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INTERNET AND THE CONSTRUCTION INDUSTRY[1]

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INTRODUCTION

Local area networks (LAN) are contributing to the use of Information Technology (IT) as a communication media between individuals and departments within organizations. Not only are LANs used to share expensive devices such as printers, plotters, disks and modems, they are becoming the major "backbones" in modern offices for sharing information, documents, discussions or correspondence and work flow. In combination with the development of high speed, digital telecommunications, these (electronically) closed organizations can open themselves to the world. Computer-based communication backbones are spreading to encompass whole industries, countries and the entire world. In the developed world the so-called "information highways" are becoming the most important national investments in the infrastructure, as reflected in the US National Information Infrastructure project[2] and a European parallel.[3]

The traditional electronic ways to diffuse engineering and architectural knowledge employ magnetic (diskettes) or optical media (CD-ROM - Compact Disk Read Only Memory) to distribute software and various construction documents such as building codes and standards, product information, technical literature, and research papers. However, finding out what products exist, or how can they be obtained, is still an obstacle to the rapid, effective dissemination of construction information. This problem is followed by the delay to have the products delivered. In addition, even stable information like the ones listed above has to be constantly updated. Therefore, magnetic or optical information storage is not necessarily appropriate for dynamically changing data, like that for a construction project.

IT and networks provide new opportunities for the distribution of construction information. The largest wide area network existing on Earth is the Internet.[4] It is an inter-network consisting of over 20,000 networks that connect over 2.2 million computers and is estimated to be used by 20 million people.[5] 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

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1 This is a shortened form of a paper submitted to the International Journal of Construction Information Technology. A copy of the full paper can be found at http://www.irc.nrc.ca/vtcit94.html. The reader is advised to pay careful attention to the footnotes in this paper as they provide Internet addresses to many of the applications and features described in this paper. My co-author, Dr. Ziga Turk, has created one of the most successful Internet access nodes for the construction industry, it can be located at http://audrey.fagg.uni-lj.si

2 gopher://is.internic.net/11/infoguide/about-internet/nii/

3 http://www.earn.net/EC/bangemann.html

4 http://www.internic.net/infoguide/gopher/about-internet.html

5 gopher://is.internic.net:70/00/infoguide/about-internet/history/timeline

(Krol, 1993; Carroll[6] and Broadhead, 1994). Generally, the technology is maturing rapidly, even exponentially. By relaxing the "acceptable use policy" Internet access is not only limited to government, educational and research organizations and it is opening up to the commercial users. In fact, using free software and having minimal on-line fees, Internet is accessible by anyone with a personal computer and a modem. The Internet can therefore provide the necessary backbone for the diffusion of construction technical information to researchers, architects, engineers and builders.

I'M ON THE INTERNET!

It is so easy to say "I am on the Internet", but "where?" is the appropriate question. At the end of this paper the readers will realize that there are different Types of Internet Access and various Levels of Internet Connectivity, and depending on the type of application used and the equipment and cabling available, the readers also will realize that they want a faster Type of Access or a higher Level of Connectivity.

The paper describes four Types of Internet Access: (1) access through a Gateway Service, (2) Remote Modem Access, (3) Point to Point Protocol (PPP) or Serial Line Internet Protocol (SLIP) access, and (4) Direct Internet Access. In addition, the paper describes five Levels of Internet Connectivity: (1) E-mail and List Servers, (2) Telnet, (3) FTP (File Transfer Protocol), (4) Gopher, and (5) World Wide Web (WWW). Although the types and levels all appear to be completely different in functionality, they have surprising similarities such as quickly sending sparse messages around the world.

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[7]). Most service administrators can enforce access restrictions on portions of their data to non-paying clients (based on the IP number and passwords). The host computer access logs can be used to charge the users for various types of transfers such as number of bytes, connect time or documents downloaded.

TYPES OF INTERNET ACCESS

Before describing the software part of the Internet, it is necessary to first describe the Types of Internet Access; basically these are hardware issues. The Levels of Internet Access are described in increasing order of speed, functionality, and cost.

The first level, Access through a Gateway Service, means that the user is directly connected to a service such as Compuserve[a], but the user is only remotely connected to the Internet from that service. Typically, the user is restricted to the services offered by the gateway and is restricted to browse only locations provided by that service. However, most users of these types of service can send e-mail to Internet addresses. In addition, as of today, there is a limited number of Gateway Services that provide direct access to the Internet; however, demand is growing for additional functionality and these Gateway Services will respond in the near future.

Remote Modem Access allows the user to access a host server in a "terminal emulation" mode. That is, the user is connected to the host server but the software that connects to the Internet is resident on that host machine, NOT the user's computer. Normally, all that is required is a terminal or computer and

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6 Jim Carroll, C.A, gives seminars and can be reached by sending email to jcarroll@jacc.com.

