

## 46. [Introduction] The Lessons of Lucasfilm's Habitat

When *Ultima Online* (a very large-scale, commercial, many-user, graphical virtual environment also called a "Massively Multiplayer Online Roleplaying Game" or MMORPG) was rolled out in 1997, rapidly acquiring more than 100,000 users, strange things began to happen. People—including one writer for the digitally-savvy magazine *Wired*—were shocked, shocked to find that players enjoyed killing each other online. Can't we all just get along in cyberspace? they wondered.

"It is a mistake to assume that the users will all undertake the sorts of noble and sublime activities that you created the system to enable," Chip Morningstar and F. Randall Farmer replied, six years before the question was posed. They knew the answer ahead of time because they had already implemented Habitat. Almost all the major issues raised by *Ultima Online*, and later by Sony's *EverQuest*, were exposed in developing Habitat's virtual world, which presented a two-and-a-half-dimensional view to users using modem-linked Commodore 64s. This primitive graphical environment provided numerous lessons in online interaction and the shared experience of a simulated world.

This discussing of Habitat bears on two approaches to new media that are represented well in other anthologies: computer-mediated communications and virtual environments. With regard to the latter perspective, often considered using William Gibson's term "cyberspace," it is *Cyberspace, First Steps*, from which this article is taken, that remains the essential resource both for understanding those virtual environments which look like physical spaces and for understanding the online experience through the metaphor of space. The computer-mediated communications perspective includes related studies of the networked computer as a social and cultural environment, undertaken within a variety of networked systems including MOOs, graphical virtual worlds, and chat spaces

Many of the essays here in *The New Media Reader* consider the computer as a stand-alone or networked system for asynchronous writing and reading, or for some similar activity. The usual questions about "single-player" new media experiences often still apply to environments like Habitat; it is intriguing just to look at the partial list of objects that constitute the virtual world, just as it can be helpful to consider the components of a programming language, computer game, or electronic literature work. But considering those networked systems that provide a real-time communications system, with a graphical representation of each user in a simulated space, brings different dynamics of user activity and information exchange to the forefront—highlighting, as Morningstar and Farmer explain, the role of economics, the futility of naive central planning in systems where many users have a large role, and the need for extreme robustness and reliable standards, neither of which is usually a concern for the computer gaming industry. What isn't needed to tackle such issues is a 1 GHz chip: a look back reveals that for such investigations, a Commodore 64 will do nicely.

—NM

Some genuinely new issues with virtual environments were exposed in the late 1990s. For instance, a class-action lawsuit was brought against Origin by *Ultima Online* players after they experienced downtime and lag. No problems inspired that much ire on *Habitat*, despite its more primitive underlying technologies.

### Further Reading

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# The Lessons of Lucasfilm's Habitat

## Chip Morningstar and F. Randall Farmer

### Introduction

Lucasfilm's Habitat project was one of the first attempts to create a very large-scale, commercial, many-user, graphical virtual environment. A far cry from many laboratory research efforts based on sophisticated interface hardware and tens of thousands of dollars per user of dedicated computing power, Habitat is built on top of an ordinary commercial on-line service and uses an inexpensive—some would say “toy”—home computer to support user interaction. In spite of these somewhat plebeian underpinnings, Habitat is ambitious in its scope. The system we developed can support a population of thousands of users in a single shared cyberspace. Habitat presents its users with a real-time animated view into an on-line simulated world in which users can communicate, play games, go on adventures, fall in love, get married, get divorced, start businesses, found religions, wage wars, protest against them, and experiment with self-government.

The Habitat project proved to be a rich source of insights into the nitty-gritty reality of actually implementing a serious, commercially viable cyberspace environment. Our experiences developing the Habitat system, and managing the virtual world that resulted, offer a number of interesting and important lessons for prospective cyberspace architects. The purpose of this chapter is to discuss some of these lessons. Our hope is that the next generation of builders of virtual worlds can benefit from our experiences and (especially) from our mistakes.

Due to space limitations, we will not be able to go into as much technical detail as we might like; this will have to be left to a future publication. Similarly, we will only be able to touch briefly upon some of the history of the project as a business venture, which is a fascinating subject of its own.

Although we will conclude with a brief discussion of some of the future directions for this technology, a more detailed exposition on this topic will also have to wait for a future occasion.

