

# **Distributed Virtual Reality: Applications for Education, Entertainment, and Industry**

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*Case was twenty-four. At twenty-two, he'd been a cowboy, a rustler, one of the best in the Sprawl. He'd been trained by the best ... He'd operated on an almost permanent adrenaline high, a byproduct of youth and proficiency, jacked into a custom cyberspace deck that projected his disembodied consciousness into the consensual hallucination that was the matrix.*

William Gibson, *Neuromancer*, 1984 (1)

*Cyberspace is a globally networked, computer sustained, computer generated, multi-dimensional, artificial, or virtual reality. In this world, onto which every computer screen is a window, actual, geographical distance is irrelevant. Objects seen or heard are neither physical, nor, necessarily, representations of physical objects, but are rather-- in form, character, and action-- made up of data, of pure information. This information is derived in part from the operations of the natural, physical world, but is derived primarily from the immense traffic of symbolic information, images, sounds, and people, that constitute human enterprise in science, art, business, and culture.*

Michael Benedikt, *Collected Cyberspace Abstracts*, 1990 (2)

*We foresee that computing environments in the next decade will be very widely distributed, ubiquitous, open-ended, and ever changing. All the computers in the world will be mutually connected. New services will be added from time to time, while old services will be replaced. New computers will be connected, and the network topology and capacity will be changing almost continually. Users will demand the same interface to the environment regardless of login sites. Users will move with computers and will move even while using them. Users will also demand much better user interfaces, so that they will be able to communicate with computers as if they are communicating with humans.*

Mario Tokoro, *Toward Computing Systems for the 2000's*, 1991(3)

## **Abstract**

This text addresses virtual reality and how can it be networked to support multiple-user immersion environments, joined over long distance. The sites are networked using low band modem-to-modem over telephone lines, the Internet, and high bandwidth telecommunications. The major contribution is a discussion of the networked virtual reality projects produced at the STUDIO for Creative Inquiry, Carnegie Mellon University. The project team has designed and constructed the *Networked Virtual Art Museum*, an art museum, which joins telecommunications and virtual reality. And, other distributed virtual reality applications, including a virtual city, a *Virtual Design and Teleconferencing Station*, the *Virtual Show Room*, and a *Virtual Test Track*, among other projects. The conclusion forecasts a not so distant future where education, entertainment and industry will employ networked immersion environments.

## **Introduction**

The promise of virtual reality has captured our imagination; networks will render it accessible. There can be little doubt that networked immersion environments, cyberspace, artificial or virtual reality, or whatever you want to call it will evolve into one of the greatest ventures to ever come forward. Virtual reality will draw from and affect the entire spectrum of culture, science, and commerce, including education, entertainment, and industry. It will be multi-national, and will introduce new hybrids of experience for which descriptors presently do not exist.

Earlier in this text, Gibson, Benedikt, and Tokoro are cited. At first reading they might appear to be divergent tracks, but welding them together contributes significantly toward the framing of a "matrix," a "computer-sustained, computer-generated, multi-dimensional, artificial, or virtual reality," that is "widely distributed, ubiquitous, open-ended, and ever changing." They also suggest three essential areas of recent cultural and technical development:

- 1) The formation of a cyber culture, which includes individuals who prefer to inhabit the domain of distributed digital media – electronic bulletin boards, databases, and multi-user simulation environments, including virtual reality. These inhabitants more or less live in such domains; the majority of their time is occupied within them. There they can alter their identities, their manner of social interaction, and their relationship with society. They become virtual beings in a virtual place. By living in such domains, a society becomes established, and a morality may emerge. What kind of morality will this be? Will it be governed? By whom and for what? This line of questioning becomes even more involving when one considers distributed virtual reality as a three dimensional environment, that may contain private spaces or residences, which contain personal objects and possessions.

- 2) The emulation of the physical world, and private spaces may have doors, closets, and windows that look out onto multi-dimensional vistas. Toolkits allow for the transformation of the world, and extensions of it are comprised of a never ending field of pure data. The field of data can include all walks of commerce and produce worlds which do not fit our present descriptors. Some

experiences will be familiar, like going shopping, or going to a concert. Other things will be unusual, like going to an ancient place or another planet.

3) The pervasiveness of the data field is everywhere, and people move about with computer devices. Interfaces become intuitive. Guides or agents co-inhabit the domains. Agents acquire knowledge, become familiar, and grow old with us.

While this could read as science fiction, extensive research is already being conducted in networked or distributed virtual reality. It currently constitutes a very small industry, but one with great potential for growth. Our research in virtual reality at the STUDIO for Creative Inquiry at Carnegie Mellon University (CMU) investigates this field, and relevant applications within it.

