WAN OPPORTUNITIES FOR DISTRIBUTED CONSTRUCTION INFORMATION

Dana J. Vanier, Researcher
Institute for Research in Construction, National Research Council Canada
Ottawa, Canada

Ziga Turk, Assoc.Prof.
Faculty of Civil Engineering, University of Ljubljana
Ljubljana, Slovenia

Abstract

The electronic distribution of construction documents such as building codes and standards, product information, technical literature, and research papers using magnetic and optical media is fast becoming commonplace. Wide Area Networks (WAN) and most notably the Internet can provide new opportunities for the distribution of construction information. Generally, this technology is maturing rapidly and access to the Internet is now widely available. As a result, it is now possible to provide new services for the distribution of construction information to researchers, architects, engineers and builders. In the paper we describe the underlying technology and review the opportunities for its employment in research and practice in the construction industry.

1 INTRODUCTION

1.1 BUILDERS AND THE INFORMATION SOCIETY

Local area networks (LAN) are contributing to the employment of information technology (IT) as a communication media between individuals and departments within organizations. Not only are LANs used to share expensive devices like printers, plotter, disks, modems, etc., they are becoming the major backbones in modern offices for sharing information, documents, discussions or correspondence and work flow. With the development of high speed, digital telecommunications, these (electronically) closed organizations can opening themselves up into the world. Computer-based communication backbones are spreading to encompass whole industries, countries and the entire world. In the developed world the creation of the so-called "information highways" is becoming one of the most important national investments in the infrastructure, as reflected in the US National Information Infrastructure project[1] and a European parallel.[2]

The traditional ways of spreading engineering and architectural knowledge electronically is to use magnetic (diskettes) or optical media (CD-ROMs) to

---

1 gopher://is.internic.net/11/infoguide/about-internet/nii/
2 http://www.earn.net/EC/bangemann.html

distribute software and various construction documents such building codes and standards, product information, technical literature, and research papers (Bourdeau,1991; CCB, 1993). However, finding out about which products exist, or how can they be obtained, are still obstacles to the rapid, effective dissemination of construction information. This is followed by a time lag to have the products delivered to the client. In addition, even stable information like the ones listed above has to be constantly updated. Therefore, magnetic or optical-based information is not that appropriate for dynamically changing information, like that created within a building project.

1.2 OPPORTUNITIES FOR INFORMATION DISSEMINATION

Wide Area Networks (WAN) provide new opportunities for the distribution of construction information. The largest wide area network existing on Earth is the Internet.[3] It is an inter-network consisting of over 20000 networks that connect over 2.2 million computers and is estimated to be used by 20 million people.[4] Originally started as a communication tool between military contractors in the USA, it is now becoming a communication standard for everyone dealing with computers and computer networks(Krol,1993). Generally, the technology is maturing rapidly. By relaxing the "acceptable use policy" Internet access is not only limited to government, educational and research organizations, it is opening up to the commercial users. In fact, using free software, Internet is accessible by anyone with a personal computer and a modem. As a result, the Internet can provide the necessary backbone for the distribution of construction technical information to researchers, architects, engineers and builders.

This paper proposes the use of WANs to access the abundance of construction information that is distributed around the world. Included in the benefits of this type of application are ease of access, instantaneous updates, and rapid information exchange. Other opportunities include the availability of multiple editions of documents, friendly standardized user interfaces, and transparent information access. WANs also provide opportunities to link into other computer programs on distributed servers and to efficiently browse and search large text documents.

The paper describes various distribution technologies such as TCP/IP, FTP(File Transfer Protocol), Gopher, Wide Area Information Service(WAIS), and World Wide Web(WWW). It demonstrates a distributed information base using Lighting Resources, a diskette-based prototype developed at the Institute for Research in Construction (IRC), and using other technical publications from the IRC and the University of Ljubljana.

2 TECHNOLOGIES

The chapter provides a brief introduction to the WAN technologies available on the Internet.

2.1 GENERAL

Physically the Internet consists of computers that are connected to the network through a network adaptor. The network consists of the wires and the hardware that modulates and routes digital signals from one computer to another. Logically the computers are grouped into networks - one network being limited to an

---

[3] `http://www.internic.net/infoguide/gopher/about-internet.html`

[4] `gopher://is.internic.net:70/00/infoguide/about-internet/history/timeline`

organization or a department. Each network has a unique number, as do each computer within the network. The data sent from one computer to another are broken into fairly small packets which are then broadcasted into the network. Using these addresses, the routing software sends the packets, perhaps over different routes, to the receiving computer, which then reassembles them into the original data. An even more abstract view would reveal that the packets are catalogued by type and that packets of a particular type (*e.g.* electronic mail, files, hypertext) are sent, and expected, by different applications on the sending and the receiving end. It appears as if each application uses a different "channel" of the network.

To understand each other's communication the sender and the receiver must used a standardized protocol. The *lingua franca* of the Internet is the Transmission Control Protocol (TCP), often called the Internet Protocol (IP) and identified as TCP/IP. The basic vocabulary is mainly preoccupied with addressing, handshaking and transmission of raw data. However, there are several application protocols that specialize in the exchange of particular types of data such as files, hypertext information, or electronic mail. In the following subsection some of the most useful Internet services for information exchange and network collaboration are described. These have many common characteristics:

- A service consists of a client program, server program and an application protocol they all use to communicate. The computer running the server program is often called "host".
- The server software's main task is to provide the information. The client's task is the user interface and the presentation of the information. They have client-server architecture. The role of the server is the information provider and the role of the client is the information requester.
- Application protocols are based on the TCP/IP.
- Servers can be contacted by more than one client at a time, and as a rule, clients work with only one server at a time, but can appear to be working with many servers.
- Clients and servers communicate with each other using a specialized protocol. The names of the protocol end with letter P for protocol (*e.g.* FTP, HTTP)
- The client program is a normal program. However, the server software is a deamon (program names end with D for demon, *e.g.*FTPD, HTTPD). Therefore, server machines must be multi-tasking machines, where more than one program can run at a time. This feature is not needed for client machines.
- All listed services are interactive applications, but do not work in real time - in theory no connection is too slow to use any of the services.
- Access to the information server is generally restricted: a client must have permission to log on. But the majority of servers also offer public access to anyone.
- Since there may be hundreds of thousands of servers in the world, there exist specialized search engines to find information offered by these servers.[5]
- For all the listed services, high-quality freeware or shareware clients exist for the DOS/Windows™, Macintosh™ and UNIX™ workstation.[6] Server software of good quality is also available for multi-tasking operation systems. An ideal server machine would run UNIX™ but there are reasonably good

---

[5] Perhaps the most complete is: http://cui_www.unige.ch/meta-index.html

[6] http://www.ncsa.uiuc.edu/SDG/Software

implementations for most services for DOS/Windows™[7] and Macintosh™ [8] as well.

