The Quantum Matrix:
A Three Dimensional Data Integration and Collaboration Tool
For Virtual Environments

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ABSTRACT

If a picture is worth a thousand words, what if they could walk and talk? How would you like to bring a whole new dimension to your ideas; to use visualization to convey a sense of time and motion, to use imagery to give your ideas vividness; to use sound to give them voice and view them three dimensionally. The *Matrix* allows you to do all of this and much more. The *Matrix* resembles Rubik's cube, but its purpose is to store, manage and access data of all types and to view them in three dimensions in virtual environments such as the CAVE and on your desktop. The current version can store, access and view almost anything that is in digital form, including:

Text files	Pictures
Video Clips	Sound Files
Spreadsheets	URL's
HTML pages	Databases
CAD drawings	Gantt Charts
Business Graphics	VRML models
Executable Programs	OLE (Object Link & Embedded)

The *Matrix* is a three-dimensional multimedia and document management tool. The *Matrix* anticipates the convergence of electronic media into one consistent environment for analysis and representation. the *Matrix* uses VMRL and OpenGL technologies to allow the user to be immersed in their data as with Cinerama, IMAX and Virtual Reality Environments. The *Matrix* allows the user to exercise their creativity by interactively placing and organizing their data three dimensionally and navigating through and viewing data and documents in 3D (monocular and binocular – stereo). The *Matrix* user interface is simple to use. Employing the now familiar "drag and drop" method to manage data and documents. Items can be placed into the matrix grid at a user selected matrix cube location. Upon dropping a document on a cube it appears as a mapped image onto the surface. Navigating through the 3D Matrix-space is fun. All navigation uses real-time animation giving you instant feed back as to where you are. Data drilling is as simple as mouse click on a Matrix cube. Double clicking the on an object in the matrix activates that object. Data dreams was an image that preexisted the program by several years. The dream was to create a new way of organizing and exploring data. The Qube image was created using Microstation by Bentley Systems, Inc. The figure was modeled using Poser by MetaCreations and composited using Adobe Photoshop.
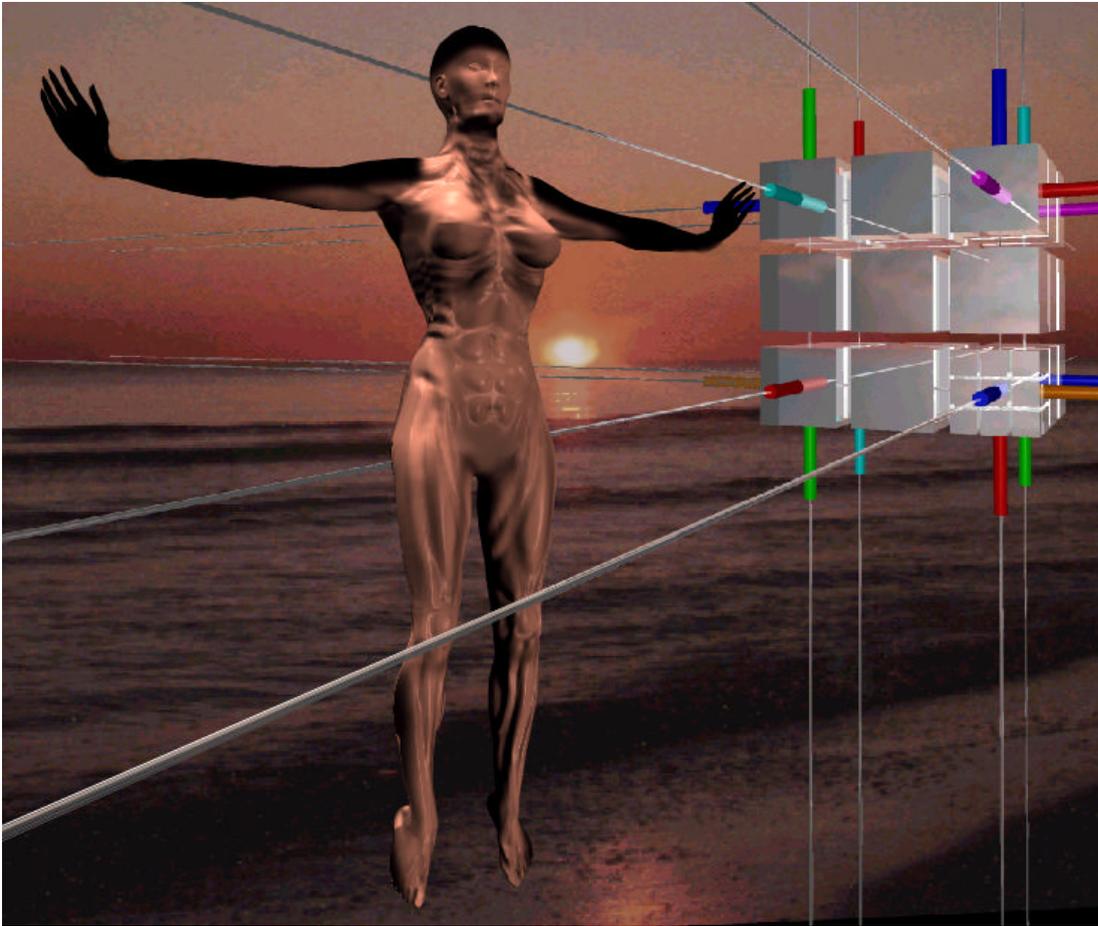
Figure 1: **Data Dreams**

1 THE PHILOSOPHICAL AND THEORETICAL BASIS OF THE QUANTUM MATRIX

As you may be know or suspect, most architects are borderline schizophrenics and so it is with the ideas behind the *Quantum Matrix*. The *Quantum Matrix* is bi-polar. On the one hand we have kindergarten and on the other hand we have quantum mechanics and virtual reality.

One Saturday morning I and two of my dear friends, and fellow faculty were discussing our memory or lack there of, and lamenting the fact the as we have grown older we cannot remember anything, especially meetings, where we have put important papers, and worst of all is the web. Where we have I stored that critical e-mail or where

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did I put those web pages necessary for the paper we are writing, but even more insidious than all, the "why am I here syndrome?" Why in the world did I keep that stupid document page in the first place?

One of these august gentlemen noted that the only time he could recall that he could remember where he put anything was in kindergarten and that he attributed to the nuns who demand that he put the toys back in the milk crate boxes. "Wouldn't it be wonderful if we still had boxes to put our stuff in he mused?" This in turn led to Robert Fulghum's book   All I Really Need to Know I Learned In Kindergarten[2] which is the first part of the **Quantum Matrix** epiphany. Fulghum writes:

> *The inspiration for brevity came to me at a gasoline station. I managed to fill an old car's tank with super-deluxe high-octane go-juice. My old hoopy couldn't handle it and got the willies -- kept sputtering out at intersections and belching going downhill. I understood. My mind and my spirit get like that from time to time. Too much high-content information, and I get the existential willies -- keep sputtering out at intersections where life choices must be made and I either know too much or not enough. The examined life is no picnic.*
>
> *I realize then that I already know most of what's necessary to live a meaningful life -- that it isn't all that complicated. I know it. And have known it for a long, long time. Living it -- well, that's another matter, yes? Here's my Credo:*
>
> *All I really need to know about how to live and what to do and how to be, I learned in kindergarten. Wisdom was not at the top of the graduate-school mountain, but there in the sand pile at Sunday school. These are the things I learned:*
>
> *Share everything.*
>
> *Play fair.*
>
> *Don't hit people.*
>
> *Put things back where you found them.*
>
> *Clean up your own mess.*
>
> *Don't take things that aren't yours.*
>
> *Say you're sorry when you hurt somebody.*

Wash your hands before you eat.

Flush.

Warm cookies and cold milk are good for you.

Live a balanced life -- learn some and think some and draw and paint and sing and dance and play and work every day some.

Take a nap every afternoon.

When you go out into the world, watch out for traffic, hold hands and stick together.

Be aware of wonder. Remember the little seed in the Styrofoam cup: the roots go down and the plant goes up and nobody really knows how or why, but we are all like that.

