelligent agent monitors user preferences to create a knowledge base that dynamically filters the hyperlinks presented to the user.

Extending Mosaic to support customized views

We are building an interface agent for Mosaic that helps users find the various types of Internet data available on the WWW. Our approach is similar to that undertaken by others who have developed autonomous agents to provide personalized assistance with meeting scheduling, electronic mail handling, electronic news filtering, and selection of entertainment.[11] The idea is to augment Mosaic with an intelligent interface agent that can learn the particular interests, habits, and preferences of individual users and then help them obtain the desired information in a way that reduces the number of links offered to the user. We accomplish this by supplying the interface agent with domain-specific background knowledge about user preferences and interests. At runtime, the interface agent uses this knowledge to find and recognize information of interest to the user. The agent must also be capable of acquiring knowledge on its own and building appropriate rules and facts in the knowledge base by monitoring user behavior over time (a form of machine learning).

Our approach aims at having Mosaic customize the link-following processes to suit a user's unique interests, habits, and access patterns. The system customizes the hypermedia environment supported by Mosiac by creating links dynamically, using rule-based algorithms or neural networks. This approach is much more flexible than many of today's closed hypermedia systems and still provides the user with the power to ask for more information when needed rather than statically displaying all available links on a particular topic every time.

Figure 3 depicts the system model we propose. Initially, users (and agents) store information about particular interests in the knowledge base. The rules and facts are used as input to the HTML Language Generator. User-specific HTML code (and links) are then generated at runtime. This requires communication with other Mosaic agents and servers (much like Archie servers are used) to find the relevant information on a particular topic or subject.

The goal of our work is to demonstrate that an intelligent interface agent can be used to satisfactorily limit the number of links offered to the user while simultaneously providing users with a more effective interface to the WWW.

The World-Wide Web is still evolving at a rapid pace. Clearly, distributed hypermedia systems on the Internet will continue to be an active area of development in the future. We believe that the flexibility of the WWW design, its use of hyperlinks, and the integration of existing WAIS and Gopher information resources, make the WWW ideal for future research and study. We also realize that highly interactive multimedia applications will require more sophisticated tools than currently exist. The most significant issue that needs to be resolved is the mismatch between WWW system capabilities and user requirements in the areas of presentation and quality of service. The lack of adequate directory services will continue to plague WWW users, and future work on distributed hypermedia systems will need to address these issues.

References

1. E. Krol, *The Whole Internet: User's Guide and Catalog*, O'Reilly & Associates, Sebastopol, Calif., 1992.
2. C. Adie, "Network Access to Multimedia Information," Edinburgh University Computing Services, Edinburgh, Great Britain, Aug. 1993. Available at ftp://ftp.edinburgh.ac.uk/pub/mmaccess.
3. K. Hughes, "Entering the World-Wide Web: A Guide to Cyberspace," ftp://taurus.cs.nps.navy.mil:/pub/mbmy/world-wide-web-guide.ps.Z, 1994.
4. T. Berners-Lee, "The HTTP Protocol as Implemented in W3," ftp://info.cern.ch:/pub/www/doc/http-spec.txt.Z, Jan. 1992.
5. R. Brandwein and M. Sendall, "HTML Converters," http://info.cern.ch/hypertext/WWW/Tools/Filters.html, 1994.
6. R. Vetter, C. Ward, and S. Shapiro, "Experiences With Projected Multimedia Presentations," *Proc. Third Annual Conf. Multimedia in Education and Industry*, Assoc. for Applied Interactive Multimedia, Columbia, S.C., 1994.
7. W. Hall, "Ending the Tyranny of the Button," *IEEE Multimedia*, Vol. 1, No. 1, Spring 1994.
8. "The WWW Virtual Library," http://info. cern.ch/hypertext/DataSources/bySubject/Overview.html, June 1994.
9. "What's New with NCSA Mosaic," http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/whats new.html, June 1994.
10. "World-Wide Web Growth," ftp://nic. merit.edu, 1994.
11. "Intelligent Agents," special issue, *Comm. ACM*, Vol. 37, No. 7, July 1994.

Ronald J. Vetter is an assistant professor in the Department of Computer Science and Operations Research at North Dakota State University in Fargo. His research interests include high-performance computing and communications, multimedia systems, and high-speed optical networks.

Vetter received the BS and MS degrees in computer science from North Dakota State University in 1984 and 1986, respectively, and his PhD in computer science from the University of Minnesota, Minneapolis, in 1992. Vetter is a member of the ACM and the IEEE Computer and Communication Societies.

Christopher G. Spell is the system administrator in the Mathematical Sciences Department at the University of North Carolina at Wilmington. His research interests include operating systems, communications, and multimedia systems. Spell received his BS in computer science from UNCW in 1993.

Charles R. Ward is assistant vice chancellor for academic affairs and professor of chemistry at the University of North Carolina at Wilmington. His research interests include the application of multimedia technology in chemical education.

Ward received the BS degree in chemistry from Manchester College in 1970, and the MS degree in chemistry from Purdue University in 1975. He received the PhD degree in science education from Purdue University in 1978. He is a member of the American Chemical Society and the Association for Applied Interactive Media.

Readers can contact the authors through Ronald Vetter, North Dakota State University, IACC Bldg., rm. 258, Fargo, N.D., 58105: e-mail rvetter@plains.nodak.edu.