The ease with which it is possible to create servers on the Internet is resulting in a vast quantity of information being made available. This also spawned the creation of new servers which specialize in finding the right information. The most widely-used Internet services, listed according to the growing complexity of client/server software and demands for networking speeds, are Telnet, FTP, Gopher and Gopher+, WAIS, and WWW.

2.2 TELNET

Telnet enables users to access a remote server on the network as if it were their own. In parlance, it enables the user to "log into a host" server so that programs run on that server, but the input-output is redirected to the local client. Since Telnet only transfers data that is typed on the keyboard or shown on screen (which are both limited by the speed of human typist or reader) even the slowest communication lines are fast enough for this service.

The use of Telnet is universal, from programming or using complex engineering software on a remote supercomputer to queries into information systems provided by travel agents, airlines, libraries and government agencies. Each of those programs offers a different user interface to access the information and limit the options to transfer that information to the local computer. In a way, this is why the popularity of this service is falling.

2.3 FILE TRANSFER PROTOCOL (FTP)

File Transfer Protocol or FTP is a service which transfers files between the client and the server. FTP can move files from the client to the server, or retrieve files from the server. One uses commands like **put**, **get**, or **mkdir** to transfer files or to work with the server.

Typically, password protection is available to prevent unauthorized use of the server. Anonymous FTP access[9] is available on many servers around the world, normally with few restrictions. A prime use of anonymous FTP is to access shareware, graphical images, and updates to software applications.

A few servers in the world contain directories of files from many of the FTP servers ("FTP sites" in parlance). These servers may be queried as to where a particular file can be obtained. The service is called Archie.[10]

2.4 GOPHER

Users of the FTP service must spend a lot of time changing directories and viewing their contents (using respective commands such as **cd** and **dir**). So in 1986, at the University of Minnesota, they developed a server that automatically creates a menu from the file names in a directory. The menu is displayed by the client and the file names are the menu options. If an option is selected, then the server either sends

---

[7] http://www.rpi.edu/Internet/Guides/decemj/internet-tools.html

[8] http://www.uth.tmc.edu/mac_info/machttp_info.html

[9] Anonymous FTP means that the users log on the server with "anonymous" as the user identification and their Internet Protocol number as the password.

[10] gopher://istge.ist.unige.it

the contents of the selected directory or the selected file. Because of the simplicity to organize information for Gophers (you only need to organize files into directories) there are now thousands of Gopher servers around the world.[11]

Later on Gopher servers provided access to Telnet sessions (a menu entry would start a Telnet application), to FTP archives, WHOIS, Archie and WAIS (see below) search engines and to Gopher servers on other computers. This last feature created the so-called "gopher space" which consists of all the Gophers servers in world and enables the user to access any information on any Gopher server in the world by moving through the menu structures. The more advanced Gopher+ protocol includes multimedia capabilities and multiple representations of the same file so that dumb clients, that is, ones with only alphanumeric capabilities, show the ASCII version of the text while more sophisticated ones call a hypertext client.

Finding information in Gopher space is eased by a service called Veronica.[12] Similar to Archie, a number of Veronica servers index information on all registered Gopher menus, and their files, and allow Boolean searches of that information - the result is returned as a Gopher menu.

2.5 WIDE AREA INFORMATION SEARCH (WAIS)

WAIS is a full-text database system produced by Thinking Machines Corp, Apple Computer and Dow Jones and placed in the public domain.[13] Full-text databases allow retrieval of documents or document parts by specifying any of the words which occur in them. On the server side the information is indexed using full-text inverted index techniques. Formats that can be indexed include ASCII text, TeX, CM application of HyperCard etc. Adding support to other formats like DXF or HTML is easy. The client queries the server giving a list of words as input. WAIS returns pointers to the appropriate information and ranks the documents found, positioning what it considers best match at the top. A typical use of WAIS is rapid searching of vast quantities of poorly-structured or heterogeneous information. WAIS can search texts, DXF files, e-mail archives or FTP sites at the same time, and is often used to search *all* the information on a particular server.

2.6 WORLD WIDE WEB (WWW)

WWW initiated at the European Laboratory for Particle Physics in 1989/90 (CERN,1994). It serves hypertext and hypermedia documents and interfaces to other services on the Internet(Krol,1993). The native format of the WWW documents is the Hypertext Markup Language(HTML). It is a SGML-based language. Automatic converters from various word processing formats to HTML already exist and are free of charge. The protocol used between the client and server is the HyperText Transport Protocol (HTTP). Similar to Gopher, the HTTP server can automatically generate a HTML document from file/directory structure and serve it to the client. A graphical client it essential for a comfortable use of the WWW. Perhaps the best known client is Mosaic (Please refer to Figs. 1 and 3 for the respective DOS/Windows™ and Macintosh™ clients), developed by the

---

[11] Annual rate of growth for Gopher traffic for 1993 is 997%. This information was obtained from treese@crl.dec.com on the Internet.

[12] Veronica: very easy rodent-oriented net-wide index of computerized archives. gopher://veronica.scs.unr.edu:70/00/veronica/how-to-query-veronica

[13] A description is available at http://www.vuw.ac.nz/who/Nathan.Torkington/ideas/www-primer.html

National Center for Supercomputing Applications (NCSA). It supports both graphics and text in a hypertext environment(NCSA,1994), and is available for many different platforms.

Browsing the WWW employs standard hypertext functions like moving through a hyperlink, going back, or reviewing history. The hyperlinks may be internal, ones that refer to a different point in the same document, or external and point to some document located virtually anywhere on the Internet. The links are referenced by the Uniform Resource Locator(URL) and Uniform Resource Name(URN) which give a unique name to any information on the Internet. They also include the service type, server machine and directory/file name on that machine. Examples of URLs can be seen in the footnotes in this paper.

Unlike most other services the WWW is flexible enough to allow more than simple fetching or searching of information. The HTML+ specification enables the creation of forms through which the client side can send large volumes of textual information to the server (See Fig. 1). HTML forms can be used as front ends to databases, e-mail or conferencing systems. This technology promises to provide a universal easy-to-use, platform-independent interface to all the information on the Internet.