### **The *Networked Virtual Art Museum***

Perhaps it is useful to report on one project at the STUDIO in greater detail. The project is the *Networked Virtual Art Museum*, which joins telecommunications and virtual reality through the design and development of multiple-user immersion environments, networked over long distance. The essential areas investigated through the project include world-building software, visual art and architecture, telecommunications, computer programming, human interface design, and artificial intelligence, communication protocol, and cost analysis.

### **Visual Art and Architecture**

The fusion of disciplines is the basis for collaborative authorship of virtual worlds. The construction of the virtual museum involves the participation of visual artists, architects, computer aided design teams, computer programmers, musicians and recording specialists as well as other disciplines.

### **World Building**

The project serves as a testing site for world building software and associated hardware. (4) The programming teams have added considerably to the functions of the software tested. Public releases are in planning.

### **Telecommunications**

Critical to the project is the development and implementation of networking approaches, including modem-to-modem, server, and high bandwidth connectivity. Telecommunications specialists collaborate with the design team to resolve problems of connectivity in immersion environments. Project achievements in this area are discussed in greater detail below.

### **Artificial Intelligence**

The application of artificial intelligence, in the form of agents (or guides) and smart objects, is an essential area of development. The inclusion of investigators in the areas of interface design, smart objects, and artificial intelligence is a major component.

## **Groupware and Communication Protocol**

The project documents multi-user interaction and groupware performance, establishes protocols within networked immersion environments, and suggests standards. The contribution of communication specialists addresses aspects of documentation and standardization.

## **Cost Analysis**

Other planned study addresses the practical nature of networked immersion environments, investigates the effectiveness of information access for the end user, and profiles the end user experience. The project involves the participation of cost analysis specialists and formulates a practical cost basis for networked immersion environments.

The project team has designed and constructed a multi-national art museum in immersion based virtual reality. The construction of the museum involves a developing grid of participants located in remote geographical locations. Nodes are networked using modem-to-modem telephone lines, the Internet, and eventually high bandwidth telecommunications.

Each participating node will have the option to interact with the virtual environment and contribute to its shape and content. Participants are invited to create additions or galleries, install works, or commission researchers and artists to originate new works for the museum. Tool rooms will be available, so one can construct additional objects and functions to existing worlds, or build entire new ones. Further, guest curators will have the opportunity to organize special exhibitions, explore advanced concepts, and investigate critical theory pertaining to virtual reality and cultural expression.

## **The Museum**

The design of the museum centers on a main lobby from which one can access adjoining wings or galleries. Several exhibitions are completed, while others are under construction. The first exhibition to be conceived and completed, is *Fun House*, based on the traditional fun house found in amusement parks. The museum also contains the *Archaeopteryx*, conceived by Fred Truck and based on the Ornithopter, a flying machine designed by Leonardo da Vinci. Imagine flying a machine designed by one of the worlds greatest inventors. The team is also collaborating with Lynn Holden, a specialist in Egyptian culture, to complete *Virtual Ancient Egypt*, an educational application based on classic temples mapped to scale. The gallery exhibitions mentioned are being constructed at CMU. However, we are anticipating other additions conceived and constructed by participating nodes in Australia, Canada, Japan, and Scandinavia

Now that the framework of the museum project has been described, perhaps it is useful to discuss the essential points of one application.

## The *Fun House*

*Fun house: a building in an amusement park that contains various devices designed to startle or amuse.*

Websters Dictionary, 1992

For the first installation in the *Networked Virtual Art Museum*, a *Fun House* was designed. While making metaphorical reference to the "fun house" found throughout traditional amusement parks, the application is an investigation of interaction and perception employing networked, immersion based virtual reality. It was this world which was utilized during the first long range demonstration conducted between Carnegie Mellon University and Munich, Germany, in September 1992. A more recent demonstration, featuring a different virtual world, will be conducted between CMU and Tokyo, sponsored by the *International Conference on Artificial Reality and Tele-existence*, July 1993, Japan.

The fun house metaphor is particularly applicable as a container for virtual experience. Upon entering a fun house, one is acutely aware of being cast into a different world. And one's senses are amused and assaulted by a number of devices – trick mirrors, fantasy characters, manipulation of gravity, spatial disorientation, mazes and sound, for example. In the virtual *Fun House*, various traditional devices are adapted and some new ones are offered.

