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Hypertext: A Computer Tool to Assist Building Design

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This paper shows how hypertext, an electronic information transfer medium, can assist accessing the large volumes of architectural and engineering technical information needed in decision-making phase of building design. A technical paper on architectural details serves as a model for demonstrating the capabilities of hypertext. This example consists mostly of graphics and illustrates how the hypertext medium could act as an information source for designers in the construction industry. The objectives of the paper are to illustrate the potential of hypertext to create, disseminate, and access technical information, and to identify an electronic format for construction industry technical publications. The paper identifies the capabilities of the medium, some advantages and disadvantages of hypertext, and the potential of the medium for construction information transfer. The author suggests that hypertext systems can assist technical information transfer in the construction industry.

Introduction

The quality of decision-making in architectural and engineering design has a major effect on the performance and cost of buildings [MacKinder]. Generally, early design-decisions have the greatest effect on the direction of the design and the cost of construction and are often made with the least amount of supporting technical information [Brewer]. Despite the fact there is more than adequate information available to make sound decisions [MacKinder], that information is under-utilized. This may be due to the time constraints in the design phase, to an intuitive rather than a scientific approach to problem-solving, or to the lack of access to a proper technical library. Elaborate construction information archival and retrieval systems [Giertz 81] [Giertz 82] [Ray-Jones] and computer systems [Holmes] [ITEC] have been developed to assist designers, but still the first, and sometimes only, readily-available sources for technical information are professional colleagues and manufacturers literature [MacKinder] [Brewer].

Computer tools are currently available to assist the dissemination of technical information to designers. Computer-aided design drafting (CADD) systems, spreadsheets, word processors, and databases, have all altered the way the construction industry uses technical data. As computer technologies mature other tools are becoming readily available. Hypertext' is a provocative electronic tool for developing information bases[2] and for quickly searching and retrieving data. It employs micro-computers, high resolution graphics, database technology, and fast-access text searches. It is a medium that can be summarized as a non-sequential retrieval system that permits rapid access to large amounts of textual and complex graphical information.

This paper shows how hypertext can be used to gain access to architectural and engineering technical information in the decision-making phases of building design. It describes using hypertext as a medium to assist in the design of external walls, windows and roofs. The information base was developed from an illustrated, technical text on Architectural Details for a Cold Climate [Brand]. With this tool there is also the possibility of integrating any number of associated texts, such as Canadian Building Digests, National Building Code, and Canadian Building Abstracts, into a cohesive construction information source. The use of the proposed integrated information is not restricted to building designers, but would be invaluable in the educational sector and to building occupants.

There are over 100 cards in the existing information base. The ADCC HyperCard stack is available from the author[3].

Objective

The objective of this paper is to illustrate the potential of hypertext to create, store, and retrieve technical information for the construction industry. I will attempt to outline a tool for technical information transfer for the construction industry. I will also suggest formats for technical information transfer, illustrate capabilities of the hypertext medium, and discuss interesting and helpful user interface designs, and identify the advantages and disadvantages of hypertext. The paper will also illustrate the advantages of this tool for the teaching sector.

Architectural Details for a Cold Climate (ADCC), will be used to demonstrate hypertext. This text was selected because it epitomizes technical information needs of the construction industry. These are 'high resolution' graphics, strong relationships between graphics and text, a comprehensive database structure, references to associated technical information, and modification or expansion on a continuing basis.

Brand provides architectural detailing for building enclosure design and construction. In the present form the publication consists of more than 200 drawings, heavily cross-referred by Brand to other chapters, sections, and other publications. Brand believes that if designers are provided with technically correct details and they modify these to specific location requirements, they will not need to develop these from first principles for every task. The goal of the project was to automate the existing traditional publication maintaining all of the manual features and augmenting these with the capabilities of hypertext.