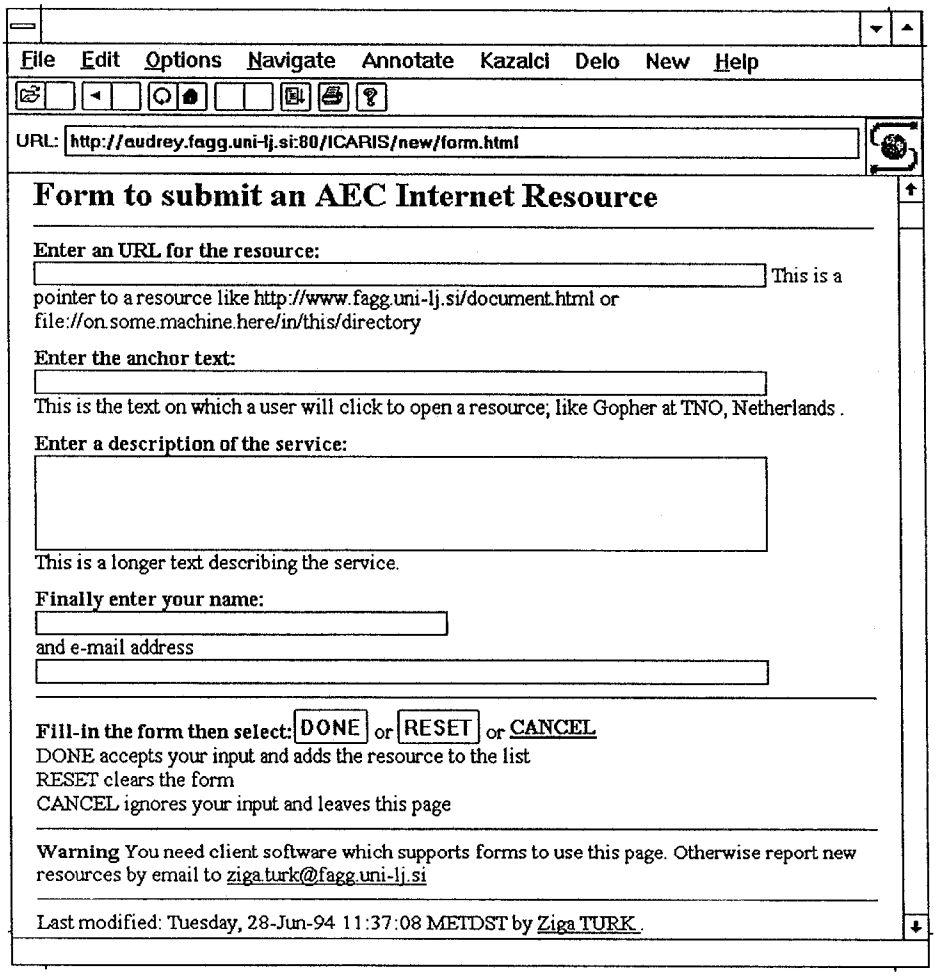

Fig. 1: Mosaic displaying a form to add information to an on-line database.

Indexed searching is an important feature in WWW. There are two main approaches to the difficult task of creating search engines for hyperspace. The spider-based approach exhaustively navigates the WWW, following the links it

finds and indexing the resulting information in one large central index. Whereas, the list-based engines rely on lists of services that are reported by the information providers to a central authority where they are indexed.

4.2 FORMATS OF INFORMATION FOR WAN DISTRIBUTION

The example in Fig. 2 provides some of the markup for HTML for the top part of the ICARIS Home Page shown in Fig.9. The angle brackets delimit the beginning <xxx> and the end </xxx> of the elements, and H, B, and HREF respectively mean header, bold and hypertext reference. The remainder is self-explanatory:

<HEADER> <TITLE>ICARIS - CIC research network </TITLE> </HEADER> <BODY>	Header information Title Page Name
<H1><IMGSRC=/icon/icaris.gif>ICARIS</H1>	Image link, H1 info
<B>ICARIS</B> is an experimental research network related to integrated CAD in civil engineering and architecture. It started as <A HREF="gopher://gopher.fagg.uni-lj.si:70/1usr/icaris"> Gopher </A> and an associated <A HREF=icaris-1.html> mailing list </A> in 1993 but will be migrated to Web. It is described in the <B> ICARIS Initiative </B> <A HREF=file://audrey.fagg.uni-lj.si/pub/icaris.zip> paper </A>.	Bold ICARIS Hypertext link to: - Gopher server - Mailing List - WWW server - File
<P> To keep in touch with the latest developments and additions to this server, please subscribe to the <A HREF=icaris-1.html> mailing list </A>.	New paragraph Subscribe instructions
</BODY>	End of body

Fig. 2: The HTML source for the page rendered in Fig. 9

The rule of a thumb for making information available on Internet is: if it is in the computer form and if it uses an industry standard format it can be used by others who have access to the same tools. The services themselves do not care about the content of the data. Some of the more popular formats include:

- ASCII text: The most reliable format, but also the most primitive.
- Post Script: It can be viewed by viewers that are available free of charge; it can be printed by most printers. It is a good format to distribute documents intended only for printing or viewing; it is difficult to create valid PostScript™ files on DOS/Windows™; and PostScript™ files are large and must be compressed.
- GIF: This is the best format for raster images; it is compact and unambiguously understood on different platforms.
- JPEG: This format for raster images incorporates compression that deliberately loses some information (that human eye does not notice it) and thus results in even smaller files.
- HTML: This is the formatting language for hypertext on WWW. It is easy to learn[14] and convertors from Windows™ Help format, TeX™, ASCII, Wordperfect™, Word for Windows™ are available.. The second author

[14] http://www.pcweek.ziff.com/~eamonn/crash_course.html

wrote a WinWord macro that automatically converts well-written papers to html.[15]

- DXF, HPGL, *.*: Any format is suitable so long as the receiving end is expected to have a program that can view that format. It is important to stress that the server does not restrict the format to be displayed, it is normally the type of client software that limits the input/output.

3 WAN PERSPECTIVES FOR CONSTRUCTION

The previous section described the services available on the Internet, this section outlines the existing and prospective uses of WAN for the distribution of information concerning construction research and practice.

