
Faculty of Engineering

Faculty Publications

Internet for Civil Engineering: 1996

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This article was originally presented at the:

Annual Conference of the Canadian Society for Civil Engineering

Edmonton, AB

May 29 – June 1, 1996

<https://csce.ca/en/publications/past-conferences/>

Citation for this paper:

Froese, T. & Waugh, L. (1996). *Internet for Civil Engineering: 1996*. Published in the Proceedings of the 1996 Annual Conference of the Canadian Society for Civil Engineering, Edmonton, AB. <https://csce.ca/en/publications/past-conferences/>

T. Froese and L. Waugh, "Internet For Civil Engineering: 1996," 1996 CSCE Annual Conference, Proceedings of the 1996 Annual Conference of the Canadian Society for Civil Engineering, Edmonton, Canada, May 29 to Jun. 1, 1996. CSCE: Montreal, Canada, 1996. Vol. 1, pp. 448-457.

INTERNET FOR CIVIL ENGINEERING: 1996

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ABSTRACT

The Internet is the most rapidly growing technology in society today and it is changing the way people work and communicate. This impact includes changes to the practice of engineering, and these changes will continue as new Internet technologies arise. This paper presents a brief background of the Internet and, in particular, the World-Wide Web. It then introduces a collection of "this year's" advances and trends in Internet technology and presents examples of how they may influence work practices. Finally, it discusses how Internet technologies can be used by engineering and construction companies now and in the future.

Keywords: Internet, Civil Engineering, World-Wide Web

INTRODUCTION

It is difficult, these days, to avoid discussion of the Internet. The “Net” is the current fad of popular technology, and is indeed a more popular technology than has been seen for some time. As with any fad, the aura currently surrounding the Internet will eventually fade, but what fundamental technologies and new human capabilities will remain?

The Internet is also interesting in that the same technology is being viewed with equal interest from popular culture, commercial industries, and researchers from many disciplines. The essential attraction for all of these is the same: a sense of significant but as-yet undefinable potential.

This paper is intended to help foster speculation about directions that the Internet is taking and possible implications for civil engineering. The reference to the current year in the title reflects the rapidity with which the area is progressing. At last year’s annual CSCE conference, for example, an introduction to the fundamentals of the Internet (Holtz and Williams 1995) was very popular and was new information for the vast majority of attendees. This year, the same information may still be useful to many attendees, but it may be less relevant for this forum since “Introduction to the Internet” packages are widely available from local corner stores. This paper provides a very brief summary of the background to the Internet and the basics of the World-Wide Web (WWW). It then identifies a number of newer technologies that are beginning to take form on the Internet, and presents examples of how they are may be used in engineering contexts. Finally, it provides some speculation on a longer-term scenario of distributed engineering collaboration that could be made possible by the capabilities of the Internet.

INTERNET BACKGROUND

The Internet can be thought of as many different things: it is an enormous array of interconnected physical computer networks; it is a set of communication protocols that support information flow over the networks; it is a collection of applications or services that utilize the networks; and it is millions of people worldwide that use and communicate over “the net”.

The Internet started in 1969 as a US Department of Defense project designed to connected four computers of different types in a fault-tolerant wide-area network. Most of the Internet’s 25 years have been dominated by a small set of applications that use command-line user interfaces. These include *telnet* for logging in to an account on a remote computer, *ftp* for transferring files between remote computer systems, *electronic mail (e-mail)* for sending messages between users on remote systems, and *mailing lists* and *Usenet newsgroups* for distributing messages to larger groups of users on the network.

One of the contributing factors to the more recent growth in Internet popularity has been the development of programs that add full graphical-user-interfaces to these traditional programs and simplify their use. Examples include e-mail programs such as *Eudora* or *Microsoft Mail* that are now very common. A more significant factor, however, started with a program called *Gopher* that, like *ftp*, allowed users to view and access directories of files on remote computers. To this basic capability, *gopher* added the ability to include “*hyper-links*” to other directories on other computers in the

directory listings. This made it possible to locate files on the Internet by “pointing-and-clicking” on hyper-links; for the first time, users could find information on the Internet without knowing the specific location of a file beforehand. Combined with this new capability, the first on-line directories and searchable databases of information available on the Internet began to appear.

The use of hyper-links for navigating around the Internet was refined further with the creation of the World-Wide Web (WWW) and web browsers (first *Mosaic*, then programs like *Netscape Navigator*¹ and *Microsoft Internet Explorer*²). These programs enhanced Gopher by allowing the contents of files to be viewed, along with format text, embedded graphics, and clickable hyper-links to other Internet documents.