The essential lesson that we have abstracted from our experiences with Habitat is that a cyberspace is defined more by the interactions among the actors within it than by the technology with

which it is implemented. While we find much of the work presently being done on elaborate interface technologies—DataGloves, head-mounted displays, special-purpose rendering engines, and so on—both exciting and promising, the almost mystical euphoria that currently seems to surround all this hardware is, in our opinion, both excessive and somewhat misplaced. We can't help having a nagging sense that it's all a bit of a distraction from the really pressing issues. At the core of *our* vision is the idea that cyberspace is necessarily a *many-participant environment*. It seems to us that the things that are important to the inhabitants of such an environment are the capabilities available to them, the characteristics of the other people they encounter there, and the ways these various participants can affect one another. Beyond a foundation set of communications capabilities, the details of the technology used to present this environment to its participants, while sexy and interesting, are of relatively peripheral concern.

Lucasfilm's Habitat was created by Lucasfilm Games, a division of LucasArts Entertainment Company, in association with Quantum Computer Services, Inc.

### What Is Habitat?

Habitat is a “many-player online virtual environment” (its purpose is to be an entertainment medium; consequently, the users are called “players”). Each player uses his or her home computer as a frontend, communicating over a commercial packet-switching data network to a centralized backend system. The frontend provides the user interface, generating a real-time animated display of what is going on and translating input from the player into requests to the backend. The backend maintains the world model, enforcing the rules and keeping each player's frontend informed about the constantly changing state of the universe. The backend enables the players to interact not only with the world but with each other.

Habitat was inspired by a long tradition of “computer hacker science fiction,” notably Vernor Vinge’s story, “True Names” (1981), as well as many fond childhood memories of games of make-believe, more recent memories of role-playing games and the like, and numerous other influences too thoroughly blended to pinpoint. To this we added a dash of silliness, a touch of cyberpunk (Gibson 1984, Sterling 1986), and a predilection for object-oriented programming (Abelson and Sussman 1985).

The initial incarnation of Habitat uses a Commodore 64 for the frontend. Figure 46.1 is a typical screen from this version of the system.<sup>1</sup> The largest part of the screen is devoted to the graphics display. This is an animated view of the player’s current location in the Habitat world. The scene consists of various objects arrayed on the screen, such as the houses and tree. The players are represented by animated figures that we call “Avatars.” Avatars are usually, though not exclusively, humanoid in appearance. In Figure 46.1 you can see two of them, carrying on a conversation.

Avatars can move around, pick up, put down, and manipulate objects, talk to each other, and gesture, each under the control of an individual player. Control is through the joystick, which enables the player to point at things and issue commands. Talking is accomplished by typing on the keyboard. The text that a player types is displayed over his or her Avatar’s head in a cartoon-style “word balloon.”

A Habitat world is made up of a large number of discrete locations that we call “regions.” In its prime, the prototype Habitat world consisted of around 20,000 of them. Each region can adjoin up to four other regions, which can be reached simply by walking your Avatar to one or another edge of the screen. Doorways and other passages can connect to additional regions. Each region contains a set of objects that define the things that an Avatar can do there and the scene that the player sees on the computer screen.

Some of the objects are structural, such as the ground or the sky. Many are just scenic, such as the tree or the mailbox. Most objects, however, have some function that they perform. For example, doors transport Avatars from one region to another and may be opened, closed, locked, and unlocked. ATMs (Automatic Token Machines) enable access to an Avatar’s bank account.<sup>2</sup> Vending machines dispense useful goods in exchange for Habitat money. Many objects are portable and may be carried around in an Avatar’s hands



Figure 46.1. A typical Habitat scene (© 1986 LucasArts Entertainment Company).

or pockets. These include various kinds of containers, money, weapons, tools, and exotic magical implements. Table 46.1 lists some of the most important types of objects and their functions. The complete list of object types numbers in the hundreds.

## Implementation

The following, along with several programmer-years of tedious and expensive detail that we won’t cover here, is how the system works:

At the heart of the Habitat implementation is an object-oriented model of the universe.

The frontend consists of a system kernel and a collection of objects. The kernel handles memory management, display generation, disk I/O, telecommunications, and other “operating system” functions. The objects implement the semantics of the world itself. Each type of Habitat object has a definition consisting of a set of resources, including animation cells to drive the display, audio data, and executable code. An object’s executable code implements a series of standard behaviors, each of which is invoked by a different player command or system event. The model is similar to that found in an object-oriented programming system such as Smalltalk (Goldberg and Robson 1983), with its classes, methods, and messages. These resources consume significant amounts of scarce frontend memory, so we can’t keep them all in core at the same time. Fortunately, their definitions are invariant, so we simply swap them in from disk as we need them, discarding less recently used resources to make room.