3.1 IRC ON-LINE

IRC has been distributing technical information for the construction industry for the past 50 years. The large majority of this information is in the print medium. The information supplied can be generally categorized into the following areas: marketing, practitioner technology diffusion, and research information. Marketing, in this delimitation, can be viewed as self-promotion for future revenues; practitioner technology diffusion deals with the distribution of construction information to the industry, and the research information is published for the research community, and a limited practitioner base, using the scientific publication network. This paper concentrates on the last two categories of technical information, recognizing that marketing has special conditions that are best left to experts in that field.

The client group for the technical information can be generally divided into practitioners and researchers. Currently, researchers generally have accessibility to WANs through their research centres or universities, whereas practitioners are slowly becoming "connected" using commercial Internet service providers. Normally, all that is required is a high speed modem of 9600 bps or 14.4 kbps and a graphics-based computer platform. Typically, the base charges are in the order of $ 20.00 to $100.00 US per month, the full monthly cost is dependent on the connect time and amount of data transmitted.[16]

Browsing the current WWW servers on the Internet provides a good view of what information can be readily made available. Organizational data, personnel lists, curriculum vitae information, and project descriptions are typical examples. This is information that is readily available and easy to maintain. In the case of a research laboratory the following data are of interest to both practitioners and researchers: researcher name, location coordinates, research field and recent publications, as well as organization structure, laboratory description, equipment resources and current projects. Information of interest to practitioners includes symposia descriptions, topics of lectures, titles of publications and descriptions of products.

The home page of the IRC WWW server illustrates the potential of accessing this type of general technical information:

---

[15] An example can be found at http://audrey.fagg.uni-lj.si:80/ICARIS/tvdmi93/hpaper.htm. A list of tools is at http://info.cern.ch/hypertext/WWW/Tools/Word_proc_filters.html

[16] Compuserve™, Mindlink™, Hookup™ or Freenet are examples of commercial services currently available.

Fig 3: IRC Home Page and associated documents

As can be seen from Fig.3, multilingual editions of these documents are also possible just by adding a pointer to the "Version Francaise". Pointing at the Organization Chart in Fig. 3 produces the screen in Fig.4.

Included with these major functional elements are details about these units as well as listings about the staff members, equipment resources, and current projects. In turn, the staff references include pointers to the functional units, projects and publications. In Fig.5, information about the Technology Diffusion Service of the Industry Liaison Branch is requested. In Fig. 5, the first reference to the Turk/Vanier paper (TVDMI93) points to the ICARIS server.

This design follows the structure of an information base developed at IRC for a CD-ROM application(Worling et al, 1992). As can be seen in Figs. 4 and 5, this is not only valuable to a research organization, but any corporate structure would benefit from the same detailed information about their operations.

Currently the information on the IRC WWW server can not be searched using the indexed techniques described earlier, but we are investigating two approaches for search engines to search for information in all the numerous documents on the server. The brute force "grep[17]" search relies on a list of files that it searches for specific word occurrences. The result returns a list of files or a list of paragraphs that match the search string. This approach can be a considerable load on the server since each search must always browse through all the files. The other possibility is to use WAIS to build a full text index of all the files on the server including the ones not in HTML, but in formats supported by WAIS. In theory the second solution should work much faster and have less load to the server. In both cases, the final effect on the end user could be similar since the real bottlenecks are the communication lines.

---

17 Grep is a UNIX utility to find lines or paragraphs containing matching words or regular expressions.

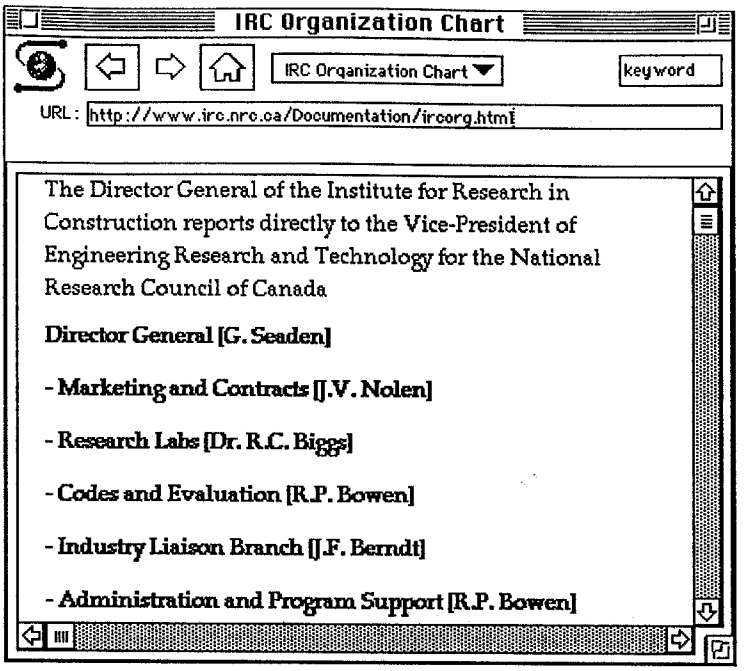

Fig 4: IRC Organization Page

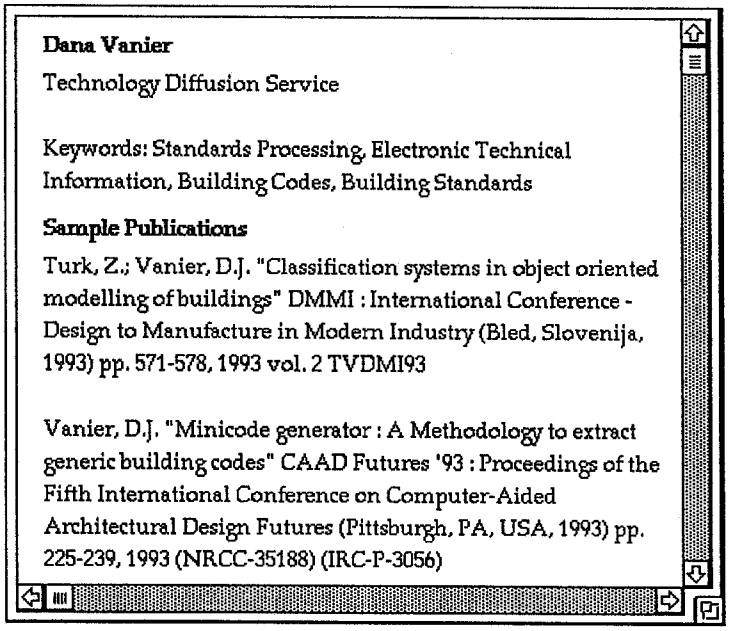

Fig 5: IRC Information Browsing showing information on Staff Members

3.2 LIGHTING RESOURCES

In addition to the organization information described above, there are other sources of IRC information that could be of interest to researchers and practitioners alike. Typically, a good application for an information base is one that already exists in electronic format (although subsection 3.4 enumerates the steps to create the proper format from hard copy information). One example shown in Fig. 6 is Lighting Resources, an electronic prototype developed at IRC.

