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Computer technology: A new architectural frontier

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Rice University, 1992
RICE UNIVERSITY

"COMPUTER TECHNOLOGY: A NEW ARCHITECTURAL FRONTIER"

by

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A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

MASTER OF ARCHITECTURE

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Abstract

Computer technology represents a virtually unexplored medium and has brought architecture to the threshold of what could potentially be one of the greatest revolutions in its history. Precedents of all creative endeavors reveal how humans typically respond to such new mediums in terms of time and application. Once recognized as a new architectural medium, computer technology promises to establish a boundless environment which will redefine human interaction.
Acknowledgements

I would like to thank Elysabeth McKee, whose faith in my abilities permitted me the opportunity to accomplish my goals. I would also like to express my appreciation for Mark Wamble, who provided clear support on a conceptual level. Thanks also to O. Jack Mitchell and William Cannady for their valuable attention. I would also like to express my sincere thanks to Dwayne Fontenot, whose technical support was invaluable.

I would also like to express special appreciation for my parents, who have diligently supported my entire education.

Andy Albin
April 1992
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History of Computing in Architecture

The wheel
... is an extension of the foot
the book
is an extension of the eye...
clothing, an extension of the skin...
electric circuitry, an extension of the central nervous system\(^1\)

-Marshall McLuhan

The profession of architecture, like all other creative endeavors, revolves around the communication of ideas. From the cryptic scribblings of primitive man to the crisply delineated electrostatic\(^2\) illustrations of today, human beings have always sought clearer and more appropriate methods of communication. The computer represents the most recent link in this continuing evolution. Its
earliest practical role in architecture involved two-dimensional representations of concepts for presentation and construction. As such, the computer offered profitable time savings and increased productivity: a powerful extension of the hand.

More recently, the realm of computer-generated architectural representation has been extended into the third-dimension. Subsequently, architects have gained the ability to construct models of their ideas that more closely resemble the possibilities of reality as we understand it. Furthermore, the incorporation of shadows, materials, reflections, and lighting through ray-tracing and radiosity programs has enhanced image quality almost to the point of photographic believability. The capacity to explore concepts at this level has transformed and extended the role of the computer from Computer Aided Drafting (CAD) tool to that of Computer Aided Visualization (CAV) tool: a powerful extension of the eye.

Technological advancement has delivered us to the threshold of yet another major leap in the exploration and presentation of architectural concepts. Just as CAD gave us the second dimension and CAV gives us the third dimension, processing speed brings us to the brink of a fourth dimension... time. High speed graphics processing engines now have the capacity to produce images in real-time. Rice University's Advanced Visualization Laboratory (RAVL) has recently developed the capability to translate three-dimensional structures from several software modeling programs into a format that can be easily manipulated over time using various input devices. The ability to travel from idea to experience with such celerity has brought the computer much closer to
its immediate architectural goal which is Computer Aided Architectural Design (CAAD): a powerful extension of the mind.

Since personal interaction is among the most effective means of communication, the next logical step in this evolution is to allow multiple users the opportunity to explore a computer simulated model simultaneously from separate locations. This unprecedented step in conceptual exploration would allow numerous individuals the chance to investigate the environment concurrently from networked terminals anywhere on the globe. As one may deduce, this necessitates the introduction of personal representation within the environment. This notion calls into question how one might choose to be perceived, considering the limitless possibilities and the need to maintain individuality: a powerful extension of identity.

As one follows the course of this evolution, one might infer a conclusion that was proposed by Marshall McLuhan over fifteen years ago, that the medium is the message. Once people have the ability interact within a computer generated realm, one may recognize that technology offers new and boundless possibilities as an environment unto itself. This, of course, will have a significant impact on the way we consider architecture, and on the structure of society in general. This new architectural frontier will redefine how we think about ourselves, our community, and our existence: a powerful extension of reality.
Computer Aided Drafting

The technology of computer graphics is on the threshold of transforming our culture. Cheap and powerful drawing processors will soon be as familiar to most of us as word processors.\textsuperscript{13}

-William Mitchell
As is the case with any tool, computers were employed when the cost was exceeded by the value of the return. As technology has progressed, increased savings in time and effort have translated into greater profit and have thus solidified the position of the computer within the profession of architecture.\(^{14}\)

The earliest introduction of computer technology in architecture, as mentioned in the previous section, could be thought of as an extension of the hand: drafting. The computer excelled here because of its inherent ability to perform repetitive functions with ease and speed. This new technology made light work of massive redundancy, particularly relevant to modern architecture, which relies heavily on repetition of mass produced details.\(^{15}\)

Although early computer graphics were valuable, they were generally limited to orthogonal representation because of hardware limitations. The graphical simplicity of architectural plans, sections and elevations, relative to axonometric and perspective views, allowed the computer to delineate with enough rapidity to avoid lengthy delays and decreased productivity. However, early computers did not easily accommodate complex forms and geometries. Such technological limitations may have been partially responsible for the proliferation of orthogonal architectural products since the nineteen-sixties and seventies.

Actual physical output was increased by the ability to modify drawings more easily. Graphical elements could be rapidly reorganized without repeated erasure or drawings. Similarly, computer representations could be conceived and executed in full scale and then printed quickly at any scale. Consequently,
these advantages may have contributed to the demise of the draftsperson as a distinct individual apart from the architect.

Regardless of the limitations, early architectural computers offered enough advantages to cause a revolution in the way architects had traditionally produced their work. For those with enough foresight and capital, the genesis of the computer age offered the promise of vast possibilities.¹⁶
Computer Aided Visualization

The second era of computer-aided architecture has been the "partition paradigm": let the designer do what he is good at and let the machine do what it is good at, and so forth.\textsuperscript{17}

-Nicholas Negroponte

Computer technology has recently improved to the point that most architects can afford the hardware and software required for more advanced graphical functions. Specifically, computers today have the capacity and speed to generate three dimensional images. This advance has extended the role of the computer from that of drafting tool into the realm of visualization, simulating images more realistically.\textsuperscript{18} Thus the computer has narrowed the gap between imagination and representation as an extension of the eye.

As any architects knows, the construction of perspectival images is no easy task. Even after all of the variables have been chosen and the construction initiated, the view quite often may not seem quite correct in the eyes of its creator, and the arduous process begins again.\textsuperscript{19} For a computer, the construction of three dimensional images is simply a matter of mathematical efficiency. Subsequently, faster mathematical computation translates into faster image generation.
This ability has also advanced the usefulness of the computer from production tool to presentation tool. Whether used simply to create underlays for hand rendering or for complex computer generated photo-realism, the computer serves as a tremendously powerful time saving and insight providing device. Such three dimensional construction can be thought of in much the same way as we have always considered physical scale models, yet the computer provides the possibility of actually generating views from any point within.

Similarly, the computer offers the added advantage of being able to simulate building materials, natural as well as artificial lighting conditions, and the appropriate interaction between the two. Using ray tracing and radiance programs, architects and designers can generate any number of realistic views using infinite options without ever having to lift an X-acto knife or purchase a piece of material.\textsuperscript{20}

These advancements mark a major step in the evolution of image generation technology and in the lives of those who can benefit from it. A new realm of visualization has unfolded, extending our perception and foretelling of the future.
Computer Aided Architectural Design

The impact of the computer, with its capacity to generate elaborate analysis, is just becoming a tool of major importance. Designers can now manipulate and compare complete theoretical concepts in order to arrive at optimum choices. No longer is there any reason to accept the mundane solution or adhere to the outdated canons of past disciplines.

The prospects of taking part in this revolution are every bit as exhilarating as the techniques that promise to make its benefits a reality.\textsuperscript{21}

-Syd Mead
As suggested in the introduction to this chapter, the first generation of computer graphics dealt with two dimensional representation, and the second generation offered the third dimension. The logical extension of this progression is the addition of a fourth dimension.

Just as computer aided visualization provided one with a position in space, computer aided design offers a location in time. This feature represents the current state-of-the art in computer graphics technology. As such, it is only available to those who can afford the highest quality in contemporary graphics generators.22

It is this ability which can finally begin to qualify the computer as an actual design tool. Not until the user has the ability to visually experience a design as a function of time will the data provide enough information to make truly informed and sophisticated decisions about its functional effectiveness and experiential appeal. This ability, of course, will only be enhanced as the technology of the future begins to provide the photo-realistic quality of computer aided visualization at speeds rapid enough to simulate vision over time.

If the past is any indication of the rate at which technology will advance in the immediate future, real-time ray shading will probably not be possible at all for at least another five years. If this is the case, the technology will not be available on a typical consumer level until the next century. Regardless of the time required and the obstacles that must be overcome, this capability will be realized.
The implications of the inevitability are staggering. When a computer generated environment can be delivered with such believability, people will begin to question the necessity for physical construction of many designs. A rift will occur between architectures that must be realized and those which may remain virtual. Consequently, there may be a division between the designers of these two distinct varieties of architecture.