Goldfish and hamsters and white mice and even the little seed in the Styrofoam cup -- they all die. So do we.

And then remember the Dick-and-Jane books and the first word you learned -- the biggest word of all -- LOOK.

These simple principles are the wisdom of the ages especially, sharing, putting things away and for architects the word "LOOK." Maybe as important as all of these together are re-learning what children institutively know, namely, how to play. Because play can make things even as dry as databases interesting.

1.2   Worlds in worlds

The **Quantum Matrix** is an n-dimensional data space. That is qubes can be placed inside of another qube. Data is stored in a qube and is organized visually by the user, placing associated or related objects adjacent to one another and categorizing information hierarchically by placing sets of similar data inside of a qube. The organization that the user decides on is up to the user. There is no requirement for a schema or data map. The **Quantum Matrix** automatically will extract a visual data tree showing paths to data and the hierarchy or relationships that the user has created. This structure allows natural hierarchies to be modeled and real world parallels to be represented and efficient searching of the database.

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1.2.1 *A definition of quantum mechanics*

Simply put, quantum mechanics is the study of matter and radiation at an atomic level. I do not pretend to be more than superficially knowledgeable about quantum mechanics nor the interpretation and philosophical foundation of the theory. However, one particular interpretation has lead to the birth of the structure of the ***Quantum Matrix***. In 1957, Hugh Everett III proposed a radical new way of dealing with some of the more perplexing aspects of quantum mechanics. It became known as the Many-Worlds Interpretation. The Many-Worlds Interpretation is an approach to quantum mechanics according to which, in addition to the world we are aware of, there are many other similar worlds, which exist in parallel at the same space and time. The existence of the other worlds makes it possible to remove randomness and action at a distance from quantum theory and thus from all physics.[4] It was this idea of worlds in worlds that is the conceptual framework for the ***Quantum Matrix***.

1.3 Virtual Environments

The Virginia Tech CAVE[TM] is one of only a few such facilities in existence in the United States. "CAVE," the name selected for the virtual reality theater, is both a recursive acronym (Cave Automatic Virtual Environment) and a reference to "The Simile of the Cave" found in Plato's Republic[6], in which the philosopher explores the ideas of perception, reality, and illusion. Plato used the analogy of a person facing the back of a cave alive with shadows that are his/her only basis for ideas of what real objects are.

The key to making good decisions is in previewing the results. Virtual Environments such as the CAVE can empower us and our constituents to spatially understand the buildings, cities, and the reality in which we exist.

2 THE PROBLEM DOMAIN

Today's software applications are for the most part, digital versions of well-known manual procedures and techniques for dealing with data. These applications tend to deal with the quantification of data and the organization of data; filtering it and packaging it into consolidated and summarized packets. What these current programs lack is the ability to assist one in interpretation and insight with respect to the meaning of the data.

Adding the third and fourth dimension of depth and time allows one to deal with an expand domain of problems which conventional methods do not have the capacity to engage.

The third dimension and fourth dimensions, space and time, also bring a sense of adventure and exploration to otherwise static, mundane, data and documents. Immersion in data allows one to experience the data and documents in new ways exploring and

seeing new relationship, because of the nature of the three dimensional paradigm. While being able to deal with time, opens the possibilities of asking "what happens if" questions and performing simulations to test various scenarios of the future. The *Qube* allows one to deal with a whole this new class of problems and to see current databases in a new light. The third dimension allows one to model the real world more accurately, so that the data model more closely resembles the spatial organizational structure of the problem being investigated or represented. The *Qube* permits the user to gain new insight as to the meaning inherent their data. By viewing the data/documents at different levels of visual aggregation, conceptual clarification may occur. By viewing the data/documents by zooming in and out and by applying various viewing filters to represent the data in different forms, key features of the data may come into focus. Finally by viewing the data/documents at different angles by rotating the cubic data-space, previously unseen relationships and perceptions may occur.

3 WHAT CAN THE QUANTUM QUBE BE USED FOR?

The computer in contemporary practice is far more an extension of the hand of the architect while much less a servant to his mind. Quality in design remains the offspring of the architect's vision, intellect, and imagination. It is in facilitation of these human processes that the power of the man-computer interaction should be most understood.

The world is dominated these days by the three "Cs" not the three "Rs": Computing, Communication and Collaboration. This has come about by the common use of computers in today's design practice, the World Wide Web and the globalization of the economy and therefore the all enterprise operations.

Perhaps the most outstanding and powerful feature of *Quantum Matrix*, certainly for business and scientific applications is that a node can be another *Quantum Matrix* (A sub data space within a data-space.) Because a node can itself become a *Quantum Matrix*, the *Matrix* escapes the simple three-dimensional definition and is more aptly described as an N dimensional Cartesian "Grid" in which any point can itself become and N dimensional Grid (data drilling);

The disassociation of the storage structure from the function of the objects allows the *Matrix* to move sure footedly into the future by being able to accommodate existing technologies and functionality required by today's applications while at the same time allowing the program to evolve with new features and capabilities as yet undreamed of.

At the users option, objects and their data may be held directly in the *Matrix* structure or as hot links to the original data that is held in the user's hard drive, on the Internet or somewhere on a corporate network. This allows one to choose between the trade-off of real-time data display versus speed. Internal storage simplifies the transfer of complex data sets, assuring that all documents and data are transferred and no links are

broken. In either storage option the original source reference is maintained. This permits updating of stored data in two ways, either *insitu* or from the web.

3.1   Research on Collaborative Engineering Tools – Department of the Navy

Several years ago, I began a research project for Department of the Navy to study collaborative engineering tools for the desktop and the web. The issues in naval architecture are much the same as in building design. Dahlgren Naval base was where computers were first used during the Second World War for computing trajectory tables, and where the term "computer bug" was coined. Dahlgren is in charge of designing the next generation of surface warfare vessels for the Department of the Navy. It used to be that the design of naval vessels was done in various locations and there was no centralized control, save for the most rudimentary collaboration meetings and passing paper and drawings back and forth. Major ship systems were basically designed separately in a partial vacuum, and it was assumed that they could in the end be made to work together. That was true to and extent, when all things were mechanical and basically operated independently, however, as more and more of a ships operation became dependent on computing, the need for more closely knit systems became a necessity. Most major ship systems are in some manner linked to the ship central nervous system, its command and control center, which is another word for computer.
System controlled by computer:
- Navigation - GPSS
- Nuclear engine controls systems
- Missile and weapons system targeting
- On carriers, flight Information systems and targeting
- Communications and logistics
- Radar and Satellite information
- Intelligence information
- Photographic and digital image processing
- Remote control of information gathering aircraft

3.2   The stove pipe system of decision making

The Navy's procurement process was archaic, and used what they themselves called the "stovepipe system" or in architectural terms the "throw it over the wall" method of project procurement and management. An admiral in San Diego would yell down one a ship's stacks and order a system; he would throw down several hundred million dollars, and wait to get his toy delivered. The admiral in the next office down the hall would do the same thing, of course these gentlemen never talked to on another, and so on. These stacks at the bottom have partitions between the ship compartment to prevent flooding to

make the compartments secure. Thus contractors are prevented from taking the initiative and talking to one another even though they know they are much in need of critical information that their co-contractors have. And even more significant, when the component is delivered it often cannot not be made to function with other dependent components. The systems often had redundant similar incompatible technologies, requiring multiple sets of similar replacement parts and specialist to maintain and operate the separate systems We as architects have a similar system, except we the wall as the metaphor in lieu of the smokestack. Both commonly lead to blown schedules, cost overruns and change orders for coordination gaffs and oversights.

3.3 The CAVE and the Tactical Admiral

The Tactical Admiral is a relatively new position in the Navy, a position created in response to the complexities of modern warfare and the recent advances in tactical and precision weaponry, and the need for coordination of logistics, force positioning, satellite imagery and various intelligence information. The old ship war room is gone forever, replaced by the CAVE. The tactical command carrier has a pair of CAVES identically configured for conducting global coordination and command decision-making. The CAVE contains a highly detailed digital terrain model of the entire world the topography, both above and below sea level, and details down to ports, highways streets, roads and buildings.