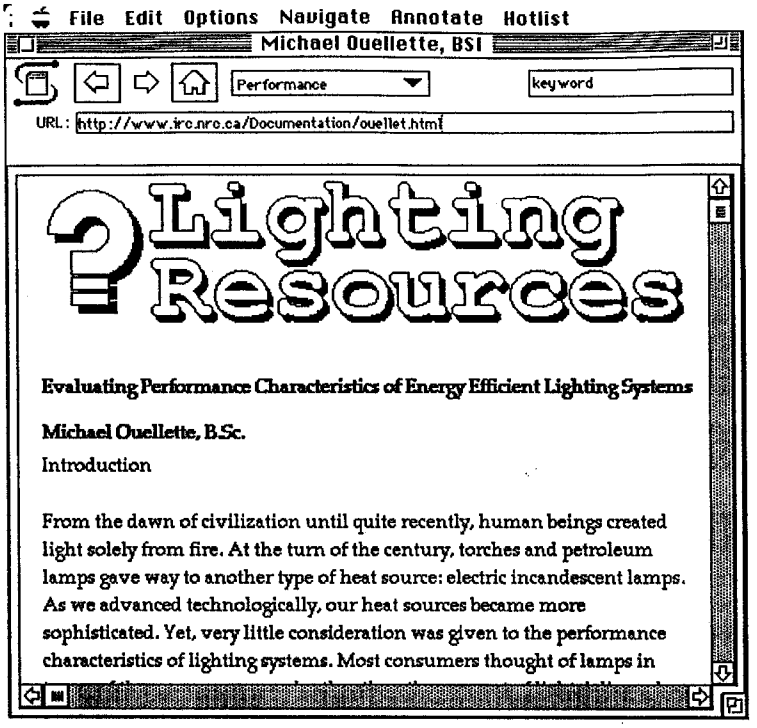

Fig 6: IRC Lighting Resources

Lighting Resources is a prototype electronic publication containing information on lighting research at IRC. It was produced in conjunction with the lighting group and other individuals involved in the Lighting symposium (Lighting, 1994). It is currently available as a prototype on diskette and runs under Windows™3.1. Lighting Resources is IRC's second prototype investigating the use of information technologies to disseminate technical information. The CD-ROM entitled *Construction Resources* (Worling et al, 1992) employed HyperCard™ and is only available on the Macintosh™ platform. Quite in contrast, the diskette version of Lighting Resources uses the Standard Generalized Markup Language (SGML) as the markup language and the Interactive Authoring and Display System Application (IADS) as the shell.[18] The features of the IADS implementation that are of interest to this WWW application are hypertext links to other documents, full colour graphics, graphical maps with cross-references fields, and full-text searching (See Fig. 7).

The move of the contents of Lighting Resources to the MacHTTP server was relatively easy. That is, modification were made to the SGML source document to HTML, graphics were converted to GIF or JPEG from ".bmp", and cross-reference links were reconstructed. HTML is similar to SGML, so brute-force semi-automated conversion (global search and replace) was used; however, tools such as FastTag/Hammer[19], Omnimark[20], TagWrite[21] and the Rainbow[22] format can convert documents from standardized formats such as Rich Text Format (RTF).

---

18 Host: sgml1.ex.ac.uk, Login: anonymous ftp, Location: /iads.

19 They are available from Avalanche Development Company and parse most common word processed documents to create SGML output.

20 Available from Exoterica, Ottawa, Canada

21 Available from Zandar Corporation

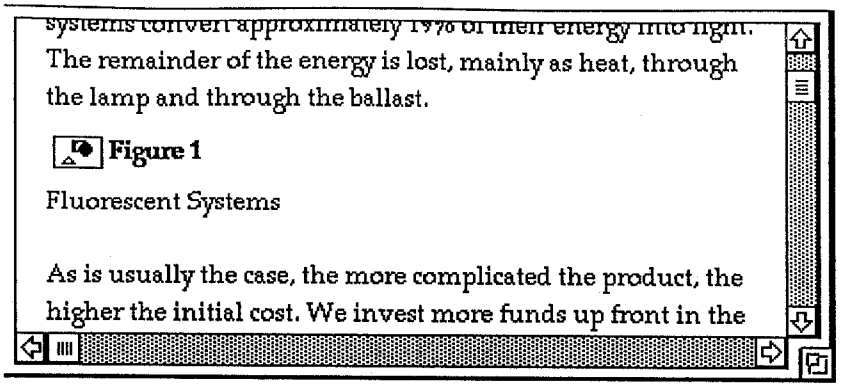

Fig 7: Lighting Resources with links to graphics

As can be seen, products such as Lighting Resources can be naturally integrated with the organization information through the authors' names or any of their affiliations.

3.3 EXCHANGE OF DESIGN INFORMATION

Internet's FTP and electronic mail services are the natural infrastructure for the lowest layers of electronic and product data interchange (EDI/PDI). Companies can send drafts and documentation using multimedia e-mail or simply transfer files using FTP. The size of engineering documents can pose a problem which can be solved either by leasing faster lines, by compression techniques, or by sending data on optical disks or magnetic media. TCP/IP can also be used to interconnect LANs in such a way that the remote networks and local LAN, and the corresponding file systems, merge into one seamless local area network (Turk, 1994).

This distributed construction information source could provide building practitioners and researchers with access to the tomes of construction information available today. These hypertext information bases could not only incorporate technical information and building codes(Watson and Ward,1992), but could also contain controlled vocabularies, national standards, international standards, national specifications, contract documents, as-built and working drawings and manufacturers drawing, specifications and instructions(Poyet,1990).

This can be an invaluable asset to members of the design team, allowing them to communicate directly to their colleagues, consultants, contractors or manufacturers without numerous telephone calls or expensive meetings. The technology can automatically provide an electronic record of all the discussions, decisions and project notes. It also allows members of the design and construction team to transfer or share word processed documents, specifications, change orders, CADD drawings, database records, and hypertext documents in a quick and efficient manner.