The important thing to realize is that such experiential virtual environments will exist, and that someone will have to define them. Enter the architect. Not only will the designer of such realms be confronted with practical issues common to reality-based architecture, he will also be responsible for the actual environment in which the designs are incorporated. Such an opportunity is unprecedented and should be met with anticipation and enthusiasm.
Computer Aided Identity

Today we're beginning to realize that the new media aren't just mechanical gimmicks for creating worlds of illusion, but new languages with new and unique powers of expression.25

- Marshall McLuhan

Just as computer aided design may require time to be significantly useful, virtual design will need more than just impressive real-time graphics to be considered architecture. Although manipulating a design as an individual on a single computer can be impressive and inspiring, the experience seems rather incomplete without someone else to interact with.
The solution to this situation is the incorporation of multi-user interaction, which would permit multiple individuals to experience the environment simultaneously over a computer network. This requires the establishment of standards which define how individuals can interact with the architecture and with each other.\(^{26}\) This also suggests a need to portray oneself for the benefit of those who might be encountered in such a realm.\(^{27}\)

As implied in the previous section, architects of the virtual realm will be free from numerous reality-based parameters and confronted with a broad spectrum of new considerations. Similarly, an individual in the environment will not be limited by the constraints of physical reality and will face a variety of unprecedented options. He could define his own appearance or alternate between appearances as easily as he changes his clothing in reality. He could even opt to be in more than one place at a time.

Interaction of this sort need not be constrained by the limits of spatial reality, just as telephone conversations and live television broadcasts are not. Most of the more technologically advanced areas of the world are already networked for rapid computer communication via satellite and fiber optics.

Currently, the primary limitations on three dimensional interaction have to do with the amount of information which can be exchanged rapidly over computer networks. Additionally, the hardware required to interpret the exchanged information fast enough is not yet affordable. Even if it were, connection to a network sophisticated enough to transmit the data is currently accessible only by universities and large corporations.
Despite these present limitations, technology and market forces will ultimately provide widespread individual access to powerful computers and networks. At such time, the multi-user environment will permit three-dimensional interaction with enough speed and detail to be useful to the architectural community and the general public.
Computer Aided Existence

When Paradigms change, the world itself changes with them. Led by a new paradigm, scientists adopt new instruments and look in new places. Even more important, during revolutions scientists see new and different things when looking with familiar instruments in places they have looked before. It is rather as if the professional community had been suddenly transported to another planet where familiar objects are seen in a different light and are joined by unfamiliar ones as well.²⁸

-Thomas Kuhn

Image 6
Once networked and equipped with suitable hardware, society as we know it will undergo transformations of staggering proportions. Although the ultimate incarnation of this concept may still be decades away, lesser forms are already in place and foreshadow that which is to come.

Examples as commonplace as the telephone and the fax machine bespeak a future of worldwide interaction. The home shopping network and 900 numbers are indicative of a trend toward decentralization and the shifting self image. Computer telephone connections provide near instantaneous access to vast quantities of information and services. Some such systems already offer immediate access to other individuals for the sole purpose of interaction and discourse.

Once routine interaction is made cost effective through computerized networking, many of today's institutions will be dramatically transformed and new societal structure will emerge. No longer will office workers be required to commute daily to central locations. No longer will urban transportation suffer from congestion. No longer will towering or sprawling office complexes be required house those upon whom the future of the economy depends. Subsequently, the emphasis of architectural priority will be shifted.

Just as reality initially shaped the product of the computer, computer technology will ultimately reconfigure reality. The architecture of the real world, as has always been the case, will reflect only that which is required by the society that created it. Technology will redefine what is required to meet the needs of modern society.
Conclusion

The extension of any sense alters the way we think and act - the way we perceive the world.\textsuperscript{30}

-Marshall McLuhan

Image 7

Computer technology has just begun to extend our senses. Knowledge of the past and awareness of the present only begin to foreshadow what lies ahead. Aided by the global consumerism, technology is being absorbed as fast as it can be developed. In the future, computer technology, in all of its permutations, will be considered as necessary for personal survival as the automobile or the telephone is today.
The computer has only begun to address the issues of architecture that we consider important by contemporary standards. For many architects, proliferation of computer technology may appear to have diminished the scope of the profession. Those with more progressive insight, however, will recognize that architecture has simply evolved and been more broadly defined. Architects must evolve with the definition and its shifting parameters if they wish to maintain or expand their field of influence.31

Architects should continue to heed LeCorbusier's respect for the field of industrial design, which has since capitalized on the electronic era. To do so will ensure that architecture remains among the most dominant of societal influences. The day is coming when architects too will be able to take advantage of the era by exploiting the possibilities of computer technology as a new medium: a vast and unexplored frontier.
McLuhan & Fiore, "The Medium is the Massage," pp. 31-40

A high-quality process by which computer images are printed on large sheets of paper.


Ibid., pp. 8-9.

The human mind perceives fluid motion at approximately thirty frames per second.

These currently include keyboards, mice, keypads, and dials.

This is concept is the basis of the thesis project as outlined further in the text.

The computer-generated architectural construct.

Computers connected either by cable, satellite, or some other means of rapid data transmission.


Ibid., pp. 142-143.

Ibid., pp. 144-145.
McLuhan & Fiore, "The Medium is the Massage," p. 22.

Images:

1 Image by Christopher Crowley from The Media Lab.
2 Two-dimensional CAD drawing by Andy Albin.
3 Three-dimensional CAD drawing by Andy Albin.
4 Ray traced drawing by Alex Barber and Collin Wisecup.
5 From the movie "Tron."
6 From the movie "Tron."
7 Advertisement for software product "Virtus WalkThrough."
Exploitation of Media

Societies have always been shaped more by the nature of the media by which men communicate than by the content of the communication.\textsuperscript{1}

- Marshall McLuhan
As Marshall McLuhan suggests, methods of communication are at least as influential as the messages they contain. Those who recognize this may exploit the medium to enhance the power of their communicative intent. The following examples indicate how effective this approach has been in the areas of art and architecture. The same lessons are as applicable to computing as to any other creative or expressive endeavor.

The development of new media evolves with respect to technological innovation. Although the effectiveness of media exploitation often parallels the progress of this evolution, a period of evaluation is usually required to recognize the full potential. Examples in art and architecture also illustrate how time is necessary for the discovery of appropriate responses to new media.
Art

There is, of course, a fundamental difference between the image of today and of the former times: now the image precedes the reality it is supposed to represent.⁴

-Richard Kearney
The development of photography is perhaps among the most important technological influences on art in the last several centuries. Although photography was initially viewed as means of portraiture, it was later recognized as an extension of artistic expression. Over a hundred years after the invention of photography, Man Ray said:

I paint what cannot be photographed, and I photograph what I do not wish to paint. If it is a portrait that interests me, a face, or a nude, I will use my camera. It is quicker than making a drawing or a painting. But if it is something that I cannot photograph, like a dream or an unconscious impulse, I have to resort to drawing or painting. To express what I feel, I use the medium best suited to express that idea.
For Man Ray, like other artists of his time, photography was ultimately recognized as an expressive medium with distinct advantages for the communication of imaginative concepts. Decades later, artists like Salvador Dali, Andy Warhol, and Roy Lichtenstein continued to exploit the same ambiguities and distinctions of artistic imagination relative to the impact of photography.
Architecture

The past went that-a-way. When faced with a totally new situation, we tend to always attach ourselves to the objects, to the flavor of the most recent past. We look at the present through a rear-view mirror. We march backwards into the future.\(^8\)

-Marshal McLuhan

Innovations in architectural technology are also frequently subject to initial misunderstanding. Just as the role of photography was originally defined in terms of the artistic precedent of portraiture, new architectural media are often misinterpreted relative to previous design conventions.\(^9\)
Roman

Few societies have been as prolific in the area of architectural technology as the Roman Empire. Although they were among the first civilizations to fully understand and exploit the properties of their indigenous materials, the process required centuries of experimentation to master the media.\textsuperscript{10}

The earliest Roman attempts at construction reveal their reliance upon previous methods of building technology. Specifically, early stone structures were assembled in ways that were formerly appropriate for timber construction.\textsuperscript{11} Greek and Etruscan precedents acknowledge limited understanding of the materials from which they were built.\textsuperscript{12}

For example, spans between the columns of Greek temples were limited by the capacity of stone to serve as a single beam. The tensile shortcomings of the material could only be counteracted by tremendous depth, which only increased the supported load.\textsuperscript{13} Although timber could be considered an adequate material for constructing ceilings, its exclusive use for this task suggests an ignorance of how to employ a heavier material for the same purpose. In addition, much of the ornament included on the pediments of Greek temples reflect the manner in which timber beams were exposed in the earlier construction of similar wooden structures.\textsuperscript{14}
The Romans ultimately solved the problem of beam spans through the development of the arch, which takes advantage of stone's inherent compressive strength. Permutations of the same technology led to an understanding of domes and vaults for use as roofs and ceilings. Further evolution led to the discovery of Roman concrete, the invention of the Byzantine pendentive, the development of the Romanesque pointed arch, and the proliferation of the Gothic buttress.
Modern

Just as the Romans struggled to come to grips with the potential of their own relatively new found materials, early modern architects and engineers were faced with the same situation. Developments in the areas of steel, glass, and reinforced concrete ultimately led to the most significant revolution in recent architectural history.²⁰

Despite the potential that these new materials offered, many of the earliest buildings to use steel structurally were clad to look as if they had been constructed of stone. Considering the advantages that steel affords, these apparently stone buildings must have looked odd at the time, with their narrow bases and vast windows. Although these features were exploitations, they had only begun to scratch the surface of the expressive capabilities of the new materials.²¹
Just as the Greeks and Romans originally employed stone as if it were wood, early modern bridges treated steel as if it were stone. It was not uncommon at the time to see such bridges expressed as arches in an attempt to maximize the extent of the span. This approach was later rejected altogether when it was recognized that the very shortcomings of stone were the advantages of steel. High in tensile strength, steel bridges were later expressed as long horizontal structures constructed as trusses or suspended platforms to exploit the properties of the new medium.\(^{22}\)
Ultimately, the high modern era of architecture realized the potential for free planning, fully glazed exteriors, and liberated corners. Examples such as Mies van der Rohe's Farnsworth House, Le Corbusier's La Tourette monastery, and Louis Kahn's Kimbell Museum indicate the extent to which the properties of the new vocabulary of materials could be exploited as expressive of the new era.