The Tactical Admiral stands in the CAVE and directs the entire battle plan from this virtual environment. He can be zoomed out to 180 miles above the earth or in the Kiber pass. He can move instantly to any location on the globe. Telemetry data of all planes, ships and troops are displayable at selectable levels of resolution. If a plane goes down he can see its position and point with a laser wand that allows the system to computes the precise longitude and latitude point for search and rescue operations. He can receive terabit bandwidth satellite data that is capable of display real-time digital video of troop movement. He can tell the rank of the commanding officer. The data is multi-spectral that means he can see day or night in good weather or bad. He might be likened to Mars, the mythical god of war. But he cannot easily view two-dimensional information from this lofty and powerful position. The simple is its Achilles heal.

3.4 AOL Time Warner home to office business tool

America Online and Time Warner and Time Warner Telecommunications see a business opportunity in the home to office market. Their unique combination of resources, Internet Service Provider (ISP), news, information, and entertainment, and broadband cable as well as common telephony - wired and wireless. Merging these technologies has lead them to consider forming a new company specifically to provide home to office services

one to work at home and to collaborate with colleagues as effectively as down the hall given a powerful and flexible enough interface. A company CEO (Chief Executive Officer) or CIO (Chief Information Officer) could operate from a remote location and perform most of their routine task. The executive at home or branch office is not significantly different in function to the Tactical Admiral.

3.5 The paradigm shift

If you were to look up the word paradigm in the dictionary, you would discover that it comes from the Greek paradeigma, which means "model, pattern, example."

> *A business definition of paradigm might be as follows:*
> *A set of rules and regulations (written or un-written) that does two things:*
>
> *1. It establishes or defines boundaries; and*
> *2. It tells you how to behave inside the boundaries in order to be successful.*
>
> *A paradigm shift is a change to a new game, a new set of rules. Every paradigm will, in the process of its use, uncover problems it cannot solve; and those unsolvable problems provide the catalyst for triggering the paradigm shift. You can recognize a paradigm shift by watching for people messing with the rules, because that is the earliest sign of significant change.*
>
> *Paradigms, The Business of Discovering the Future, Barker*[3]

The need for a CAVE compatible tool for multi-media data storage with collaboration and communication capabilities is thus evident by our encountering an unsolvable problem within the context of the existing paradigm. This tool and interface needs to be appropriate to the CAVE environment but also functional on the desktop using conventional workstation technology, without super computer capabilities. Thus it we have a paradigm shift. This problem occurs when one switches to three dimensions and is further exacerbated by stereographic immersive environments.

4 APPLICATION DESCRIPTION

The *Qube* is a three-dimensional, multimedia document management, and collaboration tool. The *Qube* anticipates the convergence of electronic media into one consistent environment for analysis, representation and communication. The *Qube* allows the user to exercise their creativity by interactively placing and organizing their data three

dimensionally and navigating through and viewing data and documents in 3D (monocular and binocular – stereo).

Navigating through the 3D Matrix-space is fun. All navigation uses real-time animation giving you instant feed back as to where you are. Data drilling is as simple as mouse click on a *Matrix Qube*. Double clicking the left mouse button on an object in the matrix activates that object.

One of the strengths of virtual environments is their profound ability to display complex three-dimensional structures of all manner and variety. <u>One of the problems of this technology is its inability to deal with common data and media.</u> One of the goals of the *Quantum Matrix* is to solve this problem.

4.1   Program Architecture

The program architecture is based in part on Microsoft's Distributed Component Object Model (DCOM) framework. The *Qube* uses VMRL and OpenGL technologies to allow the user to be immersed in their data as with Cinerama, IMAX and Virtual Reality Environments. The program consist of a core sever level of code through which the user interface and the functional components communicate and interact. This structure is based on a plug-in paradigm that eases maintenance and allows new components to be easily added.

The program can be viewed at a logical level, as a network of cooperative, distributed, and reusable services that support a business solution. The components are layered in three general groups of user services, business service, and data services.

4.2   ActiveX Application Components – pseudo MIME

The business functionality of the *Qube* incorporates a set of impersonator application components that allow one to view and manipulate a broad range of applications without the necessity of having the native software for these applications. These applets read and manipulate the data of various file types in their native format. While similar to Internet MIME these tools offer more extensive capabilities and functionality beyond just viewing.

MIME stands for Multipurpose Internet Mail Extensions, and refers to an official Internet standard that specifies how messages must be formatted so that they can be exchanged between different email systems. MIME is a very flexible format, permitting one to include virtually any type of file or document in an email message. Specifically, MIME messages can contain text, images, audio, video, or other application-specific data.

The current version of the *Qube* can store, access and view almost anything that is in digital form, including:

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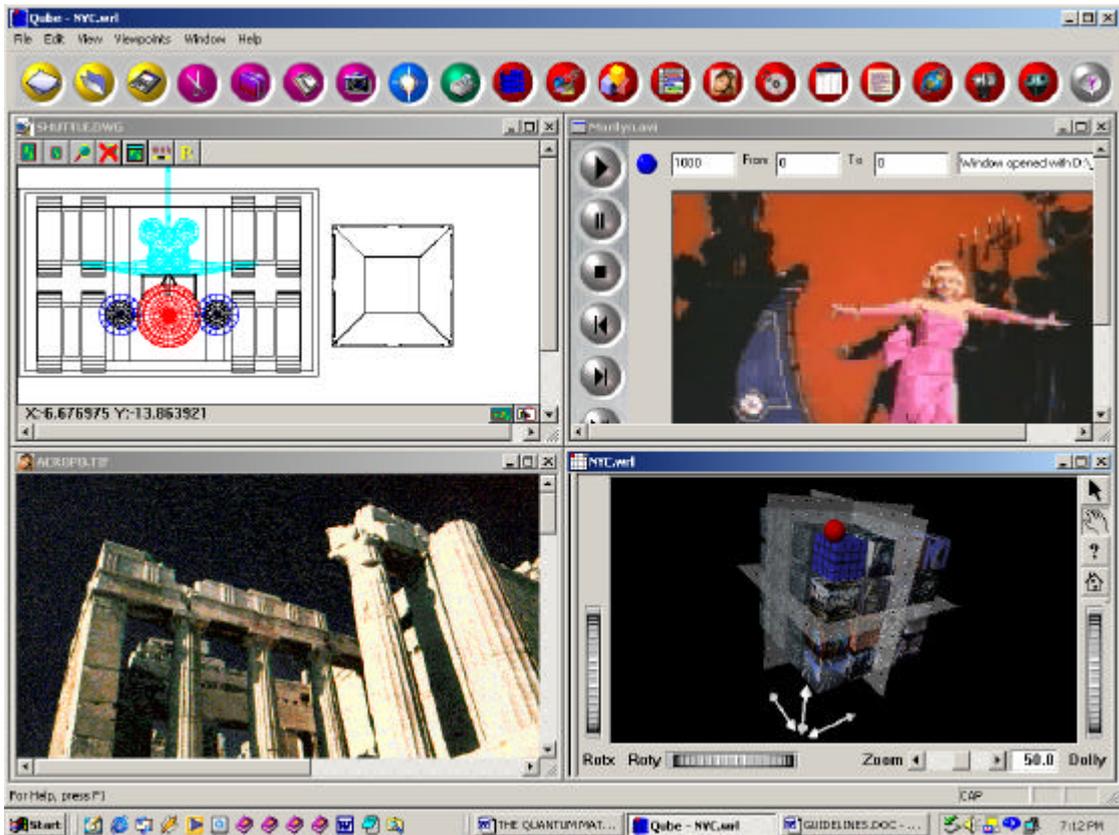|	
Text files	Pictures
Video Clips	Sound Files
Spreadsheets	URL's
HTML pages	Databases
CAD files (dwg, dxf & dgn)	Gantt Charts
Business Graphics	3D VRML and Inventor models
Executable Programs	OLE (Object Link & Embedded)

Figure 2: **Multi Document Interface**

Figure 2, shown above illustrates the *Qube* Multi Document Interface with four active applications, an AutoCAD drawing of the space shuttle, a Movie – <u>Diamonds are a girl's best friend</u>, an image of the Acropolis, and the Qube itself.