WORLD-WIDE WEB BASICS

E-mail may still be the true workhorse of the Internet, but it is the WWW that embodies the current popular vision on the Internet. WWW browsers are programs that run on users’ computers (clients) for accessing and viewing documents from the Internet. The documents are made available by servers attached to the Internet through the *Hyper Text Transfer Protocol (HTTP)*. The documents, which are formatted using the *Hyper Text Markup Language (HTML)*, contain formatted text, embedded graphics and other binary information, and “clickable” hyper-links to other documents on the WWW. Given this basic capability, anyone wishing to provide information can construct a collection of WWW documents—a Web Site—with, for example, a central “*front door*” or “*Home page*” that introduces the site and provides directories to all of the information on the site.

Users who access the web documents see the fully formatted text and graphics and can click on links to switch to the linked documents. Other types of files that cannot be viewed directly with the browser (e.g., an audio or CAD file) can be downloaded and opened with the appropriate software. WWW documents are not limited to one-way information flow or to “static” documents. For example, documents can contain forms for users to provide information back to the server. The server passes this information on to be processed by an executable program. The program may, for instance, retrieve information requested by the user from a database, format it as a “dynamically generated” HTML document, and pass it back to the server to be returned to the user.

One of the largest challenges for users of the WWW is finding the information they’re interested in. Every document has a unique address, called a Universal Resource Locator (URL). If the URL of a desired document is known, it can simply be typed into the browser to access that page. The URL’s of previously viewed pages can be saved as bookmarks in the browser to simplify returning to that page. Generally, however, users are looking for a certain kind of information rather than a specific page of known location. Increasingly, the URL of the home page for companies can be guessed by using the company’s name in a typical URL, for example, the address for Apple computer’s home page is www.apple.com, IBM is www.ibm.com, etc., but this is still of limited use in finding information generally.

More commonly, useful information is found by following links from other related pages. That is, once a user finds a page relating to their general topic of interest, that page may well have links to related pages, which in turn will link to other pages, and will eventually lead to the desired information. Finally, information on the Internet can

often be found by using one of many sites that exist on the Internet specifically to help locate information. Such services include directories that contain large collections of links sorted by category (e.g., Yahoo³) and searchable databases that contain even larger collections (gathered automatically by WWW “robot” programs that follow Internet links and return information to their server) that can be quickly searched for related keywords (e.g., Alta-Vista⁴).

CURRENT TRENDS

This section lists several current trends in Internet use and technology that have the potential to significantly impact the way that the Internet is used. These include the following:

- Connectivity
- Desktop Video Conferencing
- Java and Distributed Applications
- Intranets
- Connecting the Web to Enterprise Systems
- Electronic Commerce
- Network-based Computers
- Education

Connectivity

The level of Internet connectivity that will be common in the future will be a critical factor in determining how the Internet is used. By connectivity, we mean the ubiquity or pervasiveness of connections, the connection speeds, and available data flow or bandwidth. The current trends for some of these factors are clear. The number of people with Internet connections is currently growing at a fantastic rate and shows no signs of slowing. Current statistics show that the number of adults in the US that have on-line access either through direct Internet connections or through on-line service subscriptions such as America On Line is approaching 10% of the population⁵. As of February 1996, there are approximately 10 million computers connected to the Internet^{6,7}, and approximately one in every 100 of these is set up as a WWW server⁸.

Connection speeds are also increasing. Not only are 28.8 kilobits per second (Kbps) modems replacing earlier generations as the standard modem speed, but alternatives to modems are starting to appear such as the high-speed digital phone service called *Integrated Services Digital Network (ISDN)* with speeds of 56 Kbps and greater, depending on the configuration, and cable modems that use the television cable network, with theoretical speeds of 500 Kbps and hardware under development to deliver 30,000 Kbps⁹. Perhaps the most significant trend in this area is the increasing involvement of traditional telephone and cable TV companies into the Internet access market (e.g., AT&T WorldNet Service,¹⁰ Rogers Communications Wave¹¹). New wireless (i.e., cellular) technologies are also being developed. Yet another issue is whether the capacity of the Internet can keep up with increasing load. While it may seem impossible for the network to accommodate the growing demand, the available capacity of the Internet is also increasing with new networks and new network technology, thus it is not clear if “capacity” will be exceeded or not. It is difficult to say

now exactly what direction Internet connectivity will take other than that it is generally towards more and faster connections.

Desktop Video Conferencing

Desktop Video Conferencing (DVC) is live video-based communication between two or more users from their desktop computers. Although DVC is not related to the WWW and, at present, may be more common on local networks or through direct connections such as ISDN lines than over the Internet, several options exist for DVC over the Internet and it is becoming another important Internet application.