Subsequently, further development of the new materials brought us hundred floor towers, elevators, curtain walls, and covered stadiums, to name a few. Just as the history of architecture evolved for thousands of years as refinements of Greek and Roman developments, so too will the evolution continue as an extension of modern discoveries.²³
Computing

The computer abolishes the human past by making it entirely present. It makes natural and necessary a dialog among cultures which is as intimate as private speech, yet dispensing entirely with speech. 24

-Marshall McLuhan

Many parallels may be drawn between the histories of art, architecture, and computing. Art speaks to us about effective communication through new media. Architecture indicates how time is required to understand appropriate uses for new media. Effective use of electronic technology is subject to the same sorts of transitions.
Although architectural computing will continue to serve as an effective method of creating and recording designs for the the world in which we live, its true potential may not yet be fully realized. Just as it took years to understand the possibilities of photography as an artistic medium, or of stone and steel as architectural media, electronic technology is still in a state of transition.

Architectural history suggests that designers must set aside preconceptions of an old medium if they are to recognize greater potential of a new medium.\textsuperscript{25} As Man Ray articulated, a new medium can create unprecedented methods of communication while simultaneously enhancing established methods.\textsuperscript{26} Such may be the case for the future of computing technology with respect to architecture.
Conclusion

It is impossible to understand social and cultural changes without a knowledge of the workings of media.\textsuperscript{27}

-Marshall McLuhan

These examples help illustrate how humans typically approach and respond to new media. Individuals with adequate hindsight should be able to distinguish between minor incremental changes and major paradigmatic transitions. Such
awareness will suggest when preconceptions should be superseded by fresh perspectives. Current electronic technology may represent such a significant transition and warrants careful consideration with respect to all creative and communicative endeavors, including architecture.
Notes:

2. Ibid.
7. Ibid.
17. Ibid., p. 75.
18. Ibid., p. 98.
25 Winn, p. 4.
26 Schwarz, p. 7.

Images:

1 "Bald Eagle" by Andy Warhol, 1983.
3 "Glass Tears" by Man Ray, 1930-33.
4 "Woman with Rose Head" by Salvador Dali, 1935.
5 "Apollo Temple IV" by Roy Lichtenstein, 1964.
6 Temple of Concord, Sicily, late fifth century B.C.
7 Marquette Building, Chicago, 1894.
8 Cast iron bridge, Coalbrookdale, England, 1776.
9 Historic view of the future.
10 Title image from Roger Dean's Views, 1975.
Virtual Architecture

Electric circuitry profoundly involves men with one another, Information pours upon us instantaneously and continuously. As soon as information is acquired, it is rapidly replaced by still newer information. Our electronically configured world has forced us to move from the habit of data classification to the mode of pattern recognition. We can no longer build serially, block-by-block, step-by-step, because instant communication insures that all factors of the environment and of experience co-exist in a state of active interplay.¹

-Marshall McLuhan

Image 1
Architecture is defined as the art or science of building habitable structures.\(^2\) This practice has always been considered to be within the realm of the physical environment. Electronic technology, however, offers the possibility of designing habitable structures that are specifically intended to be experienced via computer network.\(^3\) Multi-user simulated designs belong to the realm of the virtual. Virtual reality is a term coined by a leading computer theorist and developer, Jason Lanier, to describe such computer-generated, three-dimensional constructs.\(^4\)
Precedents

In premodern societies, social constructions of reality took form slowly and invisibly, and the symbolic universes that people wove about themselves seemed to be permanent fixtures of life.

In modern societies - born out of social and physical mobility, with people beginning to suspect that there were different possibilities of realities - individuals and groups gained, or tried to gain, more options.

In the postmodern world we are all required to make choices about our realities.5

-Walter Anderson

The concepts of virtual experience originate from numerous sources, including dreams, drama, fiction, and telecommunication. The dream probably represents the most ancient of these, inspiring conscious conceptualization for self-improvement beyond mere self-preservation. Desire to communicate the dream has manifest itself in drama and literature. Finally, telecommunication offers a potential to actively participate in the dream.
As proposed by Man Ray, imagination is the foundation of creativity. Psychology suggests that the phenomenon of the dream is closely related to the imagination. Because dreams can juxtapose images and ideas that otherwise might never be associated, such visions cause us to draw new parallels, consider alternatives, and reevaluate the familiar. Daydreams permit the individual to create a preferential world of such imaginative complexity. The virtual environment may permit an individual to visualize the dream.
Drama

Image 3

One method of communicating the dream is through drama. Theater, cinema, and television are all attempts at dramatic expression. Although these media may be effective for the conveyance of concepts, they permit little or no interaction by the spectator. The virtual environment not only offers the possibility of visualizing the dream, it can permit dramatic interaction with others.
Science-fiction writing today presents situations that enable us to perceive the potential of new technologies.\textsuperscript{10} 

-Marshall McLuhan

Another attempt to describe the dream is through the written word. Science fiction is particularly applicable because it relies heavily on imagination for visions of the future. Recently, authors like William Gibson, Bruce Sterling, Vernor Vinge, and Rudy Rucker have attempted to describe the future possibilities of communications technology.

In particular, Gibson portrays a future where individuals tap neurologically into a vast network that is frequently referred to as "the matrix." While "jacked in" to the matrix, "console cowboys," who might otherwise be known as computer hackers, attempt covert infiltration of corporate/governmental institutions in search of the future's most valuable commodity, information.\textsuperscript{11}

In a similar fashion, Vinge's characters interact as virtual entities for whom anonymity is critical to maintain subtle power over other individuals. In a desperate attempt to prevent detection, the characters exploit their knowledge of technology in a struggle for the combined processing power of the world's computer network.\textsuperscript{12}

In the spirit of fictional excitement, these stories tend to be more than a bit sensational, but they do offer fresh perspectives on how interaction might occur and what the virtual environment might be like. Additionally, they draw attention
to potential subversions of the medium. The vision of science fiction writers and futurists serves as inspiration for those who are actively supporting, theorizing about, or actually developing tomorrow's technology. 13
Telecommunication

Historically, technological development has always striven for increased speed and quality of interactivity. Computer technology brought us the modem and the fax machine and promises further advancements in communication. Those with networked computers currently enjoy digital mail which takes only seconds or minutes to reach its destination. Even more convenient is the ability to request direct, text oriented interaction with an individual at another terminal. Typing as
if writing to one another, participating individuals can see the text of the other as it is entered and can respond immediately.14

An idea displayed in movies such as "2001: a space odyssey" and "Blade Runner" is the concept of the "videophone," with which participants may observe live images of each other during discourse, thereby enhancing communication through the interpretation of gestures and the nuances of facial expression. Although tele-conferencing is now a reality, research on the videophone concept has been underway for years and implementations are currently being installed in some institutions of the federal government.
Definition of Architecture

It is with sensitivity to the dimensions, nuances, and subtleties of spatial distinction that the abilities to understand, to be moved by, and eventually create architecture originate.\textsuperscript{15}

-William Mitchell

Architects must exercise flexibility in defining architecture if they wish to advance their profession relative to the new technological medium. This task involves an analysis of just what qualities of architecture are fundamental. There may be certain undeniable features that can be applied broadly enough to include and influence the creation of virtual architecture.
One of the best known and most widely accepted definitions of architecture is that of firmness, commodity, and delight. Such a concise definition is inherently vague and requires thoughtful consideration to extract specific meaning.¹⁶

Firmness:
Architecture is locatable. It exists somewhere in space or time. It is accessible.

Commodity:
Architecture must accommodate. It must serve some function. It must facilitate.

Delight:
Architecture must inspire. It should convey meaning. It should communicate.

These characteristics are just as applicable to virtual architecture as they are to reality based architecture. They have always served as an index upon which to rely for guidance, and they probably always will. Architects who recognize these to be fundamental will make a smooth mental transition from the creation of one form of architecture to another.
The New Environment

Designers often establish design worlds implicitly, through their choices of design media and instruments.\textsuperscript{17}

-William Mitchell

Image 7

The environment is a term used to describe the computer-simulated place of interaction. It is made available to numerous participants via computer network and can support three-dimensional architectural representations. Although this document proposes what such an environment could be like, it is not intended to suggest what virtual architecture should be; rather, its purpose is to imply
what virtual architecture could be. Furthermore, it is intended to indicate that
designers will be responsible for more than just the architecture; they will define
the entire environment.

Biblical reference to God describes him as the architect of the universe. In the
same spirit of creation, virtual architects will define the environment, methods of
construction, and even procedures for interaction. Such freedom and
responsibility is unprecedented in the history of architecture.

The possibilities of such an unrealized environment are still wide open.
Numerous of earthly considerations which we take for granted need not be
implemented in the new environment unless deemed necessary. Many of these
considerations, however, may be implemented optionally for individual
flexibility. This potential suggests that the designer impose as few constraints
as possible in an effort to maximize freedom and facilitate assimilation.
Boundless Architecture

Environments are not passive wrappings, but are, rather, active processes which are invisible. The groundrules, pervasive structure, and overall patterns of environments elude easy perception. Anti-environments, or countersituations made by artists, provide means of direct attention and enable us to see and understand more clearly. The interplay between the old and the new environments creates many problems and confusions. The main obstacle to a clear understanding of the effects of the new media is our deeply embedded habit of regarding all phenomena from a fixed point of view. We speak, for instance, of "gaining perspective."  