7 http://www.eb.com/

a high speed modem of 9600 bits per second (9600 bps) or more. Typically, the base charges are in the order of $20.00 to $100.00 per month; the full monthly cost is dependent on the connect time and amount of data transmitted.[8]

Modem Access is acceptable for some Levels of Internet Connectivity but normally it provides limited access to the higher Levels. Typically this means that a command line interface is used in place of a Graphical User Interface (GUI) and, as a result, the program is less friendly and more confusing to novice users. Although text-based (no graphics) applications or client programs such as Lynx can run on both Gateway Services and Remote Modem Access, these applications do provide functional access to the highest Levels of Internet Connectivity.

Point to Point Protocol (PPP) or Serial Line Internet Protocol (SLIP) access is a hybrid between the previous Type of Internet Access and Direct Internet Access. PPP or SLIP allows the user to use a high speed modem of 9600 bps or greater to connect to an Internet node. PPP or SLIP Access is identical to Direct Internet Access, with the exception of the speed of connection.

Direct Internet Access is the top level of Internet Access. Direct Internet access means that the user can interactively and immediately access the Internet and all its functionality, it also means that it is the most expensive Type of Internet Access. An additional factor is there are varying speeds of Direct Internet Access connection ranging from a 56 kbps (kilo or thousands of bps) connection to T1 connections at 1.5 mbps (million bps) to T3 connections at 40 mbps (Carroll and Broadhead, 1994). CANARIE, the Canadian Network for the Advancement of Research, Industry and Education, is currently attempting to bring all of Canada up to the T1 level. Initiatives in the USA such as the National Research and Education Network (NREN) indicate that networking involving "Gigabit speeds" is possible in the near future (Carroll and Broadhead, 1994).

LEVELS OF INTERNET CONNECTIVITY

General

Physically the Internet consists of computers that are connected to the network through network adaptors. 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 organization or a department. Each network has a unique number, as does each computer within the network. The data sent from one computer to another are broken into fairly small packets which are then broadcast 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. This analogy can be used for all five Levels of Internet Connectivity; that is, sparse messages are shipped around the world with nothing more then Sender Address, Message Body and Receiver Address.

To understand each other's communication the Sender and the Receiver must use a standardized protocol. The Internet standard 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, acknowledgements 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. These have many common characteristics:

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[8] Compuserve®, Mindlink®, or Hookup® are current examples of commercial services.

- A service consists of a client program (running on your computer), the host server program (running on the host server) and an application protocol they all use to communicate.
- The client program's task is the user interface and the presentation of the information. The host server program's task is to supply the information. This is a client-server architecture.
- The client program is a standard program running on your computer. However, the host server software is a deamon, that is, it responds automatically to inquiries from many client programs.
- Host servers can be contacted by more than one client program at a time, and as a rule, client programs work with one host server at a time, but can appear to be working with many host servers.
- All services described in this paper are interactive applications, but do not work in real time - messages are passed constantly from the client program to the host server.
- Access to the host server is generally restricted: a client program must have permission to log on. In fact, the majority of host servers offer public access to anyone, this is call "Anonymous" access.
- Since there may be hundreds of thousands of host servers in the world, there exist specialized programs to find where these are located and how to access information offered by host servers.[9]
- High-quality freeware or shareware client programs exist for the DOS/Windows[a], Macintosh[a] and UNIX[a] workstation.[10] Host server software of good quality is also available for multi-tasking operation systems. An ideal host server machine would run UNIX[a] but there are reasonably good implementations for most services for DOS/Windows[a][11] and Macintosh[a] [12] as well.

E-mail and List Servers

E-mail is rapidly becoming the standard for communication in the 1990's. Not only does it permit effective communication within a LAN; with the proper hardware and software, there is also the possibility of transmitting information to the entire Internet. There is not much to say about E-mail except that it is fast, efficient, reliable, and inexpensive; and by the way, one can also keep an audit trail for all correspondence received and sent. What more can you ask for from a communication tool? Typically E-mail addresses are identified by the "@" (pronounced 'at') sign in the Small Machine Transport Protocol (SMTP) address. My e-mail address is 'Vanier@IRC.LAN.NRC.CA'; an e-mail address is not case-sensitive, so the address can be in upper or lower case characters. I put my address in uppercase so there is no confusion between the L's or I's and the number "one". The address actually means that my e-mail address is on a mail server named "IRC" that is a part of LAN router, in the NRC gateway in CAnada. Most commercial software packages permit sending e-mail messages outside of the LAN, this will normally be found in the SMTP option in addressing the messages.

List Servers are a simple extension to the e-mail protocol. They are simply lists of e-mail addresses, tied to a specific topic, waiting passively on an e-mail server. Any incoming message to the list will be rebroadcast to all the members on the list. It is an extremely efficient method to get information out; however, it can be annoying to users who may receive multiple broadcasts of the same message.