When an object is instantiated, we allocate a block of memory to contain the object's state. The first several bytes of an object's state information take the same form in all objects, and include such things as the object's screen location and display attributes. This standard information is interpreted by the system kernel as it generates the display and manages the run-time environment. The remainder of the state information varies with the object type and is accessed only by the object's behavior code.

Object behaviors are invoked by the kernel in response to player input. Each object responds to a set of standard verbs that map directly onto the commands available to the player. Each behavior is simply a subroutine that executes the indicated action; to do this it may invoke the behaviors of other objects or send request messages to the backend. Besides the standard verb behaviors, objects may have additional behaviors that are invoked by messages that arrive asynchronously from the backend.

The backend also maintains an object-oriented representation of the world. As in the frontend, objects on the backend possess executable behaviors and in-memory state information. In addition, since the backend maintains a persistent global state for the entire Habitat world, the objects are also represented by database records that may be stored on disk when not "in use." Backend object behaviors are invoked by messages from the frontend. Each of these backend behaviors works in roughly the same way: a message is received from a player's frontend requesting some action; the action is taken and some state changes to the world result; the backend behavior sends a response message back to the frontend informing it of the results of its request and notification messages to the frontends of any other players who are in the same region, informing *them* of what has taken place.

## The Lessons

In order to say as much as we can in a limited space, we will describe what we think we learned through a series of principles or assertions surrounded by supporting reasoning and illustrative anecdotes. As cyberspace develops, a more formal and thorough exposition may be called for.

We mentioned our primary principle earlier:

**The idea of a many-user environment is central to cyberspace.**

It is our deeply held conviction that one of the defining characteristics of a cyberspace system is that it represents a many-user environment. This stems from the fact that what (in our opinion) people seek in a virtual world is richness, complexity, and depth. With our best science and technology we do not possess the ability to produce an

Table 46.1

### Some important objects

Object Class	Function
ATM	Automatic Token Machine; Access to an Avatar's Bank Account
Avatar	Represents the player in the Habitat world
Bag, Box	Containers in which things may be carried
Book	Document for Avatars to read (e.g., the daily newspaper)
Bureaucrat-in-a-box	Communication with system operators
Change-o-matic	Device to change Avatar gender
Chest, Safe	Containers in which things may be stored
Club, Gun, Knife	Various weapons
Compass	Points direction to West Pole
Door	Passage from one region to another; can be locked
Drugs	Various types; changes Avatar body state, e.g., cure wounds
Elevator	Transportation from one floor of a tall building to another
Flashlight	Provides light in dark places
Fountain	Scenic highlight; provides communication to system designers
Game piece	Enables various board games: backgammon, checkers, chess, etc.
Garbage can	Disposes of unwanted objects
Glue	System building tool; attached objects together
Ground, Sky	The underpinnings of the world
Head	An Avatar's head; comes in many styles; for customization
Key	Unlocks doors and other containers
Knick-Knack	Generic inert object; for decorative purposes
Magic Wand	Various types, can do almost anything
Plant, Rock, Tree	Generic scenic objects
Region	The foundation of reality
Sensor	Various types, detects otherwise invisible conditions in the world
Sign	Allows attachment of text to other objects
Stun Gun	Nonlethal weapons
Teleport booth	Means of quick long-distance transport; analogous to phone booth
Tokens	Habitat money
Vendroid	Vending machine; sells things

automaton that even approaches the complexity of a real human being, let alone a society. Our approach, then, was and is not even to attempt this, but instead to use the computational *medium* to augment the communications channels between real people.

If what we are constructing is a many-user environment, it naturally follows that some sort of communications capability must be fundamental to our system. However, we must take into account an observation that is the second of our principles:

**Communications bandwidth is a scarce resource.**

This point was driven home to us by one of Habitat's nastier, externally imposed, design constraints, namely, that it provide a satisfactory experience to the player over a 300-baud serial telephone connection (one routed, moreover, through commercial packet-switching networks that impose an additional, uncontrollable latency of 100 to 5000 milliseconds on each packet transmitted).