"Time" has ceased, "space" has vanished. We now live in a global village... a simultaneous happening.  

-Marshall McLuhan

Image 8
One major difference between architecture of reality and virtual architecture is that the former is bound by place and the latter is not. Personal experience of place bound architecture requires that one travel topographically to its physical location. Although methods and speeds of transportation may vary, we cannot escape this fact of reality. Virtual architecture, on the other hand, is not subject to the same limitations. The virtual environment may be traversed as quickly as blinking, qualifying it as place boundless.\textsuperscript{22}
Reality based preconceptions about spatial organization are also subject to reevaluation in the virtual environment. Although the Cartesian model of space can and will be an applicable option, it is only one way of considering spatial representation. Entities within the environment could exist just as easily in fewer or greater than three dimensions. Similarly, Cartesian spaces need not be arranged as if they were contiguous. Two apparently adjacent exits from a space could lead to two vast and completely disparate realms that in reality would overlap each other. Subsequently, any two computer-generated spaces could be organized as if they were literally connected. Also, passing through an exit does not necessitate that it exist from the other side, or that it lead back to the place of origin.
Conclusion

The computer is by all odds the most extraordinary of all the technological clothing ever devised by man, since it is the extension of our central nervous system. Beside it, the wheel is a mere hula-hoop.\textsuperscript{23}

-Marshall McLuhan

Despite all the foreseeable advantages of the virtual environment, one must recognize that it is simply an extension of reality and not a replacement for it. Technology is intended as an enhancement in the evolution of human interaction. It does not preclude or eliminate the necessity for physical human interaction, nor will it be necessary for all architects to embrace it to its fullest
extent. The possibilities for the virtual environment merely suggests that all facets of human interaction need not require physical presence. Technology may ultimately loosen many of the constraints of the physical which may be considered extraneous, unnecessary, or counterproductive.
Notes:

20. McLuhan & Fiore, p. 68.
23  McLuhan & Fiore, "War and Peace in the Global Village," p. 35.

Images:

1  From the movie "Tron."
2  From the movie "Brazil."
3  Sketch by Syd Mead from Oblagon, p. 165.
4  Rendering by Syd Mead for movie "Blade Runner" from Oblagon, p. 100.
5  1881 hand-free telephone from Vintage Telephones of the World, p. 15.
6  Photo of the Acropolis from A History of Architecture, p. 139.
7  From the movie "Tron."
8  From the movie "Tron."
9  M.C. Escher's "Relativity" from M.C. Escher: The Graphic Works, #67.
10 From the movie "Tron."
An Environment

The important thing is to realize that electric information systems are live environments in the full organic sense.¹

-Marshall McLuhan

This section is entitled "An Environment" because it is a suggestion of what could be. As suggested previously, an important consideration in the creation of an environment is the preservation of as much freedom as possible.² Beyond that, designers may incorporate as many diverse and unique features as they deem suitable or interesting.
This section also discusses precedents of computer environment creation, some of the lessons learned, and some forms of bases for conceptualization.\(^3\) It also delineates what limitations are currently unavoidable due to technological constraints, and what sorts of things will be possible when these constraints are overcome.
A critical factor in the creation of any virtual environment is interaction. Without someone else with whom to communicate or share the experience, an individual might find the environment to be of limited use and interest. Some of the earliest forms of computer-enhanced human interaction were through games in which programming and networking permitted two or more participants to respond to each other simultaneously. The use of modems enabled players to communicate over existing phone lines over great physical distances.
Proliferation of the internet, a massive network linking primarily universities and large corporations, has spawned the creation of a new type of virtual environment. Multi User Domains, or MUDs as they are referred to, have offered not only potential support for dozens of simultaneous participants, but also user extensibility of the environment. Purveyed as a text-oriented medium, users may log in under a name of their choosing, travel from one described location to another, encounter and interact with other individuals along the way, and add their own personalized extensions to the environment. Although the actual host program must reside on a reasonably powerful computer somewhere on the network, individuals may connect to the environment from any worldwide location within access of the internet. The popularity of these environments continues to increase as more of them are initiated at institutions everywhere.
Yet another multi-user environment, known as Habitat and purveyed over an online service for Commodore computers, has many of the same features as MUDs, with the added benefit of two-dimensional graphic representations of people and places. At considerable expense, thousands of users have created characters for themselves and interacted with each other just for entertainment. Since then, a faster and much more extensive version of the Habitat-type environment has been implemented in Japan.
The shop.
A neat little garbage, 6 feet high. A man, dressed in denim and an apron, is standing and talking. A golden ring is on a shelf above.

"The Official Regenesean Newspaper"

A slim frog
A cute little bear

The port of entry is on the right.

The frog suddenly appears right before your eyes.

Frogs jump from side to side.

"Frogs take ringing!"

Frogs jump into little boats you put here.

"Frogs take transit stop!"

A frog fetches something from another dimension.

Frogs jump: "Is the new alien in town on the end?"

Frog takes a human.

"Frogs say: That's Snack. He's the new alien in town..."

Frogs jump quickly.

Frogs kiss the alien frog.

"Snack..."

You gag at the alien frog being kissed.

Frogs jump: "Eeeek!"

Frogs say: "Be careful of the bear... he bites."
Perhaps taking a cue from Habitat, there is now a similarly styled two-dimensional MUD in existence on the internet. BSX, which is run from a computer located somewhere in Sweden, is based on alien existence in the sense that new characters choose their appearance by specifying which planet they wish to be from. Very much interested in the potential of this new medium, I, along with Rice Advanced Visualization Lab's research assistant Dwayne Fontenot, decided to apply for "wizardship." As approved wizards we embarked upon the creation of "the moon" and various objects which might be found there, including a device known to Calvin and Hobbes fans as a transmogrifier. With this device, the user could change his own appearance or the appearance of others while risking a chance that malfunction would cause the transmogrifier to vanish, leaving its most recent wielder portrayed graphically as a pig. BSX has stirred the interest of many who see its visual aspect as an intriguing enhancement of an older theme. The concepts and technology employed for games like these foreshadow more practical future uses of networking.
Present Goals

We have now become aware of the possibility of arranging the entire human environment as a work of art, as a teaching machine designed to maximize perception and to make everyday learning a process of discovery.⁹

-Marshall McLuhan

Within virtual architecture, decisions must be made about what the environment should be like. What are the goals of the environment we are creating? Which elements of reality should be incorporated? How far will existing technology permit us to implement any ideas that we might have?
Possibilities and Considerations

In a computer-simulated environment there is no weather. There is no gravity. There are few limits. Consequently, the creator must define everything about the environment, incorporating those elements of reality deemed appropriate. Structure is necessary to provide order and to permit people with different desires and levels of skill to understand, exploit, and enjoy the environment.
The infinite possibilities of the virtual environment easily boggle the mind. In order come to grips with these, we must examine some fundamental issues that will help begin to define a direction. Many of these considerations are simply dictated by the technology that is currently available. Others may be considered necessary to promote assimilation and transition from reality.\textsuperscript{10}

The implications for virtual architecture are equally as limitless.\textsuperscript{11} Issues such as scale are called into question because of the possible ability of the user to change sizes. There exists the potential for dynamic architecture which could move from place to place, change colors or apparent materials, alter its size, or cease to exist altogether at random intervals. It could be filled with virtual people (or clients) to test the possibilities of a design under consideration for reality. It could display in different ways to different people based on their aesthetic preferences. It could serve as a virtual meeting place for those who might otherwise have been required to live in the same geographic area to accomplish common tasks.
Options and Limitations

A designer must find a design problem representation of sufficient computational efficiency to allow the problem to be solved within practical time and resource limits.\textsuperscript{12}

-William Mitchell

![Image 8](image)

Numerous technological variables influence the capacity of the individual to maximize use of the environment. The potential for graphics processing depends largely on the capacity of the machine to calculate quickly and the quality of the output devices employed. The ability to interact depends on the amount of information that the network can handle and on what sorts of input
devices are involved. Interaction also involves the quality of the interface through which data is transmitted and received.\textsuperscript{13}

The hardware and networking options define the existing potential. Currently, the average individual does not possess the means by which to do complex computer graphics in real time from home. Even if one were to acquire a computer fast enough to handle rapid generation of images, the exchange of information for interaction within the graphics would easily overwhelm the capacity of existing phone lines.\textsuperscript{14}

From an institution such as a university or large company, an individual may, however, access the means by which to do advanced interaction. Powerful computers connected to fast networks are not uncommon. Subsequently, a three-dimensional multi-user environment is currently possible.
Production

The first step in precise formulation of a design world is to specify the primitives... out of which designs may be assembled.¹⁵

... selection of the primitives and axioms for a design world establishes some domain of formal possibilities for a designer to explore, and the designer must be concerned that the domain is appropriate to the task at hand.¹⁶

-William Mitchell

To build any three-dimensional environment, the designer is required to define the elements out of which perceivable images will be generated. The complexity of the appearance of these elements may be permitted to vary as a function of the user's computer.

As Le Corbusier indicated in his book Towards a New Architecture, most architectural forms can be derived from a few basic solids.¹⁷ Rectangular solids, pyramids, cones, cylinders, and spheres are all basically mutations of each other and can be employed in an infinite number of compositions. Out of these primitives, every object in the virtual environment can be constructed.
Hey kids...
How the primitives interact with each other is another matter. Whereas solids in reality can only exist within sufficiently large voids, geometries composed of polygons may occupy portions of the same apparent space. Intersection testing, a complex mathematical process, is necessary if computer generated solids are to behave as they do in reality.\textsuperscript{18} Similarly, the primitives are free to exist anywhere unless gravity or some other such force is implemented to govern behavior.