4.3   How deep does the rabbit hole go?

Down, down, down. Would the fall NEVER come to an end! `I wonder how many

miles I've fallen by this time?' she said aloud. `I must be getting somewhere near the centre of the earth. Let me see: that would be four thousand miles down, I think--' (for, you see, Alice had learnt several things of this sort in her lessons in the schoolroom, and though this was not a VERY good opportunity for showing off her knowledge, as there was no one to listen to her, still it was good practice to say it over) `--yes, that's about the right distance--but then I wonder what Latitude or Longitude I've got to?' (Alice had no idea what Latitude was, or Longitude either, but thought they were nice grand words to say.)

<u>*ALICE'S ADVENTURES IN WONDERLAND and Through the Looking Glass*</u>[1]
Lewis Carroll

The **Quantum Matrix** is a very deep rabbit hole. The default view of the **Qube** is a three dimensional array of 4 by 4 by 4 cubes, four planes of sixteen **Qubes** or a total of sixty-four **Qubes**. This would seem a modest and limiting amount of data, but consider each **Qube** is a data object, which could be hundreds of pages in length. More significant, however, is the fact that a **Qube** can hold another **Qube**. With just two levels we have 4096 documents, and with just 10 levels we have 1.15 Quintillion objects.

Table 1 below shows how the number of stored objects grows as **Qubes** are embedded in other **Qubes** in the dataspace. Figure 1 shows the 3D **Qube** interface with a **Qube** in a **Qube**.

Table 1: **Size of the qube data space**

Qube Levels	Base No. of Qubes	Qube Multiplier	Total Qube Objects
1	64	1	64
2		64	4096
3		64	262144
4		64	16777216
5		64	1073741824
6		64	68719476736
7		64	4398046511104
8		64	281474976710656
9		64	18014398509482000
10		64	1152921504606850000

4.4   User interface description

All the information related to a given project can be stored in a visually labeled **Qube**. Further, as a **Qube** can be subdivided for additional storage. A sub component of project can be placed within another **Qube**, and different project can have its own **Qube**.

A good analogy would be like walking down the aisles of a discount department store, furniture outlet, or hardware store. Boxes are stacked on the shelves, with a sample or picture of the merchandise shown on the front of the box. Some boxes might hold other, smaller boxes (of different types of nails, for example).

How did the boxes get on the shelves in the first place? They were brought there by the manager; and organized; and placed on the shelves in a location selected by the store manager. The *Qube* operates similarly. The user takes delivery of packages of data from various sources and of varying types. The user then selects a storage location for the data. A picture of the item is captured and is pasted on the surface of the selected *Qube.*
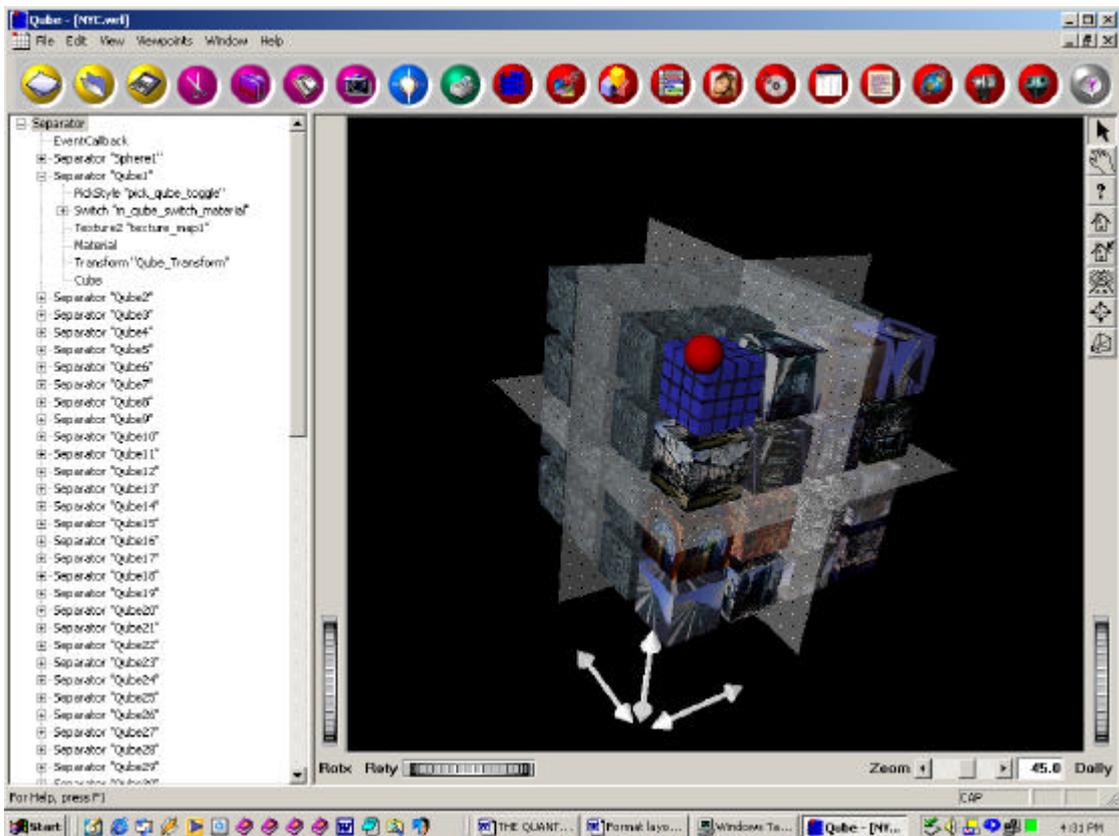

Figure 2: **Qube in Qube**

The *Qube* user interface is quite simple and intuitive to use. Employing the now familiar "drag and drop", "point and click" method to manage data and documents. Items can be placed into the **Qube** grid at a user selected matrix node. Upon dropping a document on a *Qube* it appears as a mapped image onto the surface. Clicking the mouse on a mapped *Qube* activates whatever document type or application stored in the *Qube*. If the *Qube*

contains another ***Qube*** we open the embedded ***Qube***. The Qube interface is designed using the multi document interface common, to many windows applications. This interface allows multiple documents to be active at one time within the application window and multiple views of each document as well. For example we could have a right, left, top and perspective view of a three-dimensional VRML model – one document, many views of the data.

4.4.1   Screen capture
The Qube interface has a very powerful screen capture capability that allows the user to select the entire screen, a window or a client area of an application. Right clicking the mouse in an active application window captures a snapshot of the application document, or web page. The user can view, crop, edit and annotate the image, prior to assigning the document to a ***Qube***.

5 NAVIGATION AND DATA MINING

The primary business purpose of the Quantum Matrix is to provide an understandable and comprehensive tool for organizing and exploring large amounts of data without having to be a management information system guru. Navigation controls are intended to be intuitive and yet give powerful control over access to information and tools related to a task or project.

5.1   Navigation and Data Drilling Concepts - Worlds in worlds

Data drilling and navigation in the case of the ***Quantum Matrix*** are inextricably bound together. In the user interface in the main graphics viewport adjacent to the upper left hand side of the ***Qube*** array is a red sphere. This sphere recalls the words of Morpheus, played by Samuel Jackson's in the movie "The Matrix". "You take the red pill and I show you how deep the rabbit hole goes." The red sphere is home base of the qube the outer most level. The red sphere's purpose in the interface is two fold. First it tells us at what level we are in data drilling; if the sphere is red we are at the outermost level home. Second, when we are in a lower level the sphere is mapped with a satellite image of the world, indicating that we are in an inner world.

Pausing the mouse over the sphere will display the current level into which we have drilled. Selecting the sphere when we are at an inner level takes us up a level. Double clicking with the left mouse button take elevates us to the outer most ***Qube***.