The Internet could be visualized as the backbone of communications for a design network. Building designers transmit drawings, sketches and specifications via FTP, and the Internet allows use of services such as EDI, Gopher and WWW for

---

[22] Rainbow is a SGML-like neutral format developed by Electronic Book Technologies, in conjunction with several other key SGML vendors and promoters

flexible, robust information requests. It could also assist the transfer of information about building codes as suggested by Williams(1993).

Generally, we feel that the enumerated Internet services do not provide the necessary security, locking and version control capabilities to be directly used in a framework for collaborative design environment. However, these are server features that can be developed in the future to meet these demands from the information suppliers.

3.4 BUILDING CODES AND STANDARDS

Hypertext is regarded as a key technology in the passive representation of building codes and regulations(Vanier,1989; Vanier,1990; CD-REEF, 1992; Thomas and Worling,1992; CCB, 1993). WWW, backed with a WAIS full text search engine, makes it possible to convert paper documents into the WWW format quickly and efficiently. For example, there are plans to create a WWW interface into a more advanced forms of hypertext like the PLINTH[23] system (Casson, 1993) which includes typed links and graph browsers not provided by the WWW.

A current project at the University in Ljubljana is to convert the latest drafts of Eurocode1 and Eurocode8 (EN 1991, EN 1998) to WWW. Eurocode8 is being converted to Windows™ Help format; from there it can be translated to HTML automatically. The conversion procedure for Eurocode1 is as follows:

- Using OCR software, the paper version of Eurocode1 is scanned, recognized, spell-checked and split (according to contents) into documents up to 5kbytes in size (to achieve transfer times below 5seconds on slow communication lines).
- A 'text to html' filter is applied to create about 85% of the HTML markup, the rest is done manually.
- The hypertext links for the table of contents and the explicit cross-references are done semi-automatically with human intervention.
- The figures and tables are scanned and inserted as bitmaps.
- The next and previous links, and the link to the table of contents, are added to each page automatically.
- The document is searched for words that are listed in the Canadian Thesaurus of Construction Terms (TC/CS, 1978); each word is substituted with a pointer to an index page of this word. The index page contains pointers to all words in the documents accompanied by some characteristic text, (e.g., nearest section number and title). The index page also contains a pointers to related words ('See Also' references).
- The documents are indexed using WAIS.

The expected result of the work is shown Fig. 8. Due to unclear copyright policies of international standardization bodies it is still not known whether such versions of their documents will (or can) be offered publicly on the WWW.

---

[23] http://www.aiai.ed.ac.uk/~andrewc/plinth/datasheet/contents.html

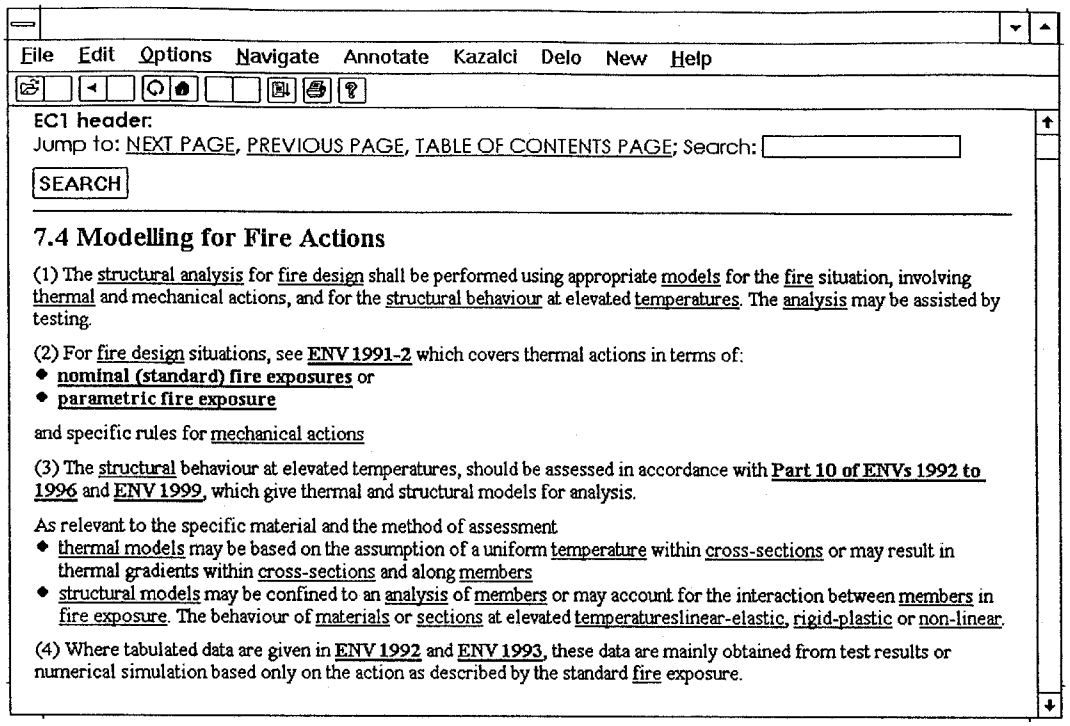

Fig. 8: Eurocode 8 as a HTML document displayed by Mosaic.

These internationally activities can be directly referenced by other documents on the Internet, such as those produced at the IRC dealing with building codes.

3.5 JOINT DEVELOPMENT OF STEP MODELS

International standardization committees are ideal customers for Internet services, and the WAN distributed information seems to provide an ideal collaboration infrastructure. A move in that direction is the Step On-Line Information System SOLIS[24] which includes dial-up and FTP access to STEP documents and some e-mail discussion lists. Another interesting development is the EXPRESS to HTML converter[25] which translates EXPRESS models into hypertext; that is, so that one can quickly move from entity's use to entities definition.

The authors can envision a global WWW-based EXPRESS authoring tool. The components would include:

- A central organization would provide administrative tasks, central search engines, participants lists etc., but would delegate the responsibilities for the definition of certain concepts or schemas to an organization somewhere on the Internet. This organization would fix the URL of *the* definition of the concept.
- Developers of a schema would provide a hypertext definition of their schema. All external references would be hypertext links as well and lead to the outside world such as EXPRESS definitions, word dictionaries, thesauri, programming language implementations, or Mosaic annotations. Hypertext links could be connected to textual and graphical comments (as with

---

24 `file://ftp.cme.nist.gov/pub/step`

25 `http://www6.informatik.uni-erlangen.de:1200/Express/exp2html.html`

EXPRESS-G) and discussion threads could be sent over e-mail or entered in a form. These would complete the modelling framework.