Additionally, communication is necessary between the individual and the computer to enable navigation and perception within the environment. These are issues of interface which permit interaction. They may be addressed either in hardware or in software, although most likely a combination of both. Everything from keyboards, monitors, and mice to datagloves, voice input, and heads-up displays could be employed as interactive possibilities.\textsuperscript{19}

Specifications such as these will define what is currently possible for the creation of today's virtual environments. Current development should at least attempt to predict what future possibilities will become available to ensure evolution as opposed to obsolescence. In other words, designers of the virtual environment should plan for future developments.
Future Goals

The logic of reality-creation is the following: if people believe this, then they will do that.20

-Walter Anderson

Ultimately, image quality will improve to the point of realistic believability. Input and output devices will deliver audio, video, and tactile feedback of near hallucinatory proportion.
The immediate goal for the future in interface technology is to create effective experiences for our external senses to detect and evaluate. Someday, science may be able to bypass external perception and interface directly to the brain. Unraveling the body's own methods of internal communication could lead to direct stimulation and the development of completely new forms of perception and interpersonal interaction.\textsuperscript{21}
Conclusion

It is too late to be frightened or disgusted, to greet the unseen with a sneer. Ordinary life-work demands that we harness and subordinate the media to human ends.\textsuperscript{22}

- Marshall McLuhan

Despite current technological limitations, the potential to create a three-dimensional, multi-user environment exists. Precedent dictates that designers must define all aspects of the environment with forethought and flexibility. Continued technological improvements will ultimately provide greater individual access, enhanced output, and practical application.\textsuperscript{23}
Notes:

5. Ibid., pp. 281-282.
8. Ibid., pp. 296-297.
16. Ibid., p. 57
22 Marshal McLuhan, "Counter Blast," p 53.
23 Morningstar & Farmer, p. 298.

Images:

1 From the movie "Tron."
2 From the movie "Tron."
3 Sample from a text-based, multi-user environment.
4 Sample from Lacasfilm's Habitat multi-user environment.
5 Sample from BSX multi-user environment.
6 From the movie "Tron."
7 M.C. Escher's "High and low."
8 Image from movie "Tron."
9 Proposed multi-user environment interface by Andy Albin
10 From the movie "Total Recall."
Architecture of the Individual

Since the new information environments are direct extensions of our own nervous systems, they have a much more profound relation to our human condition than the old "natural" environment. They are a form of clothing that can be programmed at will to produce any effect desired. Quite naturally, they take over the evolutionary work that Darwin had seen in the spontaneities of biology.¹

-Marshall McLuhan

Interaction within a virtual environment necessitates personal representation. Freedom permitted by the medium provides options for redefining how we are perceived. We may choose to maintain human characteristics resembling the reality into which we were born, or we may opt to invent an entirely different form of presence altogether. We may choose to be portrayed differently to different people or at different times, or we may assume states which evolve constantly. We are also free to choose whether or not gender should be apparent or not. As a tabula rasa, the virtual environment causes us to reflect upon our own distinguishing characteristics.²
Definition of Self

Individuals feel free to create new identities for themselves, and entrepreneurs of reality dabble gaily in the creation of new history, new science, new religion, new politics.\textsuperscript{3}

-Walter Anderson

Image 2

We develop as individuals based on and relative to numerous genetic and contextual variables. The possibilities of alternative self definition and extended context, both of which are possible through electronic technology, will increase their impact on us all. It remains to be seen whether this will increase tolerance for each other as distinctly different people, or if it will make us all more similar.\textsuperscript{4}
Dislocation of the Physical Individual

Our new environment compels commitment and participation. We have become irrevocably involved with, and responsible for, each other.\(^5\)

-Marshall McLuhan

Just as one must travel to architecture physically to experience it in reality, one must also locate and travel to an individual to experience physical presence. Although watching live footage of a place on television or speaking to another person on the telephone are mild forms of virtual experience, they only permit slantable one-way or limited two-way interaction.
The important thing to consider about virtual life, like virtual architecture, is that it is not place dependent either. The individual is dislocated physically in favor of the ability to be anywhere at any time. We will be able to interact with anyone regardless of physical location.\textsuperscript{6}
Variety of Options

The postmodern individual is continually reminded that different people have entirely different concepts of what the world is like.\textsuperscript{7}

- Walter Anderson

In addition to our self-images, our ideas about ourselves also include ideas about what we'd like to be and ideas about what we ought to be.\textsuperscript{8}

- Marvin Minsky

All of our lives we as individuals have had to deal with own physical configurations. Sex, color, size, and shape are all genetically predetermined. There are many today who are prepared to spend money, time, and effort to alter their characteristics. It would be nice to have had some choices about our appearances. It would be also nice to change relative to the context, to slip into something more comfortable, suitable, or desirable.
As technology improves, so will our potential for self definition. Self-consciousness may be eliminated and many of the characteristics which once impeded personal interaction may subside. Perhaps infinite formal possibility will diminish the importance of appearance in favor of personality and character.
Instantaneous Multiplicity

Sometimes we regard ourselves as single, self-coherent entities. Other times we feel decentralized or dispersed, as though we were made of many different parts with different tendencies.⁹

-Marvin Minsky

It is the instantaneous nature of the new medium that affords it certain unprecedented potential advantages. Combined with its additional advantage of allowing an individual to be in more than one place at a time, it defies and to a large extent overthrows preconceptions about interaction, discourse, and productivity. In this way, it permits and encourages us to become involved on a
more extensive scale, and in a potentially more influential and influenceable manner.

As easily as opening new windows, the individual may enter other environments, thus existing simultaneously in more than one location.
Conclusion

Electric circuitry has overthrown the regime of "time" and "space" and pours upon us instantly and continuously the concerns of all other men.¹⁰

-Marshall McLuhan

The virtual environment offers the unprecedented possibility for total self-definition and multiple existence. Because the computer offers the anonymity to conceal physical characteristics, individuals may interact based other personal qualities.
Notes:


Images:

1. M.C. Escher's "Hand with reflecting globe."
2. From the movie "Total Recall."
3. From the movie "Tron."
4. Personal representation from BSX multi-user environment
5. Personal representation from BSX multi-user environment
6. Personal representation from BSX multi-user environment
7. From the movie "Total Recall."
8. From the movie "Tron."
9. From the movie "Tron."
Conclusion

We're in an age of implosion after 3000 years of explosion.¹

-Marshall McLuhan
Reality

The new electronic interdependence recreates the world in the image of a global village.²

The circuited city of the future will not be the huge hunk of concentrated real estate created by the railway. It will take on a totally new meaning under conditions of very rapid movement. It will be an information megalopolis. What remains of the configuration of former "cities" will be very much like World's Fairs - places in which to show off new technology, not places of work or residence.³

-Marshall McLuhan

In this age of constantly shifting attitudes about what our architecture should be like, we struggle with issues of density and urbanity. As McLuhan indicates, these issues will ultimately be rendered moot by the impending technology.
The question will not be how to make our cities more successful, but what to do with them. The potential for cities to sustain growth, which is now measured in millions of square feet of vacant office space, will be supplanted by corporate potential to measure growth in terms of productivity.

Virtual reality will impact physical reality in a number of ways. It is quite possible that the field of architecture will be divided into two groups; virtual and physical. Regardless of whether or not the profession of architecture chooses to embrace the new medium, it will influence the nature of what work will be available and how it will be done.

Much of the stylistic emphasis that architects rely upon will be more accommodated in the virtual world. Subsequently, the architecture of reality may be freed from such concerns in favor of rational functionalism and practicality. Ideally, the two forms of architecture will inform each other and excel in their respective areas of strength and influence.
Virtual Reality

We all become consumers of reality (although, as in other forms of consumption, not with equal buying power), and greater numbers of us also become creators of reality.

The mass media make it easy to create and disseminate new structures of reality. A new reality does not have to convert the entire society; it merely has to find its buyers, get a share of the market, and locate enough customers to fill up the theater.7

-Walter Anderson

Virtual reality will begin by being shaped by the structure of reality. But as future generations develop with respect to an alternative, the latter will increase its influence on the former. Humanity will continue to adapt as it always has.
Society

The extreme decentralizing power of the computer in eliminating cities and all concentrations of population whatever is as nothing compared to its power to translate hardware into software and capital goods into information.\(^8\)

-Marshall McLuhan

The inevitability of progress will not only force us to evaluate technology with respect to reality, but also reality with respect to technology. Networked interactivity began thousands of years ago with inventions such as the wheel. Electronic technology has already begun the decentralization of our reality, and will continue to do so at a rapid pace. The necessity for vast expanses of office space, to and from which we are so accustomed to commuting, may ultimately subside. Subsequently, those who used to inhabit these spaces may gain the freedom to reside where and with whom they wish, and even structure their schedules more to their liking. It may also cause a great rift between those who can financially afford to participate and those who cannot. Regardless, technology will bring us together while simultaneously allowing us to be apart...

Workers of the world, fan out.\(^9\)

-Stewart Brand
Notes:

1  McLuhan, "Counter Blast," p. 35.
2  McLuhan and Fiore, "The Medium is the Massage," p. 67.
3  Ibid., p. 72.
4  Ibid. p. 68-72.
6  Ibid.

Images:

1  Virtual design concept by Andy Albin.
2  Houston skyline.
3  Virtual reality apparatus. From Myron Krueger's "Artificial Reality II."
Postscript

The following pages were generated as thesis research and were presented as part of the final thesis defense. The section titled "Virtual Environment: A Specification" was written in anticipation of the creation of a three-dimensional, mult-user, computer simulation. The subsequent section titled "Virtual Environment: Findings" delineates information learned as the simulation progressed.
Virtual Environment

A Specification

Presented as part of the thesis...