Even in a more technically advanced network, however, bandwidth remains scarce in the sense that economists use the term: available carrying capacity is not unlimited. The law of supply and demand suggests that no matter how much capacity is available, you always want more. When communications technology advances to the point where we all have multigigabaud fiber-optic connections into our homes, computational technology will have advanced to match. Our processors' expanding appetite for data will mean that the search for ever more sophisticated data compression techniques will *still* be a hot research area (though what we are compressing may at that point be high-resolution volumetric time-series or something even more esoteric) (Drexler 1986).

Computer scientists tend to be reductionists who like to organize systems in terms of primitive elements that can be easily manipulated within the context of a simple formal model. Typically, you adopt a small variety of very simple primitives, which are then used in large numbers. For a graphics-oriented cyberspace system, the temptation is to build upon bit-mapped images or polygons or some other *graphic* primitive. These sorts of representations, however, are invitations to disaster. They arise from an inappropriate fixation on display technology, rather than on the underlying purpose of the system.

However, the most significant part of what *we* wish to be communicating are human behaviors. These, fortunately, can

be represented quite compactly, provided we adopt a relatively abstract, high-level description that deals with behavioral concepts directly. This leads to our third principle:

**An object-oriented data representation is essential.**

Taken at its face value, this assertion is unlikely to be controversial, as object-oriented programming is currently the methodology of choice among the software engineering cognoscenti. However, what we mean here is not only that you should adopt an object-oriented approach, but that the basic objects from which you build the system should correspond more or less to the objects in the user's conceptual model of the virtual world, that is, people, places, and artifacts. You could, of course, use object-oriented programming techniques to build a system based on, say, polygons, but that would not help to cope with the fundamental problem.

The goal is to enable the communications between machines to take place primarily at the behavioral level (what people and things are doing) rather than at the presentation level (how the scene is changing). The description of a place in a virtual world should be in terms of what is there rather than what it looks like. Interactions between objects should be described by functional models rather than by physical ones. The computation necessary to translate between these higher-level representations and the lower-level representations required for direct user interaction is an essentially local function. At the local processor, display-rendering techniques may be arbitrarily elaborate and physical models arbitrarily sophisticated. The data channel capacities required for such computations, however, need not and should not be squeezed into the limited bandwidth available between the local processor and remote ones. Attempting to do so just leads to disasters such as NAPLPS (ANSI 1983, Alber 1985), which couples dreadful performance with a display model firmly anchored in the technology of the 1970s.

Once we began working at the conceptual rather than the presentation level, we were struck by the following observation:

**The implementation platform is relatively unimportant.**

The presentation level and the conceptual level cannot (and should not) be *totally* isolated from each other. However, defining a cyberspace in terms of the configuration and

## 46. Lucasfilm's Habitat

behavior of objects, rather than their presentation, enables us to span a vast range of computational and display capabilities among the participants in a system. This range extends both upward and downward. As an extreme example, a typical scenic object, such as a tree, can be represented by a handful of parameter values. At the lowest conceivable end of things might be an ancient Altair 8800 with a 300-baud ASCII dumb terminal, where the interface is reduced to fragments of text and the user sees the humble string so familiar to the players of text adventure games: "There is a tree here." At the high end, you might have a powerful processor that generates the image of the tree by growing a fractal model and rendering it three dimensions at high resolution, the finest details ray-traced in real time, complete with branches waving in the breeze and the sound of wind in the leaves coming through your headphones in high-fidelity digital stereo. And these two users might be looking at the same tree in the same place in the same world and talking to each other as they do so. Both of these scenarios are implausible at the moment, the first because nobody would suffer with such a crude interface when better ones are so readily available, the second because the computational hardware does not yet exist. The point, however, is that this approach covers the ground between systems already obsolete and ones that are as yet gleams in their designers' eyes. Two consequences of this are significant. The first is that we can build effective cyberspace systems today. Habitat exists as ample proof of this principle. The second is that it is conceivable that with a modicum of cleverness and foresight you could start building a system with today's technology that could evolve smoothly as tomorrow's technology develops. The availability of pathways for growth is important in the real world, especially if cyberspace is to become a significant communications medium (as we obviously think it should).