The sphere also is a visual marker defining the front of the Qube. The Qubes are numbered from 1 to 16 beginning at the upper left and proceeding to 16 on the lower right. Then second plane of Qubes goes from 17-32, then 33-48 and finally 49-64. Thus

there are 64 ***Qubes*** in a single ***Matrix*** with the possibility that any or all of these may contain another ***Quantum Matrix.***

5.2   Navigation Controls

5.2.1   Splitter Window Graphics and Data

The ***Qube*** is inherently a relational data structure allowing the user to organize his data visually. The ***Qube's*** primary window is a splitter window divided into two parts. The right two thirds is a the a three-dimensional view of the ***Qube*** and the left quarter is a tree that is automatically created by the program showing the hierarchical structure of the user's database. The left part of the window can alternately display a tree of the data or the graphics elements associated with the data.

5.2.2   Graphics display window

The graphics window displays a three-dimensional view of the Qube, a 4x4x4 array of 64 cubes, each is capable of holding a data object. Associated with this view is a vertical toolbar that provides controls for viewing the Qube. The toolbar controls are:

- Selection - Arrow
- Transform - Hand
- Help - Question mark
- Home - House
- Set home - House arrow
- Zoom extents – Eye
- Move to animator – Target
- View type - Perspective box

5.3   Navigation Controls

5.3.1.   Scenegraph tree

The ***Qube*** graphics tree is one of two tabbed trees viewable in the left third of the Qube window. This view of the ***Qube's*** data shows the actual VRML scenegraph with names of the graphic objects, image maps and the ***Qube's*** index number. If a ***Qube*** holds another ***Qube*** the item may be selected and the tree expand to display the items held in the next level down in the data hierarchy.

Selecting a graphics ***Qube*** in the 3D viewer portion highlights both the selected ***Qube*** and line item in the Scenegraph tree. Selecting an item in the tree commensurately highlights the corresponding ***Qube*** in the 3D viewer window. Drilling down a level can be done either by expanding a tree item designated as another ***Qube*** or by clicking on a ***Qube*** in a ***Qube*** box.

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5.3.2. Qube data tree

The ***Qube*** data tree is the second of two tabbed views displayable in the left third of the ***Qube*** window. The ***Qube's*** database shows the names of the applications, the qube reference number, the application associated with it, and the type of data held in the ***Qube***. If a ***Qube*** holds another ***Qube*** the item may be selected and the tree expand to display the items held in the next level down in the data hierarchy.
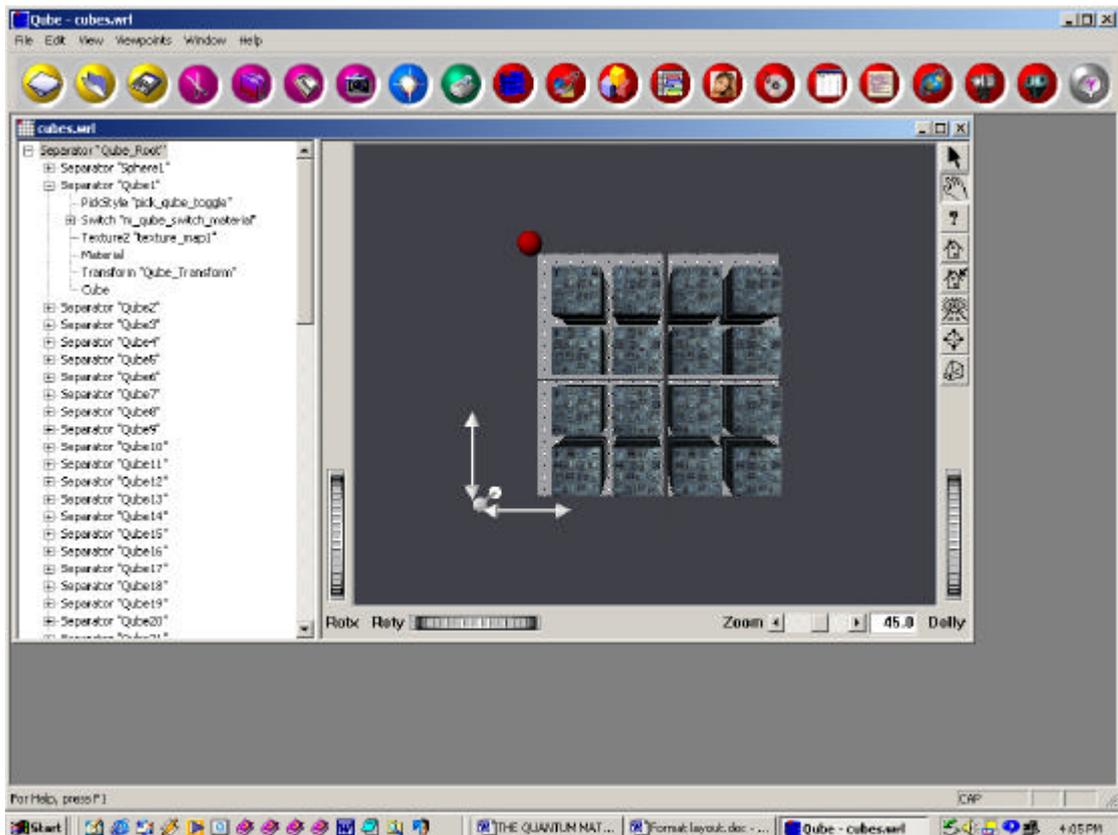

Figure 3: **Quantum Matrix Startup Screen**

Selecting a ***Qube*** in the 3D viewer portion highlights both the selected ***Qube*** and line item in the tree. Selecting an item in the tree commensurately highlights the corresponding ***Qube*** in the 3D viewer window. Drilling down a level can be done either by expanding a tree item designated as another ***Qube*** or by clicking on a ***Qube*** in a ***Qube*** box.

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5.3.3. Viewing controls

The ***Qube*** allows you to manage and to view your data and documents three dimensionally. Data/documents are positioned in the 3D grid at nodes that are ordinal Cartesian coordinates. A bitmap image snapshot of your application/document is captured and texture mapped onto a three-dimensional surface associated with a node. You experience the data and documents stored in the cube by moving through the data-space and viewing the objects stored therein, employing three space graphics and orthogonal projection conventions. Objects are represented either axonometrically or in perspective. The objects held in the grid may be rendered either opaque or transparent. Depth queuing filters such as focus and fog optionally enhance the spatial effect. These features allow the user to intuitively understand where they are in 3D data-space relative to other objects within the viewer's cone of vision.

The ***Qube*** provides several nodal display modes:

- The Quantum grid in its most basic form can be displayed as an array of floating spherical points each aligned at the intersection of the three-space Cartesian grid. The raw data and document references are associated with the grid nodes and allow one to examine the data and documents in their most rudimentary form.

- The Quantum grid can be displayed as an array of floating rectangular planes each aligned at the intersection of the three-space Cartesian grid. The object image of the document or icon data type is mapped to the rectangular plane for browsing purposes.

- The Quantum grid can be displayed as an array of floating cubes each aligned at the intersection of the three-space Cartesian grid. The object image of the document or icon data type is mapped to the faces of the cube for browsing purposes.

- The Quantum grid can be displayed as an array of floating icons each aligned at the intersection of the three-space Cartesian grid. A thumbnail image icon of the document or data type and a name flag are displayed for browsing purposes.

In the various display modes, the grid lines that represent potential associative links may optionally be displayed. Each of the display modes described above provide the potential for seeing the data from a different perspectives and thus may afford the user the opportunity for the discovery of new ways of interpreting the data and innovative approaches to problems not seen in the flat paper world.

5.3.3.1 Animation

When the transform hand tool is selected the user can animate the rotation of the ***Qube*** by holding down the left mouse button and moving the mouse in the direction of the desired rotation. The ***Qube*** will continue to rotate until the mouse button is pressed again.

5.3.3.2. Rotation

Two thumbwheel controls are located on the bottom left edge of the graphics viewport. Holding the left mouse button down on either of these controls and dragging the mouse

will effect a rotation about the X or Y axis.

5.3.3.3 Pan

When the transform hand tool is selected, and the user holds down the control key and while simultaneously holding down the left mouse button and moving the mouse in the direction of the desired pan, the view will dynamically change position in the XY plane of the screen.