DVC requires hardware for capturing video and audio signals, DVC software, and a network connection. The hardware can consist of basic video signal capture hardware (generally under \$1000 or included as a standard feature on several models of Macintosh computers) and a regular video camera; it can be included as part of a hardware/software DVC bundle (typically over \$2000, as in the Intel ProShare system, for example¹²); or it can consist of a small digital video camera that connects to a computer's serial port with no video digitizing required (e.g., Connectix's Quickcam for under \$200¹³). Software options include the CU-SeeMe software¹⁴, developed and freely distributed by Cornell University, Apple Quicktime Conferencing software, Intel ProShare, etc. The features of these packages vary, but they all show one video window on the screen for each participant in the conversation, they often have some mechanism for a shared "work pad" or white board, and various controls over the connection parameters. The video images are generally fairly small and "choppy", but we have found this to be very adequate for general conversations. The audio quality is more critical since the conversation cannot take place if good two-way voice cannot be maintained. Finally, a network connection is required. Generally, speeds in the range of 50 Kbps or better are required for acceptable quality. If this is attempted over the Internet, the users' connection to the Internet needs to be able to achieve these speeds and, even with a direct Internet connection, the speed achievable over the Internet itself is inconsistent. The alternative to the Internet is a local area network for on-site DVC or a direct connection between the two sites, typically through ISDN connections.

The writing of this paper provides an example of a typical application of DVC, since the two authors regularly converse between Vancouver and Fredericton using DVC and have even used it to give several live presentations to larger audiences.

Java and Distributed Applications

The possibility for distributed WWW-based applications is typified by recent versions of WWW browser programs such as Netscape Navigator that include the ability to execute Java applets¹⁵. Java is a C++ like language developed by Sun¹⁶ which they describe as follows:

"Java^(tm) is a simple, object-oriented, distributed, interpreted, robust, secure, architecture-neutral, portable, high-performance, multithreaded, dynamic, buzzword-compliant, general-purpose programming language. Java supports programming for the Internet in the form of platform-independent Java applets."¹⁷

The Java code for small applications can be packaged as applets, transmitted by a server over the Internet, and executed by the browser on the user's local computer, regardless of the type of computer or operating system. The applications of such a capability remains largely unexplored, but the potential exists for the Internet to migrate from a "massive, globally-distributed document base" to a "massive, globally-distributed executable application base".

The following scenario provides an example of how such a capability might be utilized in an engineering and construction context. Caterpillar Company currently publishes a lengthy handbook that lists specifications and production information for all of its heavy construction equipment. This information in its current "static" book form could easily be presented in a similar manner on a WWW site, but the information is really intended to be used in calculations for determining equipment production rates, etc. The handbook provides tutorial information on how to perform the calculations, but it would be much more useful if users could visit a WWW site and access executable programs that determine the production figures for the particular equipment fleet and particular job characteristics at hand. Only the subroutines and performance parameters for the particular equipment models being used would need to be transferred. Java is well suited to such distributed applications.

Intranets

Inasmuch as people are finding the WWW increasingly useful as a mechanism for accessing information and delivering distributed applications throughout the Internet, companies are beginning to set up "Intranets": WWW networks for internal use to provide information and distributed applications to employees within the organization.

As a simple example of an Intranet system within the first author's Civil Engineering Department at the University of British Columbia, a system is currently being considered to use the department's WWW server to create an equipment booking system. While this is not a major system, it is non-trivial with several dozen pieces of equipment (from computer projector panels to vehicles that are sometimes used by several different users each day), over 30 faculty and staff users and 200 graduate student users. The system would have forms to collect user information, booking requests, and equipment repair notices. It would dynamically produce pages showing booking schedules for available equipment. All of these would connect to a back-end database. The system would be accessible from within the department only, would use different levels of password-protected user privileges, and would have system administration options available only to system maintainers. There are clearly other options available for implementing such a system, but in an environment with widely-varying computer platforms and user behavior, there is perhaps none as convenient for both implementors and users.

Connecting the Web to Enterprise Systems

As the WWW increasingly becomes a major vehicle for organizations to deliver information to clients, collaborators, the general public, etc., it becomes increasingly difficult to manually produce and maintain individual WWW documents on the organization's server. This, combined with an increasing movement towards dynamically generating pages based on relevant data, is leading towards systems that tie

WWW servers directly into organizations' basic enterprise-wide information systems. A prime example of this is the Federal Express WWW site¹⁸, where users can track the exact current location of their Federal Express packages. Clearly, this information can only be delivered to the user if the WWW system is directly linked with Federal Express's Corporation-wide package delivery data. Another example is a system at The University of New Brunswick that allows students to apply for admission, residence, and scholarships through a WWW interface.¹⁹ A natural extension to such a system would allow university students to register for individual courses through a WWW interface (at UBC, students can do this now through an automated telephone interface, for example). Such systems would provide a direct link between the WWW and the student registration system, one of a university's fundamental information systems.