Given that we see cyberspace as fundamentally a communications medium rather than simply a user interface model, and given the style of object-oriented approach that we advocate, another point becomes clear:

### **Data communications standards are vital.**

However, our concerns about cyberspace data communications standards center less upon data transport protocols than upon the definition of the data being transported. The mechanisms required for reliably getting bits from point A to point B are not terribly interesting to us. This is not because these mechanisms are not essential (they

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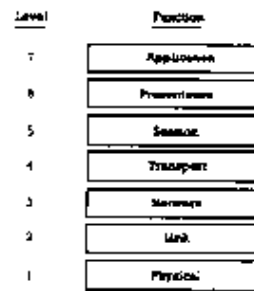


Figure 46.2. The 7-layer ISO reference model of open system interconnection.

obviously are) nor because they do not pose significant research and engineering challenges (they clearly do). It is because we were focused on the unique communications needs of an object-based cyberspace. We were concerned with the protocols for sending messages between objects, that is, for communicating behavior rather than presentation, and for communicating object definitions from one system to another.

Communicating object definitions seems to us to be an especially important problem, and one that we really did not have an opportunity to address in Habitat. It *will* be necessary to address this problem if we are to have a dynamic system in the future. Once the size of the system's user base has grown modestly large, it becomes impractical to distribute a new release of the system software every time one wants to add a new class of object. However, we feel the ability to add new classes of objects over time is crucial if the system is to be able to evolve.

While we are on the subject of communications standards, we would like to make some remarks about the ISO Reference Model of Open System Interconnection (ISO 1986). This seven-layer model has become a centerpiece of most discussions about data communications standards today. It is so firmly established in the data communications standards community that it is virtually impossible to find a serious contemporary publication on the subject that does not begin with some variation on Figure 46.2. Unfortunately, while the bottom four or five layers of this model provide a more or less sound framework for considering data transport issues, we believe that the model's Presentation and Application layers are not very helpful when considering cyberspace data communications.

We have two main quarrels with the ISO model: first, it partitions the general data communications problem in a

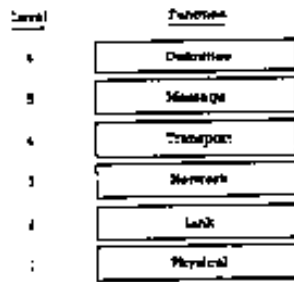


Figure 46.3. A possible alternative protocol model.

way that is a poor match for the needs of a cyberspace system; second, and more important, we think that the model itself is an active source of confusion because it focuses the attention of system designers on the wrong set of issues and thus leads them to spend their time solving the wrong set of problems. We know because this happened to us. “Presentation” and “Application” are simply the wrong abstractions for the higher levels of a cyberspace communications protocol. A “Presentation” protocol presumes that at least some characteristics of the display are embedded in the protocol. The discussions above should give some indication why we think that such a presumption is both unnecessary and unwise. Certainly, an “Application” protocol presumes a degree of foreknowledge of the message environment that is incompatible with the sort of dynamically evolving object system we envision.

A better model would be to substitute a different pair of top layers (Figure 46.3): a Message layer, which defines the means by which objects can address one another and standard methods of encapsulating structured data and encoding low-level data types (numbers); and a Definition layer built on top of the Message layer, which defines a standard representation for object definitions so that object classes can migrate from machine to machine. One might argue that these are simply Presentation and Application with different labels. However, the differences are so easily reconciled. In particular, we think the ISO model has, however unintentionally, systematically deflected workers in the field from considering many of the issues that concern us.

## World Building

There were two sorts of implementation challenges that Habitat posed. The first was the challenge of creating a

working piece of technology—developing the animation engine, the object-oriented virtual memory, the message-passing pseudo operating system, and squeezing them all into the ludicrous Commodore 64 (the backend system also posed interesting technical problems, but its constraints were not as vicious). The second challenge was the creation and management of the Habitat world itself. It is the experiences from the latter exercise that we think will be most relevant to future cyberspace designers.

Initially, we were our own worst enemies in this undertaking, victims of a way of thinking to which all engineers are dangerously susceptible. This way of thinking is characterized by the conceit that all things may be planned in advance and then directly implemented according to the plan’s detailed specification. For persons schooled in the design and construction of systems based on simple, well-defined, and well-understood foundation principles, this is a natural attitude to have. Moreover, it is entirely appropriate when undertaking most engineering projects. It is a frame of mind that is an essential part of a good engineer’s conceptual tool kit. Alas, in keeping with Maslow’s assertion that “to the person who has only a hammer, all the world looks like a nail,” it is a frame of mind that is easy to carry beyond its range of applicability. This happens when a system exceeds the threshold of complexity above which the human mind loses its ability to maintain a complete and coherent model.