Hypertext Background

Before describing the application, it is necessary to summarize the evolution of hypertext. It evolved from work initiated by Doug Englebart [Englebart] and Ted Nelson [Nelson] in the 1960's to address the needs for rapid text searching[4]. Hypertext systems were available as early as the late 19605 [Conklin] and these have evolved into today's commercial systems. Dr Peter J. Brown's [Brown] work at the University of Kent led to the development of Owl Guide [Owl] on the IBM PC and Apple Macintosh, Bill Atkinson's work led to HyperCard on the Apple Macintosh, and research and development of ZOG led to the marketing of KMS [Akscyn] on a wide variety of machines. There are similar products on other computer systems, such as Business FileVision on the Macintosh, Document Examiner on the Symbolics Lisp machine, and KnowledgePro on the IBM PC [Byte]. This is not an exhaustive list but it does indicate that the technology is available for a variety of machines. Numerous demonstration prototypes are in existence, including Notecards from Xerox PARC [Halasz], Hyperties from University of Maryland [Marchionini], Intermedia from Brown University [Yankelovich], and ZOG from Carnegie-Mellon University [Akscyn].

Hypertext has become a 'hot topic in the last year due primarily to Apple's release of HyperCard [Smith] [Goodman], to the proliferation of powerful micro-computers, to the user-friendliness of the interface [Marchionini] and to the availability of large, fast storage devices. The main targets of the developers of hypertext systems are producers and distributors of large volumes of information. Their product target is oriented towards the 51/4" CD ROM (Compact Disk-Read Only Memory) holding over 500 megabytes of read-only data. This is equivalent to approximately 250,000 pages of encoded text, 5,000 pages of facsimile information, or 2,000 video images5.

Although commercial hypertext products are relatively new, the technology could revolutionize the way we handle textual and graphical information. This revolution could be similar to the way spreadsheets altered numerical calculation: Large, complex and unmanageable batch programs running on mainframes were replaced with personalized software available on inexpensive desktop machines. Hypertext systems will change the way people read and write " [Marchionini].

Hypertext Description

Hypertext can be many things to information suppliers and users. For the hypertext user (normally an information seeker) it can offer rapid access, user-friendly information retrieval. For the hypertext author (in this case the technology expert developing an information base) it is a complete environment for creating, linking, storing, and retrieving information. The major feature of the medium is that information access is not sequential: the possible information routes are pre-determined by the hypertext author, and the hypertext user does not have to follow a specific routing to search information. Not unlike the print medium, the user can peruse the information in any way desired-following the text sequentially to maintain continuity or searching randomly[6] to pick up key words, phrases, or graphics.

The visual presentation of hypertext systems and applications is a straightforward point-and-click interface. Hypertext applications depend heavily on both the implementation of the technology by the hypertext systems designers and the application design by the hypertext author. As an example, HyperCard is heavily graphical, user-friendly, and card-based, but other hypertext systems may possess these and other features. Some applications may resemble word processors, others may mimic databases, and some will imitate flash cards, but generally all hypertext systems contain the following characteristics [Akscyn] [Conklin] [Marchionini]:

- Small chunks of self-sufficient information (nodes)
- Relationships between associated nodes (links)
- Quick traversing of networks of nodes (hyper)
- Direct manipulation interface (buttons)
- Conceptual data model representing users mental model of information

In summary, hypertext should augment rather than replace traditional retrieval systems, and should be viewed as an electronic source for the same printed word. The application for ADCC was implemented on an Apple Macintosh, but could have been developed on a number of other machines or software. In describing this application, I will remain generic in the description of the capabilities of hypertext.

The basic information packet in hypertext (see figure 1) is a node. It may be called a card, frame, or record in other systems. Contexts are analogous to files or stacks of related cards or records. Access to additional or related