Electronic Commerce

The potential to conduct commerce over the Internet is enormous. This could include not only purchasing "mail order" goods over the Internet, but also charging for accessing information or software—possibly very low amounts but high volume charges. Clearly, there are many concerns involved in conducting financial transactions over the Internet, mainly relating to the absolute security and reliability required. Some solutions already exist, and many large financial and computing institutions are striving to deliver techniques that could become the standard for conducting financial transactions over the Internet. The most significant current effort is a joint agreement, announced in February 1996 by many companies including VISA, MasterCard, American Express and Microsoft, to develop a single technical standard called *Secure Electronic Transaction, SET*, for secure payment card purchases made over open networks which, they claim, "is as revolutionary as credit cards themselves were back in the 1960s, and is poised to be just as pervasive."²⁰

The potential implications of commonplace electronic commerce are vast. A simple example is a new paradigm for selling software. It may be, for example, that companies like Microsoft will no longer sell software "off the shelf." Instead, everyone would have unlimited access to all Microsoft software directly over the Internet, possibly with free trial periods. If a user wishes to use the software, however, a charge will be transferred from the user's bank account to Microsoft, either a typical fee for unlimited use of the software program or a very small per use charge. The impact could be greater if this model were applied to charges for accessing information over the Internet. Most information available on the Internet now has been placed there either by companies in support of their core businesses or by individuals and groups because of their own interests. In the future, information providers may be able to charge per-access fees that are small enough not to deter users but significant enough over large volumes to provide the incentive for many more people to make much more information available on the Internet. Regardless of the specific outcome, it is very likely that it will soon be commonplace to conduct commercial transactions over the Internet.

Internet-terminal Computers

The advent of the Internet, fast network connections, and networked languages like Java have led to the idea of a new style of simple and inexpensive network-based computers. These computers, typically aimed at approximately \$500, would consist primarily of a processor, RAM, and a network connection, possibly using a television

for a monitor. Their software would be downloaded on demand, in the form of Java code for example, as well as from CD disks. Examples of such devices include the Atmark by Bandai²¹, based on Apple's Pippin technology²², which is currently marketed in Japan and is expected to be sold in North America by mid-1996, and the "Internet Toaster" concept being explored by Sun.^{23,24,25}

While such systems initially may be targeted largely at the computer games market, there could be implications for engineering and construction industries. If very inexpensive Internet terminal devices were commonplace, for example, they could be used in numerous installations scattered around a construction site to provide access to all project drawings, specifications, contact information, etc., from a project WWW server.

Education

This list of current Internet trends has focused primarily on technologies relating to the Internet rather than areas of application. One application area of particular interest, however, is education. A long history exists within Education of exploring alternative forms of instruction and learning, including various approaches to distance education, techniques such as video, interactive computer presentations and simulations, etc. The Internet presents a natural and powerful addition to these techniques. For example, it can be used for the following tasks:

- Providing tutorial and reference information to students
- Providing interactive exercises, simulations, case studies, etc.
- Providing forums for on-line group discussions, collaborative learning, etc.
- Provide a medium for administering and managing courses and educational programs.

An example of the use of the Internet to support graduate University Civil Engineering courses can be seen in the home page for the course "Civil 598L, Developing Computer Applications for Civil Engineering"²⁶ at UBC. Many methodologies are being examined and the optimal styles and extents of WWW-based course material is uncertain, but increasing use of the Internet for teaching is inevitable.

INTERNET POSSIBILITIES FOR CIVIL ENGINEERING

The range of applications of the Internet for engineering and construction companies is vast and it is beyond the scope of this paper to try to provide a comprehensive list. However, this section will describe some overall categories of application and provide a few examples (also see Vanier and Turk, 1994).

The most common and effective use for the Internet at present is to gather information about organizations: companies, institutions, committees, individuals, etc. While civil engineering and construction lag well behind industries such as computer hardware and software industries in Internet presence, a large and rapidly growing number of organizations have WWW sites. There are several directories of WWW sites devoted specifically to architecture, engineering and construction.^{27, 28,29}

Less common on the Internet at present, but of greater potential benefit, is specific technical data and other commercial information. Some examples do exist, such as downloadable specification sections provided by manufacturers,³⁰ directories of projects available for bidding^{31,32}, and used heavy construction equipment for sale.³³ The availability of this type of information will increase, particularly if the information providers can effectively charge for access.