5.3.3.4. Zoom

At the bottom right of the graphics viewport is a slider control that allows one to zoom in and out on the view. Zooming the view is like changing the type of lens on a camera, thus it changes the Field of View (FOV), which, affects the perspective distortion in the image. Typing a value into the edit box to the sliders immediate right also changes the view zoom. FOV is measured in degrees.

5.3.3.5. Dolly

At the bottom right of the graphics viewport above and to the right of the zoom edit control is a thumbwheel that allows one to move the camera in and out on the view. Dollying the view makes the objects larger but does not change the perspective.

5.3.3.6. Qube Selection

The selection arrow, which is the first control in the toolbar, is the most important control for the graphics viewport. It allows the user to select a *Qube*. It has three functions depending what other commands are active.

- If an item has been captured and is held on the system clipboard it maps the object on the clipboard to the selected qube.
- If *Qube* has a mapped application or document and the *Qube* is selected it activates the item stored in the qube.
- If the hide qube command is active, selecting a qube will hide it. Note: This command takes precedence over mapping and application activation.

5.3.4. Qube visibility

In order to allow the user to view a specific a set of *Qubes* and to identify more easily their content, individual Qubes and or groups of *Qubes* can be turned off and on. The light bulb icon on the main window's toolbar un-hides all hidden *Qubes*.

5.3.4.1. Hiding and Displaying

The main window's menu under the view item provides a dialog box for the control of *Qube* visibility

5.3.4.2. Cubes - Culling planes and draggers

In the Qube's graphics view port are three cylindrical arrows and three transparent planes. These three arrows and their associated plane represent the X, Y and Z axis of the Qube data-space. They provide another very powerful tool for turning sets of Qubes visibility off and on. Selecting one of the arrows with the left mouse button and dragging the mouse will move its paired culling plane in the axis of the arrow. Selecting the plane will turn off all Qubes either in front or in back of the culling plane. If you accidentally turn off the wrong qubes touch the light bulb; it will restore all qubes to view

5.3.4.3. Viewing options

Clicking the right mouse button in the graphics viewport will bring up a popup menu of viewing options that allow the user to customize the view to their liking and to toggle the view controls display on and off. The popup menu has categories of commands for:

- View Control Functions
- Drawing Style Features
- Viewing versus Selection toggle switch
- Viewport view control decoration
- Headlight toggle switch
- Display preferences – which includes stereoscopic viewing off/on switch

5.3.5. Parser – computation and logic

One of the more powerful features of the **Quantum Matrix** program is its parser and scripting capability. The parser is a full feature mathematical expression evaluator, which together with a Visual Basic like scripting language allows the user to automate nearly anything in the **Qube's** interface and to computationally relate Qubes to one another logically.

This feature allows nodes in the 3D data-space, applications and or documents to be associatively linked together thus enabling the user to implement embedded formulas and/or user defined auto-executing processes and functions with respect to both numbers, words and imagery. In other words, what you see may change what you get.

5.3.6. Qube Annotation

The **Matrix** provides annotation capabilities to allow one to comment and explain the significance of a data object and or documents stored in the grid. Further, associative linkages between documents and or data sets can also be annotated to elaborate on the meaning and purpose of the relationship. Pausing the cursor over a data item or link will display the annotation window for the item or link.

5.3.7. Searching

With the complex and ad hoc nature of the **Qube,** a strong searching capability is

necessary. The ***Qube*** automatically builds a hierarchical relational schema of the data structure of the users system. This tree schema of relationships creates the framework for efficient data searches. Search of the dataspace can be made in two ways:

- Searching for a particular document or
- A key word or phrase within a document

Each of these methods of searching has wild card and filtering capability based on PC and SQL standards.

5.3.8. Archiving Qube data

One of the most frustrating things that can happen on both Intranets and the World Wide Web are broken links. With the ***Qube***, the user can archive a complete mirror image of the entire dataspace, including: the desktop, Intranet and Internet files and documents and publish it all permanently to CD/DVD or other user selected media.

The ***Qube*** features a powerful publishing capability that is an easy "point and click" solution for publishing the ***Qube*** Dataspace to CD, DVD or equivalent media. ***Qube*** Publish can also mirror existing Web sites onto CD/DVD. ***Qube*** Publish allows for publishing simultaneously documents with advanced searching on CD/DVD and the Internet/Intranet. ***Qube*** search makes a wide range of data accessible for searching across data held in word processor files, databases, spreadsheets, email, ZIP, XML, PDF, HTML, Unicode files and more.

Indexing and searching algorithms are optimized for very fast performance on even the largest corporate networks. Search time, even with simultaneous searching of a very large indexed database, is typically less than a second

The ***Quantum Matrix*** search engine is able to search through gigabytes of text in a second because it builds an index that stores the location of words in files. The ***Qube*** then automatically recognizes and supports all popular file formats, and never alters your original files.

Since you may sometimes want to search files that ***Qube*** has not indexed, the ***Qube*** also does un-indexed as well as "combination" searches.

5.3.9. Report Generation and multi-media document integration

Enlightenment through Written Communication.

It is said that what separates us from other creatures is our ability *to* communicate using the written word. This act of passing on knowledge in written form his now been augmented by many different means in this digital age. One drawback of the digital document is that the available variety of formats makes the interchange of data more complex than it really should be. To end this hurdle in the dissemination of information, the PDF document format was created to facilitate the exchange and viewing of documents no matter what the application or platform they were created on. Unfortunately most of the document creation tools we regularly use, and with which we

are familiar, do not support saving to the PDF format. But now, with the help of the *Qube*, they all can do exactly that.

Direct to PDF from Your Printer.
The *Qube* uses a Windows printer driver that lets you preview and save documents created in any application that can produce a printed output to PDF format. It supports Windows 9x/Me, NT, and 2000/XP Just by simply printing to a printer driver, you can create a preview of your document in PDF format and then easily save it to disk, e-mail it, or publish it on the web. Then anybody, on most computer platforms, can use the free Adobe Acrobat Reader specific to their platform to view and/or print the document. It is a simple solution to a very complex task.

Empowering the Creation of Documents.
To make the process of creating and viewing complex documents easier, the **Qube** lets you embed fonts that might not be present or supported on the target computer directly in your PDF document. You can also embed document information in the attributes of the created file. Using the Qube preview interface, you can easily zoom in and navigate through your PDF document and add blank pages or delete pages from your document. You can also print multiple jobs to the same PDF document to simplify the process of creating complex documents.

6 QUANTUM MATRIX FEATURES

The Quantum Matrix was built from the ground up with a feature set and design methodology centered on change. The current feature set is impressive, but tomorrow it will be yesterday news. And a new set of ideas will be what's hot. The Qube's structure will, however allow it to adapt and change its coloration. The Qube is a software chameleon.

6.1   The accommodation of change

Today's software paradigm presumes to know, or attempts to know, the range of applications and data structures that the market place wants and needs. The *Quantum Matrix* rejects this paradigm. The *Qube's* wisdom rest in the acceptance of our inability to know, how or what sort of information the user wants to store, and manipulate. The *Qube's* mission is to computationally integrate, allowing the individual to draw upon multiple databases, varied information types, and vast analytical capability, with as much speed and power as the individual needs. The *Qube* employees the basic principals of object oriented programming: encapsulation, inheritance, and polymorphism to

accomplish this task. It uses the "plug and play" paradigm based on Distrusted Component Object Model (DCOM). All these capabilities are brought together through the uniting mechanism of a multi-dimensional object oriented nodal structure or what we call a ***Quantum Matrix.*** The idea is simple. It is an easy extension of the well-known Cartesian coordinate system that forms the foundation of all three-dimensional graphics. The ***Qube*** expands the grid concept to a visual 3D space, for interactively organizing, manipulating, and analyzing large numbers of numeric, text and multimedia data sets. What sets the ***Qube*** apart is what can be in held at a node. The ***Qube*** is an <u>object container</u>, where an object can be anything, including a processes or a replication of the object container itself.