One generally hears about systems crossing the complexity threshold when they become very large. For example, the Space Shuttle and the B-2 bomber are both systems above this threshold, necessitating extraordinarily involved, cumbersome, and time-consuming procedures to keep the design under control—procedures that are at once vastly expensive and only partially successful. To a degree, the complexity of a problem can be dissolved by “throwing money” at it: faster computers, more managers, more bureaucratic procedures, and so on. However, such capital-intensive management techniques are a luxury not available to most projects. Furthermore, although these “solutions” to the complexity problem may be out of reach of most projects, alas the complexity threshold itself is not. Smaller systems can suffer from the same sorts of problems. It is possible to push much smaller and less elaborate systems over the complexity threshold simply by introducing chaotic elements that are outside the designers’ sphere of control or understanding. The most significant of such chaotic

elements are autonomous computational agents (other computers). This is why, for example, debugging even very simple communications protocols often proves surprisingly difficult. Furthermore, a special circle of living hell awaits the implementors of systems involving that most important category of autonomous computational agents of all: groups of interacting human beings. This leads directly to our next (and possibly most controversial) assertion:

**Detailed central planning is impossible; don't even try.**

The constructivist prejudice that leads engineers into the kinds of problems just mentioned has received more study from economists, philosophers, and sociologists (Popper 1962, 1972; Hayek 1973, 1978, 1989; Sowell 1987) than from researchers in the software engineering community. Game and simulation designers are experienced in creating closed virtual worlds for individuals and small groups. However, they have had no reason to learn to deal with large populations of simultaneous users. Each user or small group is unrelated to the others, and the same world can be used over and over again. If you are playing an adventure game, the fact that thousands of other people elsewhere in the (real) world are playing the same game has no effect on your experience. It is reasonable for the creator of such a world to spend tens or even hundreds of hours crafting the environment for each hour that a user will spend interacting with it, since that user's hour of experience will be duplicated tens of thousands of times by tens of thousands of other individual users.

Builders of today's on-line services and communications networks are experienced in dealing with large user populations, but they do not, in general, create elaborate environments. Furthermore, in a system designed to deliver information or communications services, large numbers of users are simply a load problem rather than a complexity problem. All users get the same information or services; the comments in the previous paragraph regarding duplication of experience apply here as well. It is not necessary to match the size and complexity of the information space to the size of the user population. While it may turn out that the quantity of information available on a service is largely a function of the size of the user population itself, this information can generally be organized into a systematic structure that can still be maintained by a few people. The bulk of this information is produced by the users themselves,

rather than the system designers. (This observation, in fact, is the first clue to the solution to our problem.)

Our original, contractual specification for Habitat called for us to create a world capable of supporting a population of 20,000 Avatars, with expansion plans for up to 50,000. By any reckoning this was a large undertaking and complexity problems would certainly be expected. However, in practice we exceeded the complexity threshold very early in development. By the time the population of our on-line community had reached around 50 we were in over our heads (and these 50 were "insiders" who were prepared to be tolerant of holes and rough edges).

Moreover, a virtual world such as Habitat needs to scale with its population. For 20,000 Avatars we needed 20,000 "houses," organized into towns and cities with associated traffic arteries and shopping and recreational areas. We needed wilderness areas between the towns so that everyone would not be jammed together into the same place. Most of all, we needed things for 20,000 people to do. They needed interesting places to visit—and since they can't all be in the same place at the same time, they needed a *lot* of interesting places to visit—and things to do in those places. Each of those houses, towns, roads, shops, forests, theaters, arenas, and other places is a distinct entity that someone needs to design and create. Attempting to play the role of omniscient central planners, we were swamped.

Automated tools may be created to aid the generation of areas that naturally possess a high degree of regularity and structure, such as apartment buildings and road networks. We created a number of such tools, whose spiritual descendents will no doubt be found in the standard bag of tricks of future cyberspace architects. However, the very properties that make some parts of the world amenable to such techniques also make those same parts of the world among the least important. It is really not a problem if every apartment building looks pretty much like every other. It is a big problem if every enchanted forest looks the same. Places whose value lies in their uniqueness, or at least in their differentiation from the places around them, need to be crafted by hand. This is an incredibly labor-intensive and time-consuming process. Furthermore, even very imaginative people are limited in the range of variation that they can produce, especially if they are working in a virgin environment uninfluenced by the works and reactions of other designers.