3.6 INDUSTRY INFORMATION SYSTEMS

In 1994, Slovenia started a national development project TIGRA (technical information system for the building industry) sponsored by the Ministry of Science and Technology and the Building Centre of Slovenia. It is planning to use TCP/IP connectivity to create an information system for the Building Centre, connecting suppliers, building contractors and government authorities. Multimedia systems based on WWW and Windows™ will be used to gather and disseminate information. Emphasis will be placed on a system design that simplifies the supply and structuring of the information and yet does not hamper efficient access.

3.7 SYSTEMS TO SUPPORT R&D COLLABORATION

The World Wide Web can be viewed as a huge collaboration environment with its own "white" and "yellow" pages, calls for papers, publishing opportunities, and discussion systems. Since the spring of 1994 the ICARIS system (Turk, 1993) operates as a WWW server as well. The home page is shown in Fig. 9. ICARIS includes pointers to Internet resources and a distributed, bibliography of papers and reports, some available in full text with graphics.

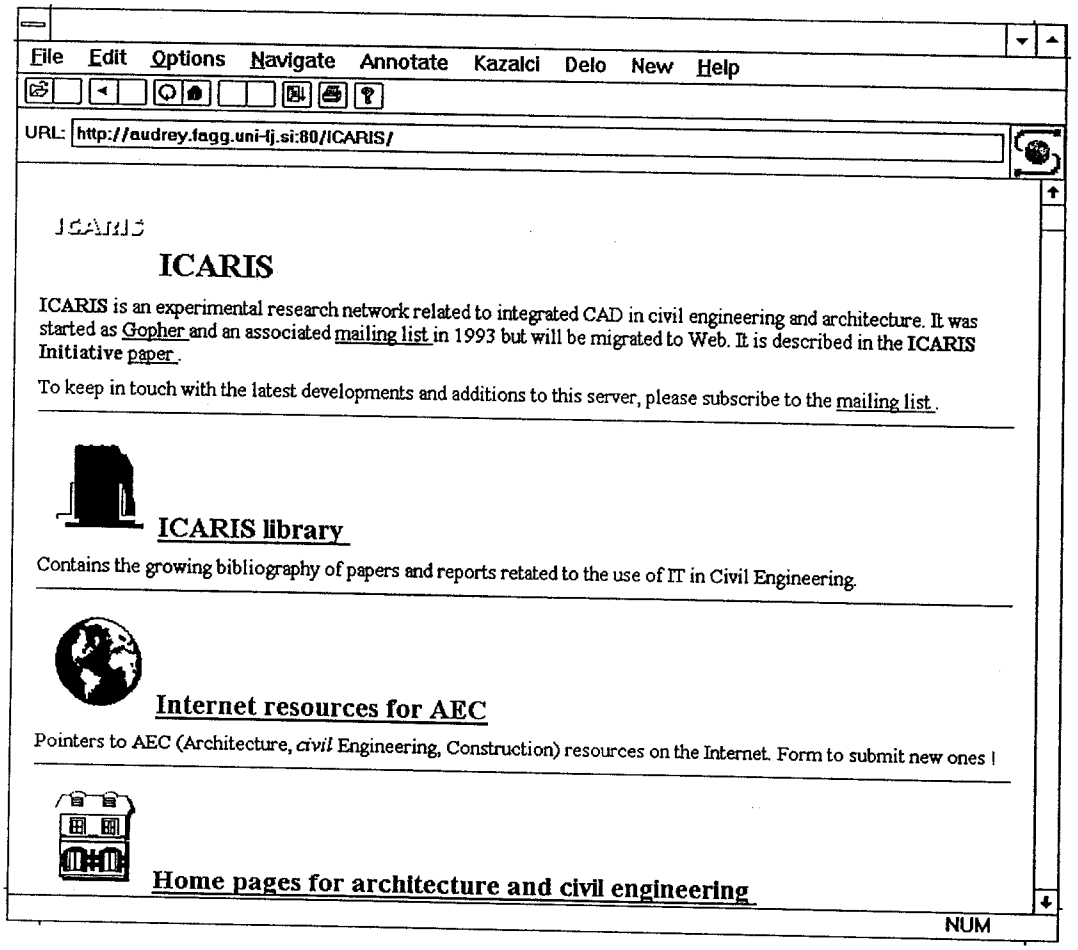

Fig. 9: The ICARIS "home" page.

3.8 OTHER EXISTING INTERNET RESOURCES

There are many interesting services in existence now, and new ones are being added so quickly that giving a listing in a document distributed on paper would not stand the test of time. These listings include on-line galleries and show rooms of architectural projects, full text publications, STEP documents, research projects summaries and reports, facts on building departments and the staff at universities and research institutions. There are also documents on the Internet that contain up-to-date directories of such services. Perhaps the most exhaustive list of pointers to Internet resources for architecture, engineering and construction industry (AEC) is Jeanne Brown's list (Brown 1994) which is updated regularly. Another good starting point for building professionals with WWW access is the ICARIS WWW server.[26] It contains pointers to most AEC home pages, including a list of the latest additions. It is also a good place to register a new resource.

4 EXPERIENCES

4.1 ACCESS AND SPEED

Internet is currently available in 62countries around the world.[27] Basically, there are two access types - a LAN may be directly, and at all times, connected to the Internet through leased lines - the solution chosen by most universities, research organizations and an increasing number of government bodies and commercial organizations. An alternative is a dial-up connection using the Serial Line Internet Protocol (SLIP). This enables anyone with a personal computer and modem to dial an Internet service provider.

The access speeds for leased lines range from 64kbps up to 100mbps (bps=bits per second). Speeds are generally lower on international and intercontinental lines. Tolerable transfer speeds for using Telnet start at 2.4 kbps and for using the WWW at 14.4 kbps (which is the speed of today's inexpensive modems). The latter would enable the transfer of the formatted text of this paper in 15-20 seconds.

4.2 ACCESS RESTRICTIONS AND BILLING

Most Internet services described in this paper are free of charge. Everyone (or their gateway organization) just pays for the communication costs. But there is a growing number of information providers that charge for their information (e.g., Encyclopedia Britannica[28]). Most HTTPD server software allows the server administrators to enforce access restrictions on portions of their data to some clients (based on the IPnumber). The server access logs can be used to charge the clients for various types of transfers such as number of bytes, connect time or documents downloaded.