Key attributes to be found in the *Fun House* include:

- Objectification of "self" within an immersion environment. Users can select their image from a library including Frankenstein, Dracula, and a doctor, among others, the Cookie Man has proven to be a favorite. When entering the *Fun House*, users can see their image reflected in real time in a mirror. They can also see the images of other users. Users can extend their hands and wave at each other – a basic and highly communicative form of human expression.
- Interaction with a client (or agent) which has an "artificial intelligence." When entering the *Fun House* a client greets you and speaks. It has a polite behavior and is programmed to face you, follow at a certain distance, and to stay out of your way. After a while, it stops following and says goodbye. Smart objects are also incorporated; touching them calls events within the program.

- Interaction with multiple users in real time. Networked telecommunications allow for the simultaneous support of multiple users within the *Fun House*. For the demonstration between CMU and Munich, the users selected the Dracula and Cookie Man personas from the library. Each user could see the other, had an independent point of view, and could move objects.
- Links to moving objects. The *Fun House* features a Merry-go-round; users can grab hold and catch a ride while music plays.
- Objects attach themselves to users. The *Fun House* features a Flying Saucer ride, where users are transported up into the space craft, and they can pilot its flight. The event calls the "beaming up" of the user and a whirring sound associated with flying saucers.
- Attributes of physical laws. The *Fun House* features a Ball Game, where users pick up a ball and throw it at targets. The ball falls, bounces, and loses velocity. Thus gravity, velocity, and friction are articulated. The motion of the ball is sound intensive.

### **New directions**

Following the *Fun House*, a number of applications for Ford Motor Company, were designed, and discussed in detail below. However while working on the applications, the project team became increasingly interested in approaching the immersion environment as a site where things can be constructed or created. For Ford, virtual reality was to be utilized as a virtual design studio, but what are other approaches?

Currently under design are three applications for a public institution or educational setting; they are also network capable: the *Music Room*, *Construction Room*, and *Painting Room*. These are friendly and intuitive environments which require little learning curve to utilize. Instructions are bilingual, in Spanish and English, and the environment is co-habited by small agents or "beasons" that are programmed with a low level artificial intelligence. There are guides to the various interactive objects, and demonstrate how the environment functions by literal illustration. In the *Music Room* they run around and make contact with the instruments, and thus play music. Users can see which instruments produce what sounds and how to perform them. intuitive controls are available for navigating around in the room.

The *Music Room* contains three basic instruments. The largest is a large six note keyboard attached to a wall. This instrument plays a pentatonic scale in three voices – orchestra, choir, and percussion. It is performed by touching the keys, or by simply waving ones hand within close proximity. The other instruments are a drum and shakers.

The *Construction Room* is designed for young children. It contains building blocks which can be assembled to construct objects, sort of a virtual Lego set. In this case, there is a nearly infinite supply of blocks, and one can enter into some of the objects created, such as a house. The "beasons" co-inhabit this site as well, bounce merrily on the blocks, and illustrate how to stack them.

The *Painting Studio* is quite literal – a site for making paintings or graffiti. The user can select from a number of "brush" effects, and choose colors.

As of this writing, negotiations are underway to present these three applications are in design stages, and intended for a public science museum setting, networked with other facilities. They are also designed for use by school districts and other institutions.

### **The Virtual City**

Another application currently under design is a virtual city. Inspired in part by the *Music Room* type applications, the city is an actual city, inhabited by a multitude of participants, and each with their own purposes. Imagine a virtual city complete with private spaces or domiciles, parks, stores, entertainment centers. As much as a grand social experiment, it also is a far reaching graphical user interface (GUI) for electronic home shopping and entertainment. Precedent for such an application as the city is *Habitat*, a commercial online service available from Fujitsu in Japan, which features two dimensional applications, and currently has 10,000 subscribers.

The concept of a city project was previously discussed, among the team. However, the conception of it accelerated, when approached by a film production company to produce a virtual set for a commercially distributed motion picture. The set would of course be a city, and from that point the virtual city began to quickly formulate.

The salient points of the virtual city include:

- a distributed, three dimensional inhabitable environment
- investigation of tele-existence in a distributed virtual construct
- capability of supporting potentially unlimited participants
- private spaces, property and moral code
- exploration of tools to alter the environment, while inhabiting it
- interface (GUI) for home shopping and entertainment

The idea of a distributed application based on the notion of an inhabited city, is fascinating. Traversing the city and encountering other inhabitants will be a startling experience.

### **Teleconferencing and design**

The last area of investigation includes distributed virtual reality as an interface for teleconferencing and design. The range of possible applications is broad, but education and industry are obvious examples.

Education can benefit with regard to long distance learning, and the industry can gain from a higher level of video teleconferencing. This raises the question, what is the advantage of distributed virtual reality over video teleconferencing. And the answer is, the relationship to the subject.