## Running the World

The world design problem might still be tractable, however, if all players had the same goals, interests, motivations, and types of behavior. Real people, however, are all different. For the designer of an ordinary game or simulation, human diversity is not a major problem, since he or she gets to establish the goals and motivations on the participants' behalf, and to specify the activities available to them in order to channel events in the preferred direction. Habitat, however, was deliberately open-ended and pluralistic. The idea behind our world was precisely that it did not come with a fixed set of objectives for its inhabitants, but rather provided a broad palette of possible activities from which the players could choose, driven by their own internal inclinations. It was our intention to provide a variety of possible experiences, ranging from events with established rules and goals (a treasure hunt, for example) to activities propelled by the players' personal motivations (starting a business, running the newspaper) to completely free-form, purely existential activities (hanging out with friends and conversing). Most activities, however, involved some degree of planning and setup on our part. We were to be like the cruise director on a ocean voyage, but it turned out we were still thinking like game designers.

The first goal-directed event planned for Habitat was a rather involved treasure hunt called the "D'nalsi Island Adventure." It took us hours to design, weeks to build (including a 100-region island), and days to coordinate the actors involved. It was designed much like the puzzles in an adventure game. We thought it would occupy our players for days. In fact, the puzzle was solved in about 8 hours by a person who had figured out the critical clue in the first 15 minutes. Many of the players hadn't even had a chance to get into the game. The result was that one person had had a wonderful experience, dozens of others were left bewildered, and a huge investment in design and setup time had been consumed in an eye blink. We expected that there would be a wide range of "adventuring" skills in the Habitat audience. What wasn't so obvious until afterward was that this meant that most people didn't have a very good time, if for no other reason than that they never really got to participate. It would clearly be foolish and impractical for us to do things like this on a regular basis.

Again and again we found that activities based on often unconscious assumptions about player behavior had

completely unexpected outcomes (when they were not simply outright failures). It was clear that we were not in control. The more people we involved in something, the less in control we were. We could influence things, we could set up interesting situations, we could provide opportunities for things to happen, but we could not predict or dictate the outcome. Social engineering is, at best, an inexact science, even in protocyberspaces. Or, as some wag once said, "In the most carefully constructed experiment under the most carefully controlled conditions, the organism will do whatever it damn well pleases."

Propelled by these experiences, we shifted into a style of operations in which we let the players themselves drive the direction of the design. This proved far more effective. Instead of trying to push the community in the direction we thought it should go, an exercise rather like herding mice, we tried to observe what people were doing and aid them in it. We became facilitators as much as designers and implementors. This often meant adding new features and new regions to the system at a frantic pace, but almost all of what we added was used and appreciated, since it was well matched to people's needs and desires. As the experts on how the system worked, we could often suggest new activities for people to try or ways of doing things that people might not have thought of. In this way we were able to have considerable influence on the system's development in spite of the fact that we didn't really hold the steering wheel—more influence, in fact, than we had had when we were operating under the delusion that we controlled everything.

Indeed, the challenges posed by large systems in general are prompting some researchers to question the centralized, planning-dominated attitude that we have criticized here, and to propose alternative approaches based on evolutionary and market principles (Miller and Drexler 1988a, 1988b; Drexler and Miller 1988). These principles appear applicable to complex systems of all types, not merely those involving interacting human beings.

## The Great Debate

Among the objects we made available to Avatars in Habitat were guns and various other sorts of weapons. We included these because we felt that players should be able to "materially" effect each other in ways that went beyond simply talking, ways that required real moral choices to be made by the participants. We recognized the age-old

storyteller's dictum that conflict is the essence of drama. Death in Habitat was, of course, not like death in the real world! When an Avatar is killed, he or she is teleported back home, head in hands (literally), pockets empty, and any object in hand at the time dropped on the ground at the scene of the crime. Any possessions carried at the time are lost. It was more like a setback in a game of "Chutes and Ladders" than real mortality. Nevertheless, the death metaphor had a profound effect on people's perceptions. This potential for murder, assault, and other mayhem in Habitat was, to put it mildly, controversial. The controversy was further fueled by the potential for lesser crimes. For instance, one Avatar could steal something from another Avatar simply by snatching the object out its owner's hands and running off with it.