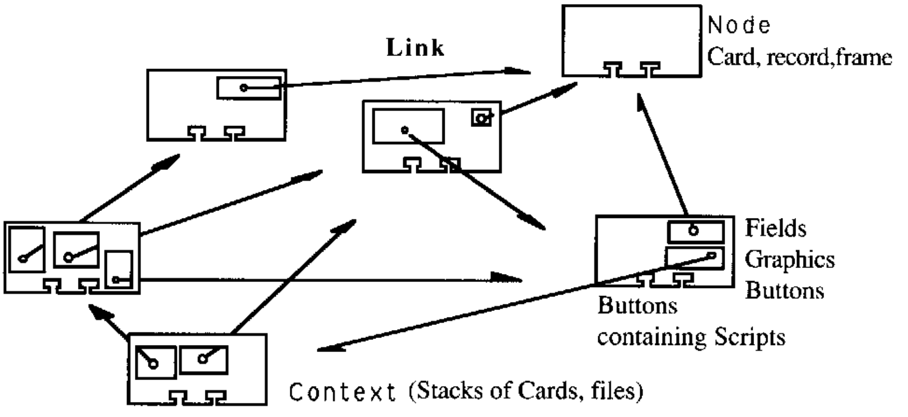

Figure I Hypertext concept

information is made by Links to other nodes. The basic components of a node are fields, graphics, and buttons. The fields are conventional data fields that are created and normally filled by the author. The data can be augmented by the user or can be browsed by the user by searching key words in all or specific fields on a card. The graphics are bitmap[7] or object[8] drawings done in the hypertext application or imported from other packages. Once the graphics are imported into HyperCard they remain in bitmap format; however, other hypertext systems permit importing both paint and object drawings (Eg. Owl Guide). A button is designed to look like a push button or can be a designated transparent area, depicted as dashed boxes in figure 2. Buttons are graphical areas on a node that initiate actions such as pointing to another file or location; popping up an interactive message on the computer screen; opening another file; or returning the user to a specific location. Most of the features mentioned above are available on all hypertext systems.

HyperCard Authoring

The hypertext author does not need to be a computer programmer as most hypertext software tools can easily be learned in a few hours and mastered in days. The software tools available for hypertext application design consist of fields, graphics[9], and buttons mentioned above (see figure 2), as well as a scripting language. In HyperCard each field, card, stack, or button can contain a unique script' which will initiate an action; this is analogous to the action or method" of an object in object-oriented programming [Goodman]. These scripts utilize a full computer programming language that permits both the hypertext author and user to customize the application to meet their specific needs. The object-oriented language in HyperCard is an English-like programming

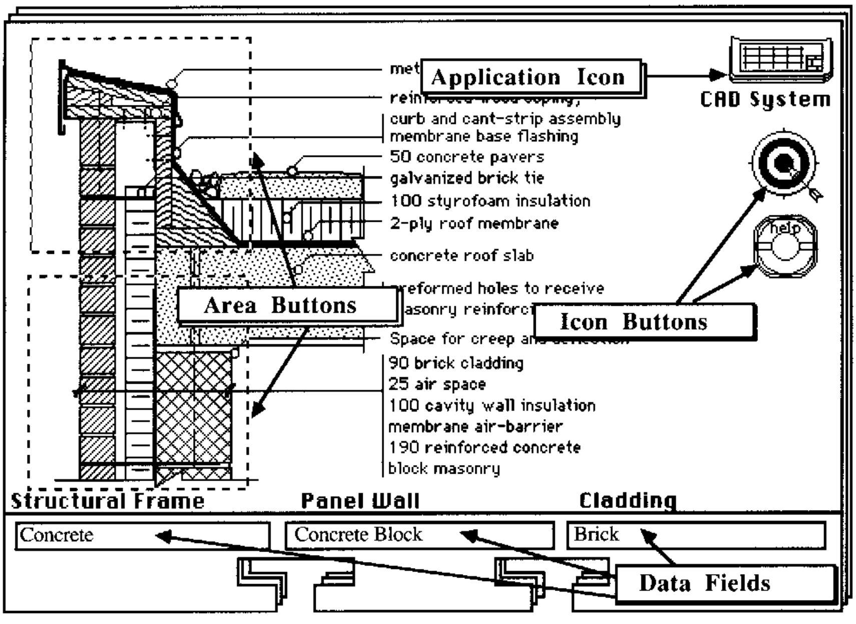

Figure 2 Detail card

environment of over 200 functions, commands, control structures, properties, constants, operators, and control structures [Gewirtz] such as: if .. *then ... else, deleteCard, mouseDown, messageBox,* dial[modem], find, play[notes], and *write.* Most hypertext systems also have this type of high level programming language that is accessible to hypertext authors and users.

The node presented to the user consists of layered graphics and data. The author can create a background and foreground overlay for the cards, and can overlay the fields, graphics, or buttons in any order. The hypertext author can reduce the data entry time and create a standard user interface by creating standard backgrounds. In figure 2 the entire image, with the exception of the construction detail, is a background template. Most hypertext systems have an equivalent feature for designing standard templates.