Computer Technology:
A New Architectural Frontier

Andy Albin

March 28, 1992
The Environment

This document is a specification for a three-dimensional multi-user computer-simulated environment. It describes some of the most important issues required for the creation of any such environment:

What are the building blocks?
How will objects be created?
What will I look like?
How will space be organized?
What will I see?
How will I move around?
How will I communicate?
What is the point of all this?

The text and diagrams included in this document are as simple as possible so that even those with little or no computing experience can assimilate.

Conventions

For the sake of simplicity, certain graphic conventions are used frequently in this document:

A person. As explained in the section titled "Persona", people in the environment need not look like this. This image is merely intended to indicate top, bottom, and orientation of an individual.

Arrows like this one, and other shaded areas indicate the direction of viewing.

A person from the top. This image is intended to indicate bodily orientation (note feet). Although the head appears to follow the view in the illustrations, a persona need not have a head to see.

Dotted rectangles indicate invisible two-dimensional boundaries.
Form and Architecture

The same geometry employed in this environment has been recognized and appreciated for thousands of years. From the time of Plato to the high modern era, these volumes and their derivatives have formed the fundamental building blocks of architecture.

The five Platonic solids:

- Tetrahedron
- Cube
- Dodecahedron
- Icosahedron
- Octahedron

Le Corbusier's *Towards A New Architecture* illustrates similar basic volumes and states his theory on the nature of form:

A clear aim, the classification of parts, these are a proof of a special turn of mind: strategy, legislation. Architecture is susceptible to these aims, and repays them with interest. The light plays on pure forms, and repays them with interest. Simple masses develop immense surfaces which display themselves with a characteristic variety according as it is a question of cupolas, vaulting, cylinders, rectangular prisms or pyramids. The adornment of surfaces is of the same geometrical order.

Absence of verbosity, good arrangement, a single idea, daring and unity in construction, the use of elementary shapes. A sane morality.

Mies van der Rohe's "Less is More" philosophy is derived from the same appreciation for the power of pure geometric form.
Space

In this environment, space must be considered in two ways: as rooms and connections. Rooms are basically three-dimensional boxes with a width (X), depth (Y), and a height (Z). The origin is at the center of the bottom of the box.

Rooms are not organized in space. They merely have exits that lead to other rooms. Therefore, a room could have no connections, a few connections, or it could be connected to every other room in the environment. Connections are not necessarily two-way.
Geometric Primitives

A geometric primitive is a single predefined solid. Apart from shape and size, a geometric primitive has a color, a line type, and a line width. For the purposes of this environment, there are currently six different kinds of geometric primitives:

- Rectangular volume
- Cylinder
- Pyramid
- Sphere
- Hemisphere
- Complex volume (example)

Symbolic Primitives

Symbolic primitives come in two forms: text and polymarkers. Both are always visible to the viewer from any any unobstructed position within a room.

Text: A B C D E... a b c d e... 1 2 3 4 5... ! @ #$ %...

Polymarker: □ ○ ✗ ● + ★

Abstract Primitives

There are currently two forms of abstract primitives: surfaces and triggers. Both are invisible to the user and are configured as two-dimensional rectangles. A surface is impenetrable to the user. Triggers are penetrable and cause something to happen when penetrated, such as: relocation of the user within the room or to another room, property changes of a user or an object, etc.
Rectangular Volume

A rectangular solid is defined by width, depth, and height dimensions (figure 1). This solid may be manipulated by scaling x, y, and z (figure 2). As a special case, all eight points may be defined individually (figure 3).

Cylinder

A cylinder is defined by two parallel circles, each with center & radius (figure 1). It may be scaled in x & y to form elliptical cylinders, & in z for height (figure 2). Circles may have non-perpendicular centers and differing radii (figure 3).

Pyramid

A four-sided pyramid is defined by width, depth, & height dimensions (figure 1). Special case 1: four co-planar base points & peak defined individually (figure 2). Special case 2: four individual points for three-sided pyramids (figure 3).
**Sphere**

A sphere is defined by a center, a radius, and the number of sides (figure 1). If not specified, the number of sides is determined by the client's default. The solid may be manipulated by scaling x, y, and z (figures 2 & 3).

![Figure 1](image1)
![Figure 2](image2)
![Figure 3](image3)

**Hemisphere**

A dome is defined by a center, a radius, and the number of sides (figure 1). If not specified, the number of sides is determined by the client's default. The solid may be manipulated by scaling x, y, and z (figures 2 & 3).

![Figure 1](image1)
![Figure 2](image2)
![Figure 3](image3)

**Complex Volume**

A polygonal solid is used to create forms not accommodated by other primitives. It is defined by a list of vertices and a list of relationships between them. Figures 1, 2, & 3 are a few examples of some possibilities.

![Figure 1](image1)
![Figure 2](image2)
![Figure 3](image3)
Graphic Objects

A graphic object is an assemblage of primitives. When each primitive is defined, it may be positioned relative to the other primitives. Once properly organized, the arrangement is grouped to define a complete graphic object. The new object is then given a "control point" which determines its location.

Graphic objects can be composed of any kind of primitive. Surfaces, triggers, text, and polymarkers can be combined with geometric primitives.
Object Construction

One of the most interesting features of any environment is the ability of the user to create objects to customize his environment. To do this, there must be some method of object construction. For the purposes of this environment, graphic objects will be created in "The Architecture Room."

In the architecture room, a user (or users) will be able to request primitives, which will appear centered on the floor (the X-Y grid). The user will manipulate each primitive's scale, color, line width and style, rotation, and location. The user will continue this process until he has assembled the primitives to his liking. Then he will tell the architecture room that he is finished, turning it into a graphic object. The room will then ask where the control point of the object should be.
**Persona**

Because the environment is multi-user and intended for interaction, there is a need to represent the individual visually. A persona is composed of primitives just like any other graphic object in the environment. Although the concept of up and down exists in this environment, there is no need for a persona to have a head or feet. There is no need, in fact, for a persona to look anything even remotely like a person in reality.

Like other graphic objects, a control point that determines where a persona is in space. This point also determines when a persona attempts to pass through an abstract primitive. The nature of verticality necessitates that this point be located at the bottom of a persona so that it may stand on a horizontal surface without passing through it.
Manipulation

An important issue in the environment is how users interact with objects. Users will be able to pick up and carry certain graphic objects. Some objects, however, should only be manipulable by specific individuals. For instance, any random player should not have the ability to walk off with the architecture. Similarly, since users are represented as graphic objects, many of them will prefer not to be picked up and carried off by anyone who chooses to. To resolve this issue, the creator of the object will determine whether others will have permission to pick it up.

When a user attempts successfully to pick up an object, the object disappears and enters the user’s inventory. One user will be able to determine what another user is carrying by typing "look username", which will list the objects in username’s possession. A user may not pick up an object if it is not within range. Also, a user will not be able to pick up any object which he cannot see.

All users and objects have control points. When a user drops an object, it appears with its control point at the user’s control point.
Navigation

Another important distinction to make is that the body need not face in the direction that it is moving. This feature allows the user to back up or travel sideways without having to rotate to face the direction of the move. The user will be permitted to choose which method of movement is preferred.

For the purposes of this environment, vertical navigation can be thought of in two ways. One is with simulated gravity, and the other is without. Without gravity, the user may select a new altitude at which point to remain. With gravity on, the user will fall from the specified altitude until encountering a supportive horizontal surface. Changes in altitude will not effect viewing angles or bodily orientation. Horizontal navigation is possible while ascending or descending.

Note: When viewing and movement are independent of bodily orientation, there is no reason to think of the body in terms of front, back, and sides. These conventions may be maintained, however, for the benefit of other users.
View

An important distinction to make concerning viewing is the difference between the direction that the body is facing, and the direction of the view. Although having a body does not necessitate having a head, or that the head reflect the direction of the view, the ability to change view without changing bodily orientation affords greater individual flexibility.

For the purposes of this environment, the user will have a full 360 degree range of horizontal viewing ability and 180 degrees of vertical viewing ability.

What the user sees is dependent upon the three variables diagramed above. Changing any one of these will effect one of the other two, yielding different results. For instance, increasing the field of view (measured in degrees) without changing the distance will widen the picture plane, thus providing more peripheral vision.
Navigation and View Interface (initial)

For the purposes of this environment, movement and rotation will occur in increments which the user may determine. The initial navigation/view interface will involve the number keys across the top of the keyboard. Hitting any of these keys, followed by enter, will activate the key’s function.

There are three mode buttons for navigation/viewing: move, rotate body, and rotate view. Each button acts like a switch and turns the function on or off. The buttons may be employed in conjunction with each other to perform different functions. Therefore, seven combinations are possible. With a particular combination selected, direction buttons 1-6 behave as follows:

7 8 9

Move: move on, rotate body and rotate view off. Buttons 1-6 move the body one increment in the corresponding direction (with respect to body) leaving view direction unchanged.
**Navigation and View Interface** (initial) continued

---

**Rotate Body** - rotate body on, move and rotate view off. Buttons 3-4 rotate the body one increment in the corresponding direction, while view direction (with respect to room) remains unchanged. Button 1 rotates the body orientation to match the view direction. Button 2 rotates the body 180 degrees from the view direction.