5 DISCUSSION AND CONCLUSION

This is a preliminary investigation of the WAN opportunities for distributed construction information. As can be seen there are numerous potential applications

---

26 http://www.fagg.uni-lj.si/ICARIS/home-ptr.html

27 gopher://is.internic.net:70/00/infoguide/about-internet/global/version_10

28 http://www.eb.com/

for this technology in the construction industry, all that appears to be missing is the data and perhaps data formats. The use of WANs is growing quickly: exponentially for many of the different types of Internet services. However, much of the currently accessible information is ill-structured for intelligent information retrieval, as can be appreciated doing a simple Archie, Veronica or WAIS search. The reasons being that the data are distributed throughout the world, located on numerous machines, encoded in various formats and maintained by individuals. Some document standardization is required so we can all easily access each other's information, intelligently. WWW provides a suitable document standard; combined with indexed Boolean searching, the construction industry can have the distributed information network that could make AEC considerably more efficient.

Imagine the scenario: you are a designer looking for a widget that does X, Y andZ. Let's check the Internet! A quick browse of the WWW indicates that widgets are also called "thingys" in the Internet construction thesaurus; there are three companies who supply components that meet your requirements; similar widgets were used on a project in your region; high resolution bitmaps confirm your details, and the video clip quickly demonstrated the parts capabilities. You notify the supplier via EDI, the parts are set aside automatically in the local depot, and your CADD database logs the transaction. Sure beats the traditional method of flipping through dated catalogues, phoning suppliers, playing voice mail tag: only to have the wrong part delivered.

How can researchers assist the industry to reach this state of electronic efficiency?

The Internet is proliferating on a "grassroots", or bottom-up approach; individuals and their requirements are establishing the demand. The same can be true for a distributed construction information network. We should publish all our work on the Internet using the appropriate technology; we should encourage our organizations to do the same; we should ensure data integration through format standardization; we should publish freely and openly; and we should cooperate.

W78 members are the vanguard for information technologies in CIB Member organizations, our colleagues in the other construction domains will follow our lead in this venture. This grassroots approach can also encourage others in the profession to do the same: manufacturers, suppliers, consultants, builders and owners can supply their information to close the net, so to speak. Soon we will have all this information at our fingertips.

REFERENCES

Bourdeau, Marc (1991), The CD-REEF:The French Building Technical Rules on CD-ROM, *Computers and Building Regulations*, VTT Symposium Series, No.125, Espoo, Finland, 27-29May, pp.117-133.

Brown (1994), *Internet Sources In Architecture And Building*, University of Nevada, Las Vegas. (gopher://una.hh.lib.umich.edu:70/00/inetdirsstacks/archi:brown)

Casson (1993), PLINTH: Integrating Hypertext, Semantic Nets and Rule-Based Systems in an Expertext Shell for Authors and Readers of Regulatory Documents, Mayfiled J. and Nicholas C. (eds), Proceedings on *Workshop on Intelligent Hypertext*, CIKM 93, Arlington, VA, USA, 1993.

CCB (1993), CCB Update, *CCB Bulletin*, Publication of the National Institute for Building Sciences, Washington, DC, Vol.5, No.2, (n.pag.).

CERN (1994), European Laboratory for Particle Physics, *The World Wide Web Initiative,* Geneva, Switzerland. (http://info.cern.ch/hypertext/WWW/TheProject.html)

EN 1991 *Eurocode 1 Basis of design and actions on structures*, CEN Technical Committee CEN/TC 250.

EN 1998 *Eurocode 8 Design of structures for earthquake resistance*, CEN Technical Committee CEN/TC 250.

Krol, Ed (1993), *The Whole Internet:User's Guide & Catalog*, 3rded., O'Reilly & Associates, Inc., Sebastapol, CA, 376p. Poyet,1990

Lighting(1994),*Effective and Efficient Lighting,* Building Science Insight Proceedings, No.19, Institute for Research in Construction, Ottawa, Canada, 64p.

NCSA (1994), National Center for Supercomputing Applications, *NCSA Mosaic Home Page for MacIntosh*, University of Illinois, Urbana-Champaign, IL (http://www.ncsa.uiuc.edu/SDG/Software/MacMosaic/MacMosaicHome.html)

TC/CS (1978), Industry, Science and Technology Canada (formerly Department of Industry, Trade and Commerce, Government of Canada), *Canadian Thesaurus of Construction Science and Technology*, Ottawa, Ontario, 2 Vols., (n.pag.).

Thomas, J. Russell, and Jamie L. Worling (1992), SGML and ODMS:Tools for Building Code Writers, *Proceedings Joint CIB Workshops on Computers and Information in Construction*, Montreal, PQ, 12-15May, pp.411-419.

Turk (1993), ICARIS Initiative, technical report presented at *CIB W78 meeting in* Singapore, Aug. (file://audrey.fagg.uni-lj.si/pub/icaris.zip)

Turk (1994), Three Prototype CDDM Systems, to be presented at *CIB W78 Workshop on Computer Integrated Construction*, VTT, Helsinki, Finland, 22-24Aug., 1994.

Vanier, Dana J. (1989), Computerization of Building Regulations, In *Proceedings of the International Conference on Municipal Code Administration - Building Safety - and the Computer*, Winnipeg, Manitoba, 24-28Sep., pp.43-62.

Vanier, Dana J. (1990), Hypertext - A Computer Tool to Assist Building Design, *The Electronic Design Studio:Architectural Knowledge and Media in the Computer Era*, The MIT Press, Cambridge, MA, pp.283-300.

Watson, A.S., and M.A. Ward (1992), Building Hypertext Representations of Regulatory Material in the Construction Industry:A Case Study, *The International Journal of Construction Information Technology*, Vol.1, No.1, pp.43-58.

Williams, Fred (1993), *A Design Standards Document Server*, Master's Thesis, Department of Engineering, Carleton University, Ottawa, Ontario. (http://www.civeng.carleton.ca/Research/Thesis/Fred_Williams)

Worling, Jamie L., B. Scott Mellon, and Dana J. Vanier (1992), Electronic Technical Information- An Access and Distribution System, *Proceedings Joint CIB Workshops on Computers and Information in Construction*, Montreal, PQ, 12-15May, pp.572-582.