Cards in the HyperCard system are designed and entered by the hypertext author in any order and the relationships of cards and buttons can be established at any time. Cards that are closely related can be placed in the same stack by the author to consolidate and simplify access to that information. It must be stressed, however that an overall system design is necessary before any hypertext application is started [Marchionini] [Yankelovich].

Data Modeling - Architectural Details for a Cold Climate

The text and graphics of ADCC is a compendium of building science knowledge for architects, design technologists, technicians, and drafters. It is not the intention of this paper to present a comprehensive view of detailing and enclosure design; but rather to demonstrate the possibilities of the hypertext medium using a well-defined information source and its inter-connection to other technical documents. The information presented in this paper will be a representative sample of this work and will address the full depth of the information base for a limited number of details.

The final data concept is illustrated in figure 3. It was modelled in consultation with Brand, to satisfy the following requirements:

- The computer graphics must be an accurate representation of the details
- Access to CADD drawings must be possible to permit user modification
- References to other sections must be inherent in the system
- References to other publications must be possible
- Key word index and lexicon of technical terms must be available
- The information base must permit modification and addition by the user
- The completed package must run on an inexpensive computer

The ADCC information base is divided into three major components (Detail Cards, Graphics Cards, and Building Science Cards) and three related information stacks (CADD Drawings, Lexicon, and Technical Papers).

Detail Cards

The Detail Card shown earlier in figure 2 presents an overall view of the architectural detail and shows the juxtaposition and dimensions of the assembly components. However, the graphical resolution of the overall Detail

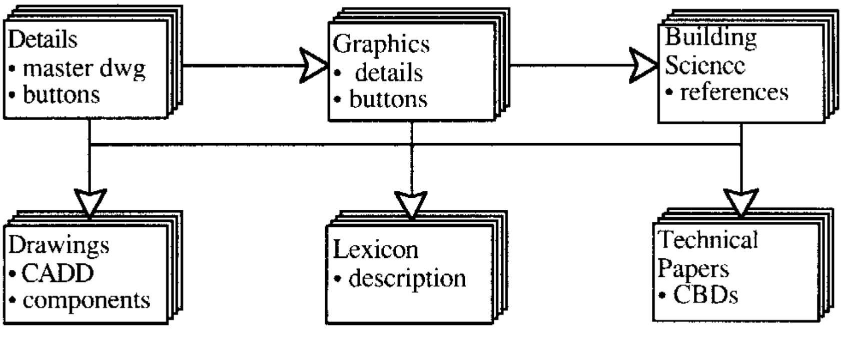

Figure 3 System model

Card is insufficient to view the finer construction detail. As in to most CADD systems, a zoom or 'blow-up' function is available via transparent buttons on the card. This zoom points to a Graphics Card containing a more detailed view of the drawing. The user can quickly move between these different scale drawings to view either the overall context or the detail.

The original CADD detail can also be accessed via a button in the top right corner of the Detail Card. The drawings for the computerized *Architectural Details for a Cold Climate* were first drawn using a CADD package and were then moved to the hypertext system. The patterns and hatching were entered in HyperCard, but could have been entered in any paint application. Other hypertext systems can display both bitmap and object drawings but may not support the editing of these images within the hypertext system.

Graphics Cards

The Graphics Card in figure 4 is an accurate architectural representation of the detail. The importance of the drawing resolution cannot be over-emphasized as design decisions have to be made based on the accuracy and the resolution of the drawing at hand. This means that the designer must be able to discern the extent of building components, follow them continuously on the drawing, and detect the topology of the components. Transparent buttons (depicted as dashed lines in figure 4) superimposed on building components and the corresponding component names are linked to Building Science Cards.

Building Science Cards

The Building Science Cards are an electronic version of the Brand layout where a text description refers to a specific area or component, identifies potential construction problems, provides building science knowledge, or suggests additional sources of information. In the HyperCard version, the Building Science Card displays an isolated view of the component(s) and has scrolling text to provide the additional information (See figure 5).