The converse of using the Internet to access information from others is to use it to distribute information to others. WWW sites can be a very cost effective way of reaching clients (e.g., Concord Pacific developments in Vancouver uses it for marketing its residential communities³⁴). Furthermore, the Internet is now, and will increasingly be, an effective tool for collaboration among participants on engineering projects. This collaboration could include the exchange of project drawings and various forms of project correspondence, procurement and other business transactions using Electronic Data Interchange (EDI),^{35,36,37} and general distribution of project information through the WWW. While these techniques may still be rare in most engineering practice, they are having a significant impact in certain sectors: in the way that collaborative AEC research is carried out, for example.

Finally, we present a scenario of how the Internet could support a paradigm of engineering and construction collaboration through networked distributed project information systems on future projects (also see Waugh et al. 1996). On design and construction projects in the future, all participants will use *Total Project Systems*, a term that describes integrated systems that have the following characteristics (Froese et al. 1996)

1. They encompass a comprehensive suite of applications that support a broad range of project design, construction, and management functions.
2. All applications contribute to and draw from a shared pool of project information.
3. They operate in a highly modular, open, flexible, and distributed framework, rather than in a prescriptive and restrictive manner.

Many of the software components of such systems may be network-based software, accessed on demand over the Internet. Through these systems, many bodies of information about the project will be made available either publicly or to specific project participants: plans and specifications, 3D renderings and walk-through animations, shop drawings, field instructions, contracts, construction schedules, procurement and billing transactions, materials tracking and inventory information, directories of participants, correspondence logs, progress photographs, marketing information, etc.

Each of these bodies of information will have an owner—a participant who is responsible for maintaining that information. In most cases, the creation, maintenance, and distribution of the information will be an automatic by-product of the participant's Total Project Systems. Each of these bodies of information will be accessible over the Internet to anyone who has appropriate permission. Data structuring and exchange standards will exist (Froese 1996) such that one participant's system can routinely access and use the information from another, automatically performing any necessary translation and interpretation. In some cases, the information providers will receive a fee specifically for providing the information, either from those accessing the information or from the project owner as part of the overall cost of constructing a

facility. The overall effect of such a capability will be significantly improved information flow and communication among the participants, and much better support of engineering, construction, and management tasks by computer tools because of the increased data that will be available to these systems without requiring users to “type it in” at each step.

CONCLUSIONS

The Internet is here now and many significant changes to it are yet to come. One way or another, the existence of the Internet and the wealth of related technology *will change* the way that engineering and construction is practiced. The more that engineers are aware of current and upcoming capabilities, the more that they will be able to harness it’s potential for the benefit of the industry.

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WWW REFERENCES

The following are the Universal Resource Locators (URL's) for on-line World-Wide-Web references for this paper. These are addresses of documents available on the Internet and can be accessed by entering the URL in a WWW browser such as Netscape. This list of Internet references is also available on-line from the first author's home page at <http://www.civil.ubc.ca/~tfroese/pubs/>

- 1 <http://home.netscape.com/>
- 2 <http://www.microsoft.com/windows/ie/msie.htm>
- 3 <http://www.yahoo.com/>
- 4 <http://www.altavista.digital.com/>
- 5 <http://www.ora.com/survey/users/charts/pop-proj.html>
- 6 <http://www.nw.com/zone/WWW/report.html>
- 7 <http://www.genmagic.com/internet/trends/index.htm>
- 8 <http://www.netgen.com/info/growth.html>
- 9 http://www.rogerswave.ca/wave/cl_faq.html#1_6
- 10 <http://www.att.com/worldnet/wis/>
- 11 <http://www.rogerswave.ca/>
- 12 <http://www.intel.com/comm-net/proshare/>
- 13 <http://www.connectix.com/>
- 14 <http://cu-seeme.cornell.edu/>
- 15 http://home.netscape.com/comprod/products/navigator/version_2.0/java_applets/
- 16 <http://java.sun.com/>
- 17 <http://java.sun.com/about.html>
- 18 <http://www.fedex.com/>
- 19 <http://www.unb.ca/UNB/Recruit/>
- 20 <http://www.visa.com/cgi-bin/vee/sf/standard.html?@2+0>
- 21 <http://www.fix.co.jp/bandai/pippin.html>
- 22 <http://quicktime.apple.com/pr/bandai13dec94.html>
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