We had imposed very few rules on the world at the start. There was much debate among the players as to the form that Habitat society should take. At the core of much of the debate was an unresolved philosophical question: Is an Avatar an extension of a human being (thus entitled to be treated as you would treat a real person) or a Pac-Man-like critter destined to die a thousand deaths or something else entirely? Is Habitat murder a crime? Should all weapons be banned? Or is it all "just a game"? To make a point, one of the players took to randomly shooting people as they roamed around. The debate was sufficiently vigorous that we took a systematic poll of the players. The result was ambiguous: 50 percent said that Habitat murder was a crime and shouldn't be a part of the world, while the other 50 percent said it was an important part of the fun.

We compromised by changing the system to allow thievery and gunplay only outside the city limits. The wilderness would be wild and dangerous while civilization would be orderly and safe. This did not resolve the debate, however. One of the outstanding proponents of the antiviolence point of view was motivated to open the first Habitat church, the Order of the Holy Walnut (in real life he was a Greek Orthodox priest). His canons forbid his disciples to carry weapons, steal, or participate in violence of any kind. His church became quite popular and he became a very highly respected member of the Habitat community.

Furthermore, while we had made direct theft impossible, one could still engage in indirect theft by stealing things set on the ground momentarily or otherwise left unattended. And the violence still possible in the outlands continued to

bother some players. Many people thought that such crimes ought to be prevented or at least punished somehow, but they had no idea how to do so. They were accustomed to a world in which law and justice were always provided by somebody else. Somebody eventually made the suggestion that there ought to be a Sheriff. We quickly figured out how to create a voting mechanism and rounded up some volunteers to hold an election. A public debate in the town meeting hall was heavily attended, with the three Avatars who had chosen to run making statements and fielding questions. The election was held, and the town of Populopolis acquired a Sheriff.

For weeks the Sheriff was nothing but a figurehead, though he was a respected figure and commanded a certain amount of moral authority. We were stumped about what powers to give him. Should he have the right to shoot anyone anywhere? Give him a more powerful gun? A magic wand to zap people off to jail? What about courts? Laws? Lawyers? Again we surveyed the players, eventually settling on a set of questions that could be answered via a referendum. Unfortunately, we were unable to act on the results before the pilot operations ended and the version of the system in which these events took place was shut down. It was clear, however, that there are two basic camps: anarchists and statist. This division of characters and world views is an issue that will need to be addressed by future cyberspace architects. However, our view remains that a virtual world need not be set up with a "default" government, but can instead evolve one as needed.

### A Warning

Given the above exhortation that control should be released to the users, we need to inject a note of caution and present our next assertion:

#### **You can't trust anyone.**

This may seem like a contradiction of much of the preceding, but it really is not. Designers and operators of a cyberspace system must inhabit two levels of "virtuality" at once. The first we call the "infrastructure level," the level of implementation, where the laws that govern "reality" have their genesis. The second we call the "experiential level," which is what the users see and interact with. It is important that there not be "leakage" between these two levels. The first level defines the physics of the world. If its integrity is breached, the consequences can range from aesthetic

unpleasantness (the audience catches a glimpse of the scaffolding behind the false front) to psychological disruption (somebody does something “impossible,” thereby violating users’ expectations and damaging their fantasy) to catastrophic failure (somebody crashes the system). When we exhort cyberspace system designers to give control to the users, we mean control at the experiential level. When we say that you can’t trust anyone, we mean that you can’t trust them with access to the infrastructure level. Some stories from Habitat will illustrate this.

When designing a piece of software, you generally assume that the software is the sole intermediary between the user and the underlying data being manipulated (possibly multiple applications will work with the same data, but the principle remains the same). In general, the user need not be aware of how data are encoded and structured inside the application. Indeed, the very purpose of a good application is to shield the user from the ugly technical details. While it is conceivable that a technically astute person who is willing to invest the time and effort could decipher the internal structure of things, this would be an unusual thing to do as there is rarely much advantage to be gained. The purpose of the application itself is, after all, to make access to and manipulation of the data easier than digging around at the level of bits and bytes. There are exceptions to this, however. For example, most game programs deliberately impose obstacles on their players in order for play to be challenging. By tinkering around with the insides of such a program—dumping the data files and studying them, disassembling the program itself and possibly modifying it—it may be possible to “cheat.” However, this sort of cheating has the flavor of cheating at solitaire: the consequences adhere to the cheater alone. There is a difference, in that disassembling a game program is a puzzle-solving exercise in its own right, whereas cheating at solitaire is pointless, but the satisfactions to be gained from either, if any, are entirely personal.

If, however, a computer game involves multiple players, then delving into the program’s internals can enable one to truly cheat, in the sense that one gains an unfair advantage over the