CADD Drawings

A mandatory requirement of the hypertext ADCC is to provide access to drawings that can be edited by the user. This is accomplished in HyperCard by launching a CADD application containing a pointer to the appropriate detail. The CADD representations of details are stored as PICT format files on the Macintosh, or an IBM hypertext implementation the drawings could store the detail in AUTOCAD. These are all well-known *de facto* drawing standards for microcomputers. The CADD drawings for a specific detail are accessed by clicking the CADD button in the upper right corner of the Detail Card shown in figure 2. This will immediately launch a CADD application package with

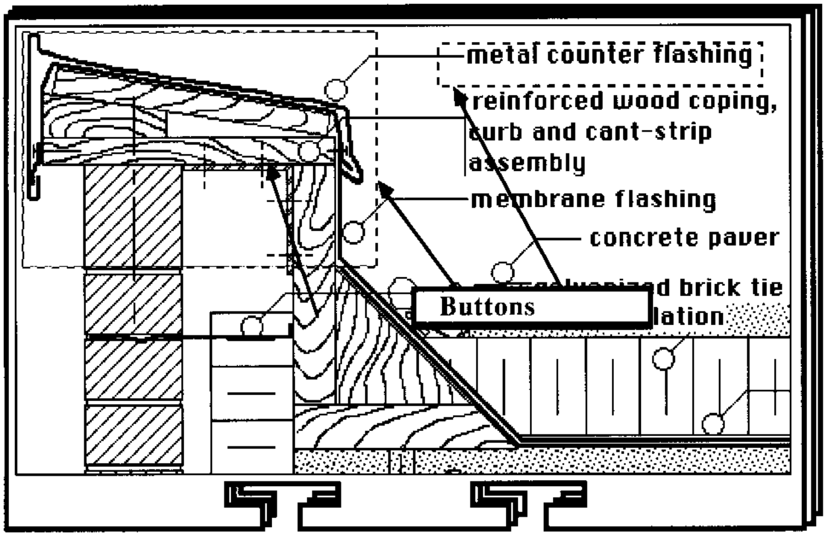

Figure 4 Graphics card

that architectural detail and permit the user to view, modify, and save the detail to meet specific requirements. The user will be returned immediately to the same Detail Card on quitting the application.

Related Technical Information

Graphics and text from any number of publications can be accessed to provide backup information to the user. This can be available in other sections or cards of the existing stack or in related stacks such as the *National Building Code, Canadian Building Digests,* and *Canadian Building Abstracts.* The purpose of this feature is to provide a wide and deep information base ranging from *National Building Code* articles to source documents from building science research. A feature of the design is that the user is automatically returned to the exact location of departure from the original stack.

Lexicon Stack

The Lexicon cards permit the user to seek information on terminology without leaving hypertext. This can be viewed as comprehensive HELP function for construction terms. This is also an auto-returning stack.

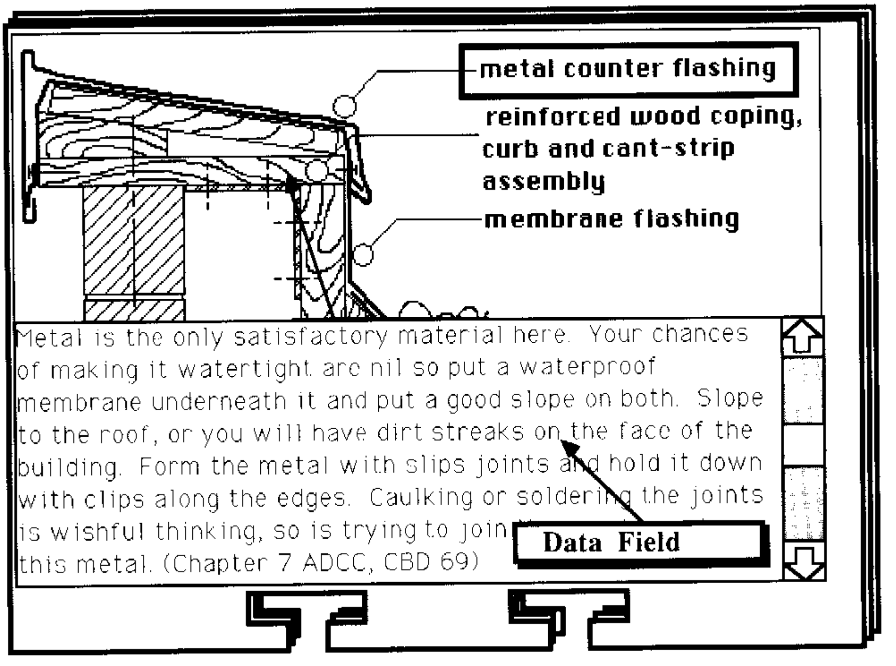

Figure 5 - Building science card

Additional Features:
A 'saver' stack is incorporated to save selected cards for later referral. This eliminates the need to search for a specific detail viewed earlier and allows the user to print the entire saver stack when desired.