6.1.1. Associative Links

The ***Quantum Matrix*** transcends the traditional approach to data management by combining imagery and real-time data sources as well as numbers and text into a multimedia 3D data-space. In 3D data-space, nodal data and or documents can be associatively linked together thus enabling the user to implement embedded formulas and/or user defined auto-executing processes and functions with respect to both numbers, words and imagery. Any node resultant may be a multidimensional image, complex data, chart, graph, text, movie, numeric array, scalar, sound, Internet site, Voice Link, or even another ***Quantum Matrix***. The associative links of the ***Qube*** provide a two-way channel in which data can be transmitted back and forth between two documents or data sets affecting a feed back loop. Data and documents, as a result, can be modified dynamically through iteration and or recursion. Clicking on a link is way of quickly moving to the linked item.

6.1.2. Real-time nodes

A ***Quantum Matrix*** node can among other things be a real-time signal processing object; performing such real-time task as providing voice/telephony communication, television/cable reception, Internet/Intranet URL links, and IEEE 488.2 GPIB (General Purpose Interface Bus) links to physical devices such as gauges, switches, and instruments. A ***Quantum Matrix*** nodal object can be modified to encapsulate the specific functionality and data storage requirements for a particular real-time task.

When connected through a high-speed broadband pipeline such as the Time Warner Telecommunication's Road Runner, cable modem, and together with a long distance service provider, the ***Quantum Matrix*** becomes a complete point-to-point communication, computation, and multimedia interface. The ability to transmit and receive all forms of data: numbers, text, drawings, pictures, video, voice, etc., makes ***Quantum Matrix*** the total system front end link to business, industry and the home. The ***Quantum Matrix*** interface provides a platform for real-time interactive collaboration. At the same time, the ***Quantum Matrix*** can serve the consumer market incrementally,

supporting voice services or voice services combined with multimedia, analytical, transaction processing and monitoring functions.

There are five grid node object types that are real-time objects:

- Date (System date)
- Time (System time)
- Process (Multitasking thread)
- Data Polling Channel
- Communication Channel

6.1.3. Customization and preferences

As previously noted the *Quantum Matrix* is a chameleon. The appearance of nearly anything in the *Qube's* user interface can be changed from the background color or wallpaper to the default image mapped onto the array cubes at start up. In addition to these more superficial cosmetic changes, the actual form of the *Quantum Matrix* can be altered.

First the matrix is not limited to the 4x4x4 dimension that is the default at start-up. The user can expand and contract the array size to their particular applications needs. Second the matrix is not confined to a square cubic configuration. The graphics can be configured to display a spherical/polar array of objects or use the three dimensional Strepinksi Triangle for the array shape.

Finally the shapes of the individual nodal element can be modeled to any platonic solids or as point, planes and spheres in addition to the default cubes.

6.1.4. Lighting

Lights can be dynamically placed and turned off and on in the model at local intersection grid points to facilitate viewing of the objects stored in interior locations. With the default 4x4x4 matrix, lights are automatically placed at the nine matrix intersection points. These lights can be turned on and off individually for a single location or for all aisles and shafts.

6.1.5. Flyover hints

Pausing the mouse over a node will cause a hint bubble to appear that describes the content of the node. The user can edit these comments, and this feature can be turned on and off,

6.1.6. Image map editing

The images that the user maps onto a node can be edited and or replaced with another selected image to represent the objects contents or purpose. This feature allows text to be overplayed as well as modification of the image bitmap.

6.1.7. Directory and file location control

Because of the nature of the **Quantum Matrix** system, there are many files and directories that bind all of the pieces together. The user can optionally direct the program to look for system and project files in any location they desire. The system can also reset itself to a default directory configuration so that lost functionality can be restored to the interface.

6.1.8. Security and data encryption

The **Quantum Matrix** because of its origins in the military is a securable program. Data can be optionally encrypted using 128-bit encryption algorithm for transmission and storage. Access to Qubes, nodes in Qubes and display of Qubes can be password protected. The primary administrator can also assign a user a security level of access.

7 VIRTUAL ENVIRONMENTS

7.1   The CAVE

The CAVE$^{(TM)}$ is a multi-person, room-sized, high-resolution, 3D video and audio environment. In the current configuration, graphics are rear projected in stereo onto three walls and the floor, and viewed with stereo glasses. As a viewer wearing a position sensor moves within its display boundaries, the correct perspective and stereo projections of the environment are updated by a supercomputer, and the images move with and surround the viewer. Hence stereo projections create 3D images that appear to have a presence both inside and outside the projection-room continuously. To the viewer with stereo glasses the projection screens become transparent and the 3D image space appears to extend to infinity. For example a tile pattern could be projected onto the floor and walls such that the viewer sees a continuous floor extending well outside the boundaries of the projection-room. Three-dimensional objects such as tables and chairs would appear to be present both inside and outside this projection-room. To the viewer these objects are really there until they try to touch them or walk beyond the boundaries of the projection-room. There are many rips and tears on projections screens where viewers have forgotten to be careful when walking within these invisible boundaries.
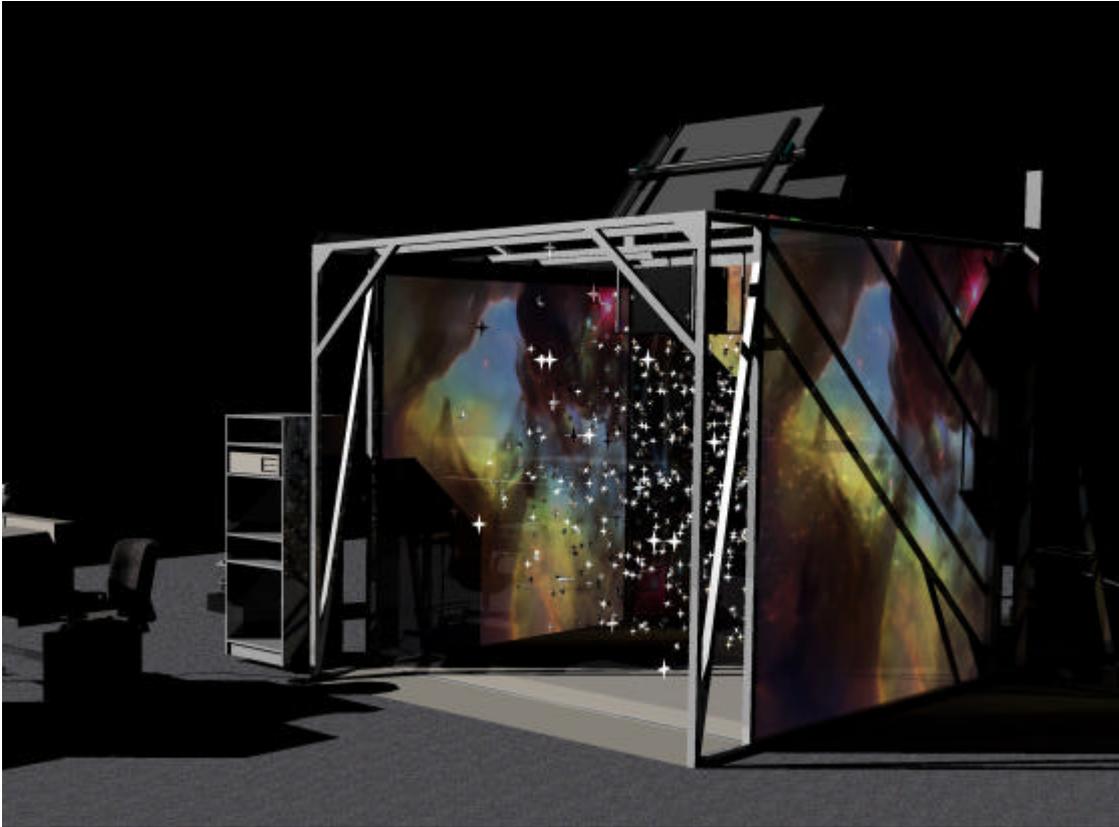
Figure 4: **The CAVE - Hubble telescope image of a deep space star field M8 Detail**

7.2   I-Wall, the VELab

One of the unique resources of the College of Architecture and Urban Studies at Virginia Tech is the Research and Demonstration Facility. It houses   the College's Virtual Environments Laboratory, which provides high-end workstations and a stereoscopic single wall VR (Virtual Reality) projection system The VELab is directly networked to the University CAVE$^{(TM)}$ facility. This lab is set up to allow one to create complex 3D models and to test them in an immersive virtual environment prior to moving to the more complex CAVE.