Telnet

Telnet enables users to access a remote host server on the network as if it were their own. This means the user "logs into a host" server, with the program running on that host server, but the input-

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

10 http://www.ncsa.uiuc.edu/SDG/Software

11 http://www.rpi.edu/Internet/Guides/decemj/internet-tools.html

12 http://www.uth.tmc.edu/mac_info/machttp_info.html

output is redirected to the local client program. 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 Level on Internet Connectivity.

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. Typically Telnet is used for the first two Types of Internet Access, namely access through a Gateway Service and Remote Modem Access.

File Transfer Protocol (FTP)

FTP is a service which transfers files between the client program and the host server. FTP can move files from the client program to the host server, or retrieve files from the host server. One uses commands like 'put', 'get', or 'mkdir' to transfer files or to work with the host server. Typically, password protection is available to prevent unauthorized use of the host server. Anonymous FTP access[13] is available on many host 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 host servers in the world contain directories of files from many of the FTP servers ("FTP sites" in parlance). These host servers may be queried as to where a particular file can be obtained. The service is called Archie.[14]

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 host server that automatically creates a menu from the file names in a directory. The menu is displayed by the client program and the file names are the menu options. If an option is selected, then the host server either sends the contents of the selected directory or the selected file. Because of the simplicity to organize information for Gopher (named after the University of Minnesota mascot) there are now thousands of Gopher servers around the world.[15]

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 Gophers servers in world and enables the user to access any information on any Gopher server by moving through the menu structures. The more advanced Gopher+ protocol includes multimedia capabilities and multiple representations of the same file so that client programs with only alphanumeric capabilities show only the text of the documents while more sophisticated client programs have a full GUI.

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

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

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

Finding information in Gopher space is eased by a service called Veronica.[16] 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.

WAIS is a full-text database system produced by Thinking Machines Corp, Apple Computer and Dow Jones and placed in the public domain.[17] Full-text databases allow retrieval of documents or document parts by specifying any of the words which occur in them. On the host server the information is indexed using full-text inverted index techniques. The client program queries the host 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 host server.

World Wide Web (WWW)

WWW was initiated at the European Laboratory for Particle Physics (CERN) in 1989/90.[18] WWW serves hypertext and hypermedia documents and interfaces to other services on the Internet (Krol, 1993).

Hypertext is fast access connection to electronic documents. This technology permits users to browse quickly over text and graphics, while permitting sophisticated keyword searches and other administrative functions such as history trails.

A graphical client program is recommended for a comfortable use of the WWW. Perhaps the best known client program is NCSA Mosaic[a] (Please refer to Figs 1 and 2 for the DOS/Windows[a] and Macintosh[a] client programs), developed by the National Center for Supercomputing Applications (NCSA). It supports both graphics and text in a hypertext environment,[19] and is available for many different platforms. Mosaic Netscape[a] from MCOM is another well-known WWW client program.[20]

Browsing the WWW employs standard hypertext functions like moving through a hyperlink to another location, going back to a previous location, or reviewing the history of locations visited. 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.

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

17 Located at http://www.vuw.ac.nz/who/Nathan.Torkington/ideas/www-primer.html

18 http://info.cern.ch/hypertext/WWW

19 http://www.ncsa.uiuc.edu/SDG/Software/MacMosaic/MacMosaicHome.html

20 Anonymous FTP to ftp.mcom.com for your own copy.

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 and directory/file name on that host server. Examples of URLs can be seen in the footnotes in this paper. The WWW is flexible enough to allow more than simple fetching or searching of information. The newest specification enables the creation of forms through which the client program can send large volumes of textual information to the host server (See Fig 1). Forms can be used as front ends to databases.