Pros and Cons of Hypertext for Information Transfer
The pros and cons of hypertext for specific applications [Akscyn] or for generic application [Halasz] are given in related papers on the topic. The list below is directly related to the requirements for technical information transfer for the construction industry.

Past Access
Hypertext provides fast access, search and retrieval capabilities for a wide variety of textual and graphical information sources. Rough benchmarks in HyperCard for specific key word searches indicate the possibility of finding a single word among 20 000 words (20 K document) in 2 seconds". Hypertext systems designers strive to reduce the time to find and display random frames to below 0.5 seconds and some systems are able to access frames in 0.25 seconds [Akscyn]. Because the key word search time for hypertext systems is dependent

on the implementation of the search algorithm and the variety of words, hypertext systems cannot be directly compared to conventional word processing text searches. Every word in a hypertext application is indexed, thereby providing near-instantaneous search and find. Because they are indexed, if specific words do not exist in the text the user is immediately notified and a 'search and find' is averted.

User Interface Design

As mentioned earlier, principal components of the hypertext system are the direct manipulation interface and the conceptual data model representing the user's mental model of information. Studies have shown that point-and-click operations (i.e. direct manipulation) speed up user interaction by 50 % over typical pull-down menus [Akscyn]. These types of interface provide a fast access, user-friendly environment that enhances information browsing for both the occasional and the 'heavy' user.

Quick Prototypes

The inherent flexibility of most hypertext systems permits quick alteration of the data structure and the user interface. This provides an excellent tool for prototyping data models and a quick, easy-to-learn database for developer / users of small personalized systems.

Popular Technology

Interest in most hypertext systems has increased drastically over the past years. The number of technical papers on hypertext systems has increased substantially and most computer magazines have published special issues devoted to hypertext All major Macintosh journals now feature sections on HyperCard; stacks are exchanged in clubs, universities, and companies; and numerous companies are selling HyperCard development expertise. This all indicates that software systems will continue to improve and costs for software and related hardware will decrease.

Graphic and text data

The construction industry relies on graphical information to explain which components are to be used and how construction components are assembled. Hypertext answers these needs for graphical representation, as well as the need for showing the graphics in conjunction with text. Methods should be developed to provide designers with the ability to search occurrences of words or components (i.e. find insulation) in text on drawings. Object drawings in place of bitmap pictures in the hypertext system would make this possible, as the text on the graphic would be identified as such and the location could easily be found.

Graphical Context
Current high resolution screens provide acceptable resolution for displaying conventional graphics but are restricted because of the finite number of addressable pixels, normally around 512 by 512. In ADCC the restricting resolution was circumvented by providing similar views of the details at differing scales and permitting the user to move back and forth between the desired views. This is a deficiency of the medium, viewing tools are needed to enable users to infinitely zoom and pan around a drawing. The use of object drawings in the hypertext systems would make this readily available.

HyperCAD
The concept of hypertext combined with computer-aided design was hinted in a paper entitled 'Neptune: a Hypertext System for CAD Applications' [Delisle], but unfortunately the paper did not delve into the possibility of hypertext addressing the needs of integrated computer-aided design [Vanier]. Hypertext's frame-based data structure, user-friendly access, robust user interface, and rapid network traversing could prove to be a radical, useful tool addressing many integrated computer-aided design requirements.