8   CONTINUING RESEARCH AND THE FUTURE

There are a number of promising areas for continued development of the *Quantum Matrix* concept. There is the possibility of commercialization of the program in the consumer arena as well as continued basic research in the Academy.

8.1   3D projection of video – Developments at Brown University

Computer Science researchers at Brown University have developed a set of C++ classes that allow one to animate texture maps using the Open Inventor software developer kit (SDK). It uses the MPEG digital video standard file format to map moving images to the surface of a 3D cube. This would allow projection of movies in virtual environments as a 3D surface. The next version of the *Quantum Matrix* will incorporate this feature.

StereoGraphics Inc. is marketing the SynthaGram™ Monitor an autostereo display (no eyewear required), and Monitor ZScreen 2000i stereo viewing panel (used with passive polarized eyewear). These Stereo3D visualization products enable realistic visualization of complex digital models, giving scientists, engineers, digital content creators and other professionals the best possible understanding of three-dimensional information.

8.2   Open Inventor and the CAVE, Dynamic Stereo on your desk top

TGS Software has implemented the CAVELib in their latest release 3.0 of Open Inventor While, Open Inventor was used to create this version of the *Qube*, the recent update solves a number of problems and extends the Qube's capabilities and makes integration with the CAVELib easier. In the past, there were limitations with Multi-threaded processes. Now Open Inventor, together with the multi-threaded CAVELib, avoids the need to duplicate the scenegraph. Enhanced integration allows view-dependent nodes, like LOD and Billboard, to function correctly. Open Inventor's well-known 3D user interface tools (draggers, manipulators) can now be used in immersive VR environments.

8.3   Qube Avatars and Limbo

Limbo is a collaboration program that allows multiple CAVEs to operate in tandem with multiple participants viewing the same model space. Each Participant is associated with an Avatar object that indicates that individuals viewing location and viewing direction. We are in the process of investigating various means of creating personalized human model avatars that can move and speak.

One of these offers some very interesting capabilities in creating these avatars. The VideoAvatar Library is a collection of functions that works in conjunction with the CAVE[tm] Library, and can be used to add static, photo-realistic three-dimensional representations of remote users, as well as other objects or agents, to virtual reality applications. The process involves obtaining views from 360 degrees around the person to be represented, then selecting pairs of these images, one for each eye, to represent the surrogate user in 3D space.

8.4   Signal processing and telephony in a *Qube*

One of the most interest and far reaching ideas is the implementation of signal processing in a cell. This would allow one to maintain online connections to various data and communications sources, including live video feed and telephony. We have experimented with video in a Qube. We have also looked at real-time connection employing Microsoft NetMeeting.

8.5   Laser and Linear radar scanning for 3D object creation

Another area that has profound implications for architecture and urban planning and design is using laser and linear radar scanning. Because of the 3D nature of the *Qube*, integrating this is a logical extension of the **Qube's** display and interface capabilities.

Large scale 3D scanning allows one to create real world three-dimensional models of whole cities, existing building and structures for complete, accurate, rapid visualization without tedious 3D modeling. Modeling the real world using conventional techniques such as close-range photogrammetry is time consuming and inaccurate and at best offers shallow approximations of the complexity and detail of the actual environment.

The Cyrax scanning system is one such system. It is operated by orienting the device toward the scene, and selecting the desired area and measurement density via a laptop computer, the scanner automatically records the three-dimensional scene (The system is capable of scanning objects in at up to 100 meters distance with an accuracy of 5 millimeters). Complete surface geometry of exposed structures and sites is remotely captured in minutes in the form of dense, accurate "3D point clouds", ready for immediate use. Cyrax point clouds are a valuable, new "deliverable". They represent a highly detailed, instantaneous 3D "virtual model" of an existing site or structure… complete with survey-grade measurements. As soon as Cyrax has scanned a structure or site, integrated software lets you use the 3D point clouds to rotate and fly around an existing site or structure to view it from any perspective and to dimension between any two points. You can also use the 3D point clouds to create wire meshes, 3D models, and 2D drawings for export to popular CAD, rendering or other software.

9   CONCLUSION

In computer graphics, it is apparent that a paradigm shift has already occurred. Immersive environments have replaced simple three-dimensional graphics. However most engaged in the use and development of 3D software are unaware of it. Much less being able to

articulate what its fundamental nature is, where it will take us, what problems it will solve, and what it boundaries are.

One might wisely ask, what causes a paradigm shift to occur? Every paradigm will, in its use encounter a set of new problems, uncovering problems it cannot solve; and those unsolvable problems provide the catalyst for triggering the paradigm shift.

What all design disciplines hold in common is the need to visualize what does not yet exist and to judge the impact of decisions, policies, and designs prior to their implementation. A single building can cost five hundred million dollars, a city cost trillions of dollars, and a forest is priceless. Because of the scale, complexity and cost of the problem domain in which we operate, it is often not possible to directly test the implications of design and planning decisions. And yet we must choose between alternative designs, concepts, construction methods and product prototypes.

The key to making good decisions is in previewing the results. The people who inhabit the cities, work in the building buildings, and live in the homes we design need to clearly understand what we as planners, designers and contractors propose. Most lay people do not understand the documents we use to plan and build from, nor can they imagine in their mind's eye, the three-dimensional object that would be the result. Immersive environments such as the CAVE can empower constituents to spatially understand the cities in which they live, be a participant in the design of the house in which they dwell, engage a physically handicapped individual in the validation of the accessibility of a facility. This particular paradigm shift is manifold in that it includes both the World Wide Web and virtual reality.

When a paradigm shifts everyone goes back to zero.

By zero I mean that regardless of what position your position was with the old paradigm -- number one in market share, leader in the technology, best reputation -- you are back at the starting line with the new paradigm. Because of this change in leverage, the practitioners of the new paradigm have a chance to not just compete with but defeat the titans of the old paradigm.
op. cit [3]

The ***Quantum Matrix*** is only the one of what I am certain will be many other concepts that will attempt deal with the problems and opportunities inherent with recognizing and embracing the issues of this "Brave New World.

Parke Xerox, Apple Computers, and Microsoft, inventors, propagators and exploiters of the Graphics User Interface (GUI), the dominant computer paradigm of the past ten years find themselves with the rest of us having to adapt. It is within this paradigm that the next paradigm finds its origins.

How are a shovel and a computer alike? Answer: They are both tools. Question: Where is the difference? Answer: The user. With a shovel you can pick up after a dog, or grow a garden. One use cleans up a mess, while the other can feed a family. Yet in both cases the shovel, the tool, is held in much the same manner and moved in the same way. The difference is in the knowledge and experience of the user.

The moral to the story is to get more out of the tool change the paradigm of use.
op. cit [3]

A sophisticated viewing public is pushing the demand for more realistic 3D interactivity. The average computer user because of Hollywood special effects and Video Games expects high-quality graphics at a real-time speed when interacting with new products.

<u>*PC Graphics and Video*</u>, Forcillo[5]

The World Wide Web with its immediacy begs for ways to bring information to the participating public in unique and efficient ways. Mike Forcillo, the publisher of PC Graphics and Video Magazine says,

After surfing the Web, playing computer video games and watching plenty of television... something still seems missing, Consumer electronic entertainment mostly lacks the fundamental ability to engage and stimulate the user's creativity. I believe this void is creating a new market niche for consumer-oriented graphics and multimedia software which will ultimately be judged more on the experience of using them, rather than for the specific purpose of the finished output...

These products entertain and enable more broad-based dynamic and personal digital communication. If you think of the Internet as a new sort of telecommunications medium, then this trend is an important step in moving us beyond the uninspiring status quo of plain text on a white screen.
op. cit[5]

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