In a teleconferencing session employing distributed virtual reality, multiple participants can share a dynamic relationship with their subject. For example, imagine a team of automobile designers discussing options via video teleconferencing. To look at the subject, they might program a pre-recorded videotape, highlighting the desired aspects.

In contrast, for the Ford Motor Company a distributed *Virtual Showroom* and *Virtual Test Track*. was designed. During this teleconference, the participants can actually traverse around the car. Open doors, hood and trunk. Test drive it. And in detailed applications, examine specific, even minute parts in detail.

While the Ford show room and driving applications were produced from from a consumer standpoint, it has become increasingly apparent that they could bring benefit to teleconferencing sessions. Their key advantage, is the dynamic relationship with the subject. Of course the subject need not be automobiles, and applications can be developed to serve a wide range of interests.

Also produced was a proof of concept demonstration of a *Virtual Design Station*, re-inforcing the actuality to approach virtual reality as a site to build things. Design is used broadly here, inclusive of other multi-media

The following are salient aspects of a design studio which would employ distributed virtual reality:

- The virtual environment supports interaction among networked remote production teams, for the purpose of industrial design and teleconferencing
- The application establishes a relationship between an actual workstation, and a virtual workstation, operators have the capability of switching back and forth, employing a windowing method
- Tele-existence is made evident thru synchronous voice communication, and the capability of each member to "see" the other members in the virtual environment
- Stations consist of display, stylus, key board and mouse; additional input devices include head mounted display, data gloves, and machine vision for voice and gesture recognition
- Design teams utilize proprietary software.

The advantages of, distributed design stations are numerous, but an essential point is economy. The other key point is human experience. Teams located in remote sites and benefit from a collective design experience.



## **Connectivity**

The basis for distributed virtual reality is a function of telecommunications. Two or more sites are joined by an operating system, which can employ a number of telecommunication delivery services:

- direct dial up lines
- Internet computer network
- high band networks
- cable television
- wireless

The project is at the forefront of the investigation of connected immersion environments. Presently a single point to point link, employing low band (9600 baud) modems is supported. The demonstration between CMU and Munich mentioned earlier, proved to be a great success, and the update delay between the two cities was imperceptible. Servers and broadband telecommunications are in planning, as discussed below.

Select functions for point to point include:

- providing all functions of the virtual world creation software in a distributed manner; the world and its attributes are distributed to each node, and one node is specified to be the controller
- providing constant views and updates of each users's object manipulations; users can move objects, including themselves, and updates to position and change occur with imperceptible update cycles
- writing and saving files to record the manipulations to objects; users can change worlds and carry an object with them into another world

## **More connectivity**

As of this writing, the team has begun the programming of a distributed client-server code. Here multiple users can share an immersion environment by interfacing with a node. The following are the points of in investigation.

- the formation of a client-server model, where multiple users can simultaneously share immersion environments
- the servers or nodes are to be located across the world and can be updated automatically via the Internet
- the nodes will offer sites for access and distribution of virtual reality software
- the nodes will support multiple platforms

The next phase of the project will be in support of broadband. And to further facilitate this phase, a consortium has recently been developed with associates located in Japan, Scandinavia, and the United States. Over the following years the members will conduct technology transfers and testbed projects. Actual

applications are scheduled for development. Members of the consortium will collaborate to produce basic elements of connectivity for distributed simulations from client-server systems over the internet to broadband ATM, cross platform graphical user interfaces and executables.

### **Conclusion**

The widely distributed models point toward the "Matrix" which Gibson so often references in *Neuromancer*. Imagine the bulletin board model applied to networked virtual reality. In addition to various worlds, rooms with tools will be available. Here participants can construct other virtual objects, including entire other worlds. Imagine a networked immersion environment, capable of supporting multiple users, with each having the possibility to change the existing virtual world or construct a new one. The promise of constructing virtual worlds while within an immersion environment is open ended. And it can be extended to any number of educational, entertainment and industrial purposes.

Distributed virtual reality has a history and has been given many different forms, shaped by varied intentions. It also has the promise of a future, marking the advancing edge of a new industry.

1-William Gibson, *Neuromancer*, Ace, New York, New York, 1984, pg 5.

2- Michael Benedikt, *Preface*, Collected Abstracts for The First Conference on Cyberspace, University of Texas, Austin, 1990, pg i.

3- Mario Tokoro, *Toward Computing Systems for the 2000's*, Technical Reports, Sony Computer Science Laboratory, Inc., Tokyo, 1990.5-1992.5, pg 17-23.

4- for further information, WorldToolKit, Sense8 Corporation, Sausalito, California. WorldToolKit is computer program for the creation of virtual reality applications.

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