Controlled Vocabulary
Full text searches provide an easy-to-implement data structure [Halasz]; however, the need for key words and indices still exists. Without a controlled vocabulary for information search, the users are randomly trying for 'word hits' based on their knowledge of the field and of the information base [Marchionini]. This works well for small information bases, stacks with non-similar terms, or for technologies with well-defined vocabulary; however this is not the case in construction. To illustrate the complexity of the construction vocabulary, one only has to look at the extent and depth of the *Canadian Thesaurus of Construction Science and Technology* [Thesaurus] and imagine a user looking for general information on paints in gigabytes of construction data. The implementation of a vocabulary or thesaurus in conjunction with large information bases is therefore mandatory for construction hypertext systems. This would focus word searches, decrease search time, reduce successive 'hits' of similar, but unrelated, terms, and reduce user frustration.

Easy Implementation
Existing manuals can be documented on hypertext systems with relative ease as most books already contain the structure and layout required for proper hypertext implementation. The sections, paragraphs, and chapters provide the fundamental layout; graphics and photos are related to specific locations in

the text, and references and footnotes are already established. Already many of these publications are in electronic form.

Integrated Construction Information

The construction industry has primary information sources: design handbooks, master specifications, national standards, and other technical publications and guidelines from government offices. Secondary sources include engineering and architectural graphs and tables, manufacturers technical information (i.e. windows, doors), and trade journals. These could all form part of an overall construction information source. Project information (i.e. contract documents, maintenance records, and even contract drawings) could be included in the hypertext system and would be useful to designers. Access to the information base could be guided by thesauri or controlled vocabularies. These could all be separate stacks in an integrated construction information base. A suggested layout for a large construction information base is shown as figure 6. Multi-media information is now a technical possibility-with computer graphics, video, and text all forming part of the entire information base. Because of the storage capacities of CD ROMs, this information is readily accessible by the user.

Multi-Media Information

A multi-media information base could include all forms of data, including text, graphics, facsimile data, animation, and voice. The development of large integrated information sources will necessitate standards for the presentation and dissemination of data. Although researchers have identified the need for standards [van Dam] [Halasz], the only standard is that there is no standard.

Hypertext as a Teaching Aid

Research [Marchionini] has indicated that the users of hypertext information bases are more likely to browse wider selections of information than users of conventional paper documents. It also indicated that in some cases that information was better understood and better retained by the users. In addition, hypertext systems would be a boon to the educational sector because the information could be more current, would be properly cross-referred, and is less susceptible to theft than paper documents.

Lost in Hyperspace

A problem identified by many [Akscyn] [Smith] [van Dam] is getting lost in a large information base. Lost in hyperspace involves not knowing where one is, not knowing how much information is available, not knowing when to stop

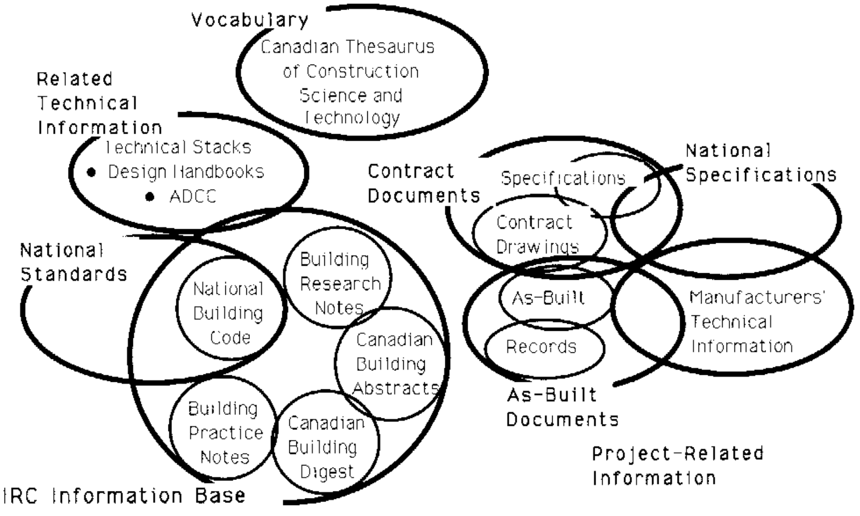

Figure 6 Integrated construction information source

looking for new leads, and not knowing when all possible leads are exhausted. This problem can be reduced in scope with the use of a strong data structure for the information and the use of global maps [Conklin].