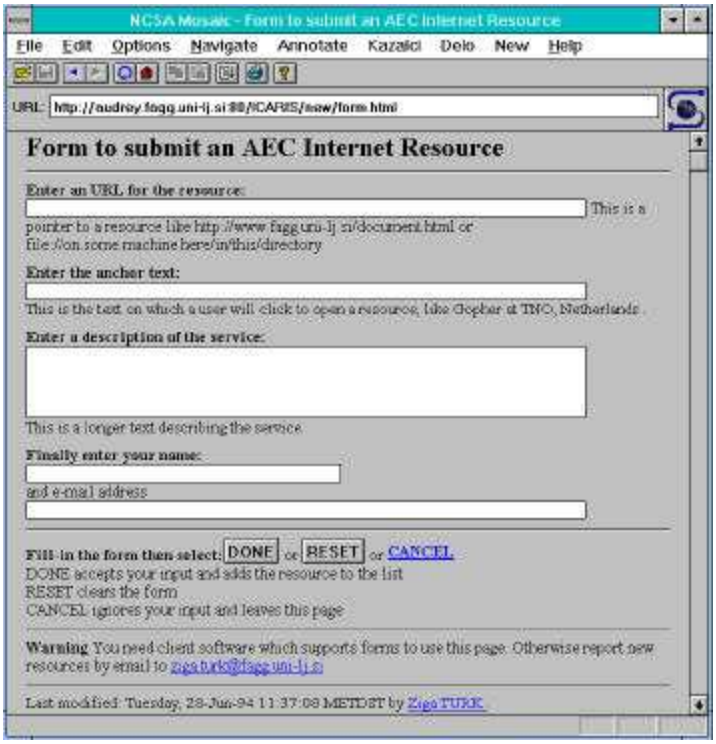

Figure 1: Form to add information to on-line database

Indexed searching is an important feature in WWW. There are two main approaches to the 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 that are reported by the providers to a central authority where they are indexed.

This technology promises to provide a universal easy-to-use, platform-independent interface to all the information on the Internet.

INTERNET PERSPECTIVES FOR CONSTRUCTION

Information On-line

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

Figure 2:

descriptions, topics of lectures, titles of publications and descriptions of manufactured products.

The home page of the IRC WWW server illustrates the potential of accessing this type of general technical information is shown in Fig. 2.

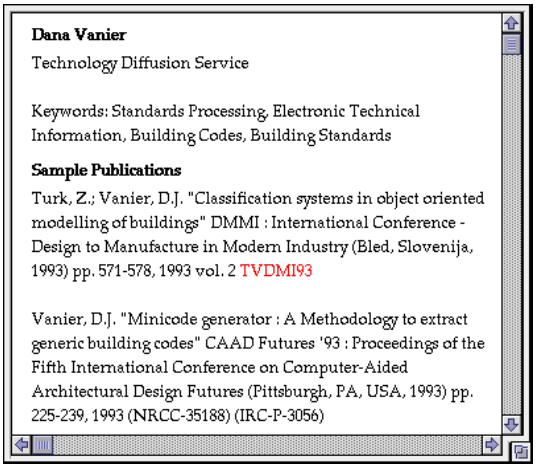

Figure 3: IRC information showing staff members

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 can be visualized as the backbone for communications in a design network.

IRC Home Page

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, as shown in Fig. 3.

Exchange of design information

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, 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.

Figure 4: Eurocode 1 as a HTML document

Building designers transmit drawings, sketches and specifications via FTP and they use of services such as Electronic Document Interchange (EDI), Gopher and WWW for flexible, robust information requests. It could also assist the transfer of information about building codes as suggested by Williams.[21]

Building codes and standards

Hypertext is a key technology in the passive representation of building codes and standards. WWW, backed with a WAIS full text search engine, makes it possible to convert paper documents or electronic equivalent such as building codes and standards into the WWW format quickly and efficiently.

A current project at the University in Ljubljana is converting the latest drafts of Eurocode 1 and Eurocode 8 to WWW. Eurocode 8 is being converted to Windows[a] Help format; from there it can be translated to WWW format, the results are shown in Fig. 4. Due to unclear copyright policies of international standards it is not known if electronic versions will be offered publicly on WWW.

Other Internet Resources

There are many interesting services in existence now. New ones are being added so quickly that providing a list in this paper would not stand the test of time.

These listings include on-line galleries and showrooms of architectural projects, full text publications, research projects summaries and reports, 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[22] which is updated regularly. Another good starting point for building professionals with WWW access is the ICARIS WWW server.[23] 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.

DISCUSSION AND CONCLUSION

This paper proposes the use of the Internet 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. The Internet also provide opportunities to link into other computer programs on distributed host servers and to efficiently browse and search large text documents.

Imagine the scenario: you're a designer looking for a widget that does X, Y or Z. Let's check the Internet! A browse of the WWW indicates that widgets are also called "thingys" in the Internet construction thesaurus; there are five companies who supply parts to meet your specs; similar widgets were used on a project in your area; high resolution images confirms your details, and the video clip quickly demonstrates the parts capabilities. You notify the supplier via EDI, the parts are set aside in the local depot, and your CADD database logs the transaction. Sure beats the traditional method of flipping through old catalogues, phoning suppliers, playing telephone tag: only to have the wrong part delivered.

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[21] Williams, Fred (1993), A Design Standards Document Server, Carleton University, Ottawa, Ontario. (http://www.civeng.carleton.ca/Research/Thesis/Fred_Williams)

[22] gopher://una.hh.lib.umich.edu:70/00/inetdirsstacks/archi:brown

[23] http://www.fagg.uni-lj.si/ICARIS/home-ptr.html

How can the industry 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. 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.

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