---

**Rotate View** - rotate view on, move and rotate body off. Buttons 3-4 rotate the view one increment of rotation in the corresponding direction, while body orientation (with respect to room) remains unchanged. Button 1 rotates the view direction to match the body orientation. Button 2 rotates the view 180 degrees from the body orientation. Buttons 5-6 adjust the view up or down one increment of rotation.
**Navigation and View Interface (initial) continued**

**Move & Rotate Body**- move and rotate body on, rotate view off. Buttons 3-4 rotate the body 90 degrees and then move one increment in the corresponding direction. Button 1 moves the body forward with no rotation. Button 2 rotates the body 180 degrees and then moves one increment. View direction (with respect to room) remains unchanged.

**Move & Rotate View**- move and rotate view on, rotate body off. Buttons 1-6 rotate the view to match the corresponding direction of movement. Body orientation (with respect to room) remains unchanged.
**Navigation and View Interface** (initial) continued

8 9

**Rotate Body & Rotate View**
- Rotate body and rotate view on, move off. Buttons 3-4 rotate the body orientation and view direction one increment in the corresponding direction.
- Button 1 snaps the body and view to face +Y direction.
- Button 2 rotates body and view 180 degrees. Buttons 5-6 adjust view up or down.

7 8 9

**Move, Rotate Body, & Rotate View**
- Move, rotate body, and rotate view on. Buttons 1-6 rotate body orientation and view direction to match corresponding direction of movement.
**Navigation and View Interface** (planned)

All features of user control must be accessible through some kind of interface. The interface may involve the use of a mouse, buttons on a keyboard, controls on the screen, or some combination. For the purpose of illustration, the following examples of control will be presented as if displayed on screen.

![Diagram showing interface elements](image)

The bar graph on the left indicates vertical position in space relative to the extremes of the space. Altitude may be changed by clicking above or below the top of the bar. The graph on the right indicates direction of vertical view and may be changed by sliding the bar up or down. Bodily orientation is always up and the shaded area indicates field of horizontal view relative to orientation. The cursor may be moved around the body with the mouse which will change orientation, view, or bodily location when clicked.

- Move
- Rotate Body
- Rotate View

The diagram above indicates how the user selects movement and/or rotation. With the move button selected, the user will travel in the direction of the mouse click. The rotate body button allows the user to turn the orientation of his body. The rotate view button allows the user to adjust the direction of his view. Combinations of buttons allow the user to perform multiple functions simultaneously.
Communication and Expression

Verbal communication between users occurs by typing messages in a text window. Hitting the return key at the end of a message sends it to all of the users within the space, unless directed at a specific user.

say Hey Sue, what time is it there in New York?
Sue says, "It's 1:30 here, what time zone are you in?"
say I live Kansas with my dog Toto...
Sue says, "So it's only 11:30 there?"
emote nods

User #1 (Bob)

Bob says, "Hey Sue, what time is it there in New York?"
say It's 1:30 here, what time zone are you in?
Bob says, "I live in Kansas with my dog Toto..."
say So it's only 11:30 there?
Bob nods

User #2 (Sue)

As indicated above, users may express action verbally. In addition, users may employ a variety of more physical options to express themselves. Temporary changes in personal appearance may involve changes in color, line width, or line style. The user may also choose to hop, spin, fluctuate scale, etc. to suggest emotional response.
Implications

For decades now people have interacted using different forms of communications technology. Fast computers and extensive networks have provided yet another forum for interaction. Existing multi-user environments rely heavily upon text for descriptions of the environment. This project attempts go well beyond the verbal environment by creating a visual atmosphere of architecture within which users may interact.

As has been witnessed in the creation of other multi-user environments, the creator cannot pretend to anticipate exactly how the users will take advantage of the environment. At best, the creator can attempt to provide enough flexibility so that the users can do as they please. Popular places of congregation and methods of expression will ultimately be decided by those who inhabit the environment. Success is most easily measured by population and activity, which indicate user interest.

Projects like this one are not final when established. A good environment changes and improves with time, reflecting technological advances, new ideas, and desires of the users. Similarly, a successful environment will grow larger architecturally to accommodate more users and to maintain diversity.

From an architectural standpoint, the environment represents an opportunity to experiment with new ideas and actually test them visually with respect to an audience. Subsequently, designs can be tested and modified easily in the context of an inhabited environment before they are committed to reality. As the popularity of environments like these increases, there may come a day when architects design architecture specifically intended to exist only within the environment.
Virtual Environment

Findings

Presented as part of the thesis...

Computer Technology: A New Architectural Frontier

Andy Albin

April 15, 1992
Findings

This document details many of the conclusions derived from the creation of a three-dimensional multi-user computer-simulated environment. It illustrates issues which required careful consideration to build the environment and to build within the environment:

How do the computers communicate?
What do the computers communicate?
How is geometry defined?
What makes the environment efficient?
How are objects manipulated?
How is geometry perceived?
What can the environment be used for?
How much geometry can the environment accommodate?

The text and diagrams included in this document are as simple as possible so that even those with little or no computing experience can assimilate.

Definitions

The environment: a three-dimensional computer-generated representation that can be inhabited by multiple individuals over a network

Primitives: pre-defined spatial volumes like cylinders, pyramids, cubes, and spheres

S-PHIGS: a compact and freely distributable computer program for rendering three-dimensional geometry

Wireframe: a mode of rendering that defines shapes by displaying the lines that connect vertices

Hidden line removal: a process that determines which defining lines of a wireframe object should be visible

Server: a computer that stores data and provides processing power to a terminal

Terminal: a computer that is networked to and dependent upon a server for much of its processing power (also known as a client)

Contents

Communication
Data Formats
Design
Repetition
Efficiency
Manipulation
Applications
Communication

A multi-user environment connects users over a network which links their terminals to a server. The server is the computer that keeps track of all the activity within the environment. When a user does something in the environment, his terminal notifies the server which passes the message to other users.

Individual terminals are known as "clients." Each client runs a program designed to communicate with the server's program. The user interacts with the client program and the client program interacts with the server program.

Because the server program knows what users may and may not do in the environment, the client program must ask the server for permission each time the user tries to do something. If the server decides that the client's request is acceptable, it informs the client that it has accepted the request. The server then notifies any other clients that are effected by the accepted request.
Data Formats

Numerous CAD programs were evaluated to determine how each stored its geometric data. Invariably, three-dimensional objects were stored as a collections of polygons. The following examples illustrate how this works:

CAD programs display two-dimensional shapes, such as this circle, as a series of line segments (12 in this case). The apparent smoothness of the shape varies based upon the number of segments.

In most CAD programs, three-dimensional shapes are simply extrusions of two dimensional shapes. Thus, an extruded circle becomes a cylinder. The data, however, is still stored as a collection of polygons. In this case, the shape is represented as 2 twelve-sided polygons and 12 four-sided polygons with 24 vertices.

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th></th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>vertex 1</td>
<td>2.1764</td>
<td>2.2591</td>
<td>-6.3372</td>
<td>vertex 13</td>
<td>5.9616</td>
<td>2.4394</td>
<td>2.9170</td>
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<tr>
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<td>4.1508</td>
<td>-5.7001</td>
<td>vertex 14</td>
<td>4.3140</td>
<td>4.3310</td>
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</tr>
<tr>
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<td>-3.8112</td>
<td>vertex 16</td>
<td>-0.3122</td>
<td>4.5030</td>
<td>5.4430</td>
</tr>
<tr>
<td>vertex 5</td>
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<td>2.5569</td>
<td>-3.0655</td>
<td>vertex 17</td>
<td>-2.0513</td>
<td>2.7371</td>
<td>6.1887</td>
</tr>
<tr>
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<td>-6.5189</td>
<td>0.0818</td>
<td>-2.7382</td>
<td>vertex 18</td>
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</tr>
<tr>
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<td>vertex 19</td>
<td>-2.1764</td>
<td>-2.2591</td>
<td>6.3372</td>
</tr>
<tr>
<td>vertex 8</td>
<td>1.3975</td>
<td>-4.3310</td>
<td>-3.5540</td>
<td>vertex 20</td>
<td>-0.5288</td>
<td>-4.1508</td>
<td>5.7001</td>
</tr>
<tr>
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<td>4.7756</td>
</tr>
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<td>-4.5030</td>
<td>-5.4430</td>
<td>vertex 22</td>
<td>4.0975</td>
<td>-4.3227</td>
<td>3.8112</td>
</tr>
<tr>
<td>vertex 11</td>
<td>-2.8695</td>
<td>-2.7371</td>
<td>-6.1887</td>
<td>vertex 23</td>
<td>5.8366</td>
<td>-2.5569</td>
<td>3.0655</td>
</tr>
<tr>
<td>vertex 12</td>
<td>-3.1838</td>
<td>-0.2621</td>
<td>-6.5160</td>
<td>vertex 24</td>
<td>6.5189</td>
<td>-0.0818</td>
<td>2.7382</td>
</tr>
</tbody>
</table>

Because of the sheer amount of data, this format is inappropriate for a networked environment involving three-dimensional geometry. In order to achieve maximum data efficiency, we developed a much more concise format for our networked environment. Simple three-dimensional shapes can easily be defined by fundamental parameters. This feature dramatically reduces the amount of data required to define geometry and permits the user to determine desired complexity.