CD ROM Technology

As CD ROM readers become more popular (prices are below $1000 CDN at this time), users will standardize on this technology for information storage and retrieval. Read / Write disks are rumoured to be only two years away from commercialization. The CD ROM technology has numerous advantages over both traditional publication methods Hartley] and other computer technologies (remote data services, magnetic media, etc.) including:

- Low mastering and copying costs as compared to traditional publications
- Information is protected and access can be controlled by distributor
- Compact disks are robust and can withstand physical abuse (Eg mailing)
- Standard interfaces for data retrieval can be provided to users
- User has control over all parts of the workstation and information base
- Multiple CD ROM disks can be stacked for gigabytes of on-line storage
- Stacks can be updated regularly on CD and addenda updated on magnetic media when required

Maintaining Information

The introduction of new technologies, such as hypertext, requires a re-thinking of how information flows, to whom, and when. Updates by the supplier and modification by the user are areas that need to be investigated. Supplier updates could be issued as new stacks (on compact disks preferably) and supplemental information on magnetic medium could automatically augment or supersede the original data. However, if the original information base has been updated by the users to reflect their specific requirements, then that additional information would have to be transferred to the new supplier edition. This may prove to be a large task for the information supplier and user. It could also be accomplished in an automated fashion similar to the existing manual method: check your old *National Building Code* and transcribe your handwritten notes to the newest edition.

Many of the problems listed have been identified by hypertext researchers [Halasz] [Akscyn] [Marchionini] [van Dam] [Delisle]. They feel that advances in the technology and a clearer understanding of the user needs will eliminate a large portion of the current hypertext limitations [Smith]. Problems identified in these and related texts, including problems of concurrent access of frames by multiple users [Halasz], static links in a dynamic environment [Halasz], identification of the proper node size for specific application [Marchionini], and intuitive versus cognitive-intensive systems [Conklin], are exciting research questions, but unfortunately are all still unresolved.

Conclusions

The prototype for *Architectural Details for a Cold Climate* demonstrates that the medium addresses a large portion of the needs of the construction industry for electronic technical information transfer. Hypertext technology can help building designers access the large volumes of architectural and engineering technical information needed in decision-making phases of building design. An integrated construction information source could provide a solid knowledge base for educators, students and design professionals that could be easily updated and quickly browsed. The robustness of the hypertext medium permits even novice computer users to add to existing information bases and to create and prototype applications quickly and efficiently. There are still numerous disadvantages of the hypertext technology, but many of these will be corrected as hypertext developers become more familiar with user needs, as user interfaces become more refined, and as the cost to store large information bases is reduced.

Hypertext technology is a new tool for developers and users of information in the construction industry. It can be the medium for an integrated information source by providing a robust, powerful user environment on a micro-computer workstation.

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Notes

1 The term 'hypertext' will be used to denote the generic technology, 'hypertext application' to mean a specific application, 'hypertext author' to mean the designer of the hypertext application, and 'hypertext user' to mean the application end-user.

2' Database' will be used throughout the text to mean a database shell or a container for data. The term 'information base' is used to denote a database containing information and the required links between information packets.

3 Asample stack is available for development review. Please provide an initialized

800k Macintosh diskette.

4 An excellent introduction and survey of hypertext systems is included in [Conklin].

5 These figures are based on 2000 characters or bytes per page of text, 300 dots per inch for a facsimile document, and 8-bits of colour on a 500 vertical by 460 horizontal video image.

6 'Browsing' in hypertext jargon

7 Bitmap or paint drawings are a representation of graphical data using computer screen picture elements (pixels), normally monochromatic, to designate shape and shading. For Hypercard on the Macintosh the resolution is 72 pixels per inch and it does not currently support colour or shades of gray.

8 Object drawing implies 'object-oriented graphics' meaning the representation of information as the combination of both data and procedure. Objects not only know what they are but also how they should act under certain conditions. Examples of objects include: polygon, circle, rectangle, and text and examples of procedures are stretch object, move vertex, and centre text.

7 Figures 2, 4, and 5 are printed output from HyperCard and all these figures appear on the screen in the same scale and at the same resolution as shown.

10 Message passing is a feature of object-orient programming that initiates a method (a specific sequence of actions) for a class of objects. The object then produces the desired results.

11 This varies for different text files (even in one hypertext system) depending on the similarity of words in the text index.