The same cylinder described previously can be defined simply by its geometry type, transformation coordinates, rotation parameters, scale parameters, two centers, and two radii. The entire format looks like this:

<table>
<thead>
<tr>
<th>CYLINDER</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0. 0. 0.</td>
<td>X, Y, &amp; Z transformations</td>
</tr>
<tr>
<td>10. 20. 30.</td>
<td>X, Y, &amp; Z axis rotations</td>
</tr>
<tr>
<td>1. 1. 1.</td>
<td>X, Y, &amp; Z scaling</td>
</tr>
<tr>
<td>0. 0. -5.</td>
<td>Center 1 coordinates</td>
</tr>
<tr>
<td>5.</td>
<td>Center 1 radius</td>
</tr>
<tr>
<td>0. 0. 5.</td>
<td>Center 2 coordinates</td>
</tr>
<tr>
<td>5.</td>
<td>Center 2 radius</td>
</tr>
</tbody>
</table>
Designing for the Environment

Creating architecture for the environment requires a unique way of thinking about geometry. Objects may be located spatially in a variety of ways. Primitives may be positioned and sized by specifying exact coordinates or by specifying how far to move and scale them. In addition, some primitives require rotational parameters to orient them precisely.

This four-sided pyramid may be constructed and positioned either by specifying the exact locations of its vertices or by building it about the origin and relocating it.

Like most CAD rendering programs, the environment requires that the points of a polygon be coplanar. Although this is not a problem for triangular polygons, most of the primitives are comprised of four-sided polygons. If all four points do not exist within the same plane, the program will not be able to display them on the screen. Polygons with non-coplanar points are referred to as "warped."
Designing for the Environment continued

Some primitives, like cylinders, spheres, and hemispheres, cannot be manipulated fully without being scaled and rotated. To configure them correctly, they must be moved, scaled, and rotated in a particular order. Failure to consider the order will usually result in erroneous manipulation.

![Diagram of object manipulation]

Rotate 75 degrees  Scale X .6  Move X 3 Y 3

In the environment, scaling and rotation occur about the origin. These functions should be performed before the object is moved to avoid unexpected results. The example above illustrates the order in which manipulation should be executed. The example below shows what happens when the same manipulations are performed out of order.

![Diagram of object manipulation]

Move X 3 Y 3  Scale X .6  Rotate 75 degrees

These two examples illustrate how the same steps performed in different orders yield dramatically different results. Although the final configuration of the second example could be considered a useful orientation, it is preferably attained by performing different manipulations in the proper order. Configuring geometry consistently will significantly reduce confusion in the composition of multiple objects and will permit others to understand the arrangement more easily.
Designing for the Environment continued

In order that an adequate number of individuals might be able to access the environment, the client program was designed to run on fairly common networked computers, known as X-terminals. Because they are dependent upon more powerful computers for much of their processing, X-terminals are somewhat limited in their ability to display complex graphics. Subsequently, a relatively simple and freely distributable rendering program, known as S-PHIGS, was chosen to help generate images.

S-PHIGS displays objects on the screen in "wireframe," which draws the lines that define shape. In addition, S-PHIGS renders only those lines which can be seen from the front of an object; a feature known as hidden line removal. Although S-PHIGS does not visually occlude any object that is behind another object, it does generate images in perspective, providing a sense of depth.

Because S-PHIGS displays its objects in wireframe, the designer must be aware of how this will impact the perception of the design. Objects with numerous facets, such as cylinders, spheres, and hemispheres, are fairly well defined visually because of the abundance of linear description. Objects with fewer facets, such as rectangular volumes and pyramids, suffer visually from simpler linear definition. Subsequently, large objects of the latter type tend to lose their clarity in the context of the former. In addition, sparsely faceted objects also lose definition up close where they cannot be view in their entirety. Fortunately, color, line type, and line width help overcome this phenomenon.
Repetition

Architecture inherently involves repetitive geometry. Efficiency of data transmission could be improved taking advantage this redundancy. The geometry of a repeated element need only be defined once. Subsequently, an individual occurrence requires only the data the makes distinct from the others.

Although this graphic composition contains twelve objects, they are essentially permutations of only three different primitives. The columns are identical except for their positions. Similarly, the steps only differ in scale and location.

Another issue of some concern has been how to create three-dimensional shapes that are not accommodated by the pre-defined primitives. Definition every point of a complex volume can create an inordinate amount of data. One answer to this problem is related to the way that a cylinder is defined.

Although the vertices of polygon 1 must be defined individually, polygon 2 is simply a copy that has been scaled and located. Like the cylinder, both ends are parallel and proportionally similar to ensure that rectangular side polygons remain coplanar. This approach also cuts geometric data almost in half by not requiring that the vertices of polygon 2 be defined individually.
**Efficiency**

One of the most important considerations in the development of the environment is efficiency. Because all data is sent over a network, it must be as concise as possible to reduce delays in transmission.

As mentioned previously, the data format developed for the environment reduces the amount of data dramatically. Similarly, elimination of geometric redundancy contributes significantly data reduction.

Another issue central to efficiency is the manner in which information is transmitted over the network. Data is sent in bursts which are referred to as packets. Each packet issued over the network is the same size, regardless of how much actual data is in the packet. To achieve maximum efficiency, each packet should contain as much information as possible. Data describing large three-dimensional constructs may have to be sent in more than one packet.

Additionally, frequent data transmission can be reduced if the client can remember information that it has been sent before. When a client encounters an object that it has never seen before or one that has changed, it simply asks the server for more information.

**Client**

May I move to room #63?

I notice that objects #188 and #391 have not changed since the last time I saw them. I also see that object #217 has changed since I last saw it and that I have never seen object #442 before.

May I have more information about objects #217 and #442?

**Server**

Yes you may. Here is information about room #63. It includes objects #188, #217, #391, and #442 and the last times their appearances changed.

Yes you may. Here is more information about objects #217 and #442.

All efforts to minimize data size and transmission frequency permit faster environmental navigation and interaction. The quantity and quality of the environmental data will always be a factor of processing power and network speed. As these factors continue to improve, so will the effectiveness of the environment.
Manipulation

Although the client knows about every object that is in the room, it only displays those which the user can see based on viewing parameters. The user may attempt to pick up any object that he can see. To allow the user to do this, the client must determine which of the room's objects are within the user's field of view. It is also possible to limit obtainable objects to those that are within a certain proximity to the user.

There may be many objects within the user's field of view that he may attempt to pick up. The question arises about how to the user specifies which object he wants. The user may ask the room to name all the objects that he sees. If there are several objects with the same name, however, the problem of exactly which one to specify persists.

One possible solution is to select the redundantly named object which is closest to the user. Another solution is to number redundantly named objects in order of proximity so the user may request the particular object that he desires.

Another issue that arises is whether or not to display the objects that a user is carrying. If so, then where, with respect to the user's bodily geometry, will the carried objects be located? If not, how will other users know what is being carried? Although users may request information about what another user is carrying, they may only get a list object names.
Applications

In the course of creating this environment, numerous practical applications have become more apparent. The following examples illustrate how this project could be used to design, display, and evaluate architectural ideas. The environment could also be employed as a forum for cataloging and exhibiting previous projects and existing structures. In addition, an environment like this one could be used to supply architects with contexts for their current projects.

Architectural Access

Because it is networked and permits multi-user interaction, the environment can be used by architects, their clients, and contractors to examine a design three-dimensionally from separate locations. An architect in Houston and a client in New York could simultaneously tour and discuss a design from their respective offices. Similarly, the same architect could review details with a consulting architect or contractor in Los Angeles without having to leave town.

An added benefit of this possibility is that individuals may access new three-dimensional changes as quickly as they are implemented. Specifications about materials or products may also be tied directly to the data so that all existing information is at the fingertips of the user.
Applications continued

Architectural Design

In addition to view and touring, the environment may also be used as a design tool by architects within the same office or from different cities. Several individuals could inhabit the same architectural space and manipulate the geometry together.

The multi-user environment could also allow architects to get useful feedback about their designs from any who are permitted to experience them on the computer. Workers who will inhabit the finished building could test their spaces before they are committed to reality. They could study proximity to other employees, organization of the furniture, or the views form their offices.

The environment could also be used by engineers, industrial designers, and others who deal with the creation of three-dimensional products. Mechanical engineers could examine the designs of machines, interior designers could devise spatial organizations, and product designers could create appliances. Even electrical engineers could use the environment to design and evaluate micro-chips, which are becoming more three dimensional with every new development.

Architectural Archive

The environment could also be used as a means of storing and reviewing previous architecture projects which were modeled on the computer. In addition, great works of architecture could be implemented on the computer to be retrieved and explored by students, professors, and professionals. In much the same way that some architecture schools maintain slide libraries of important buildings, an institution could preserve a catalog of computer models. Subsequently, individuals could access them for reference on their projects or explore them in groups to get a better idea of what the buildings are like.
Applications continued

Architectural Context

Among other things, architects are responsible for considering the contexts of their designs. Whether creating renderings, construction documents, physical models, or computer models, architects are frequently required to include contextual representations. An environment like this one would be an excellent way to distribute models of existing buildings for use in current architecture projects.

Lawyers already have a similar system for accessing information that is important to all of them. Stock brokers can also pay for access to immediate trading information. Architects could benefit from similar access to common and current information.

An architect could access the service over the network, locate a site, and request any amount of contextual data. He could then use the information to help site his design, make connections to existing structures, and illustrate his ideas. If the project were ultimately approved to be built, he could then send the data about his new design back to the service for credit. Even if his design was not to be built, the data could still be useful to other individuals who access the service.

Architects could also opt to specify the amount of information needed depending on the status of the project. Speculative design might require no more than simple massing models of the context. Approved work could justify accessing all possible information about adjacent sites. The service would be responsible for maintaining the accuracy of the information it provides, updating the data when necessary.
SELECTED BIBLIOGRAPHY


SOULE, George. The Shape of Tomorrow, New York: Signet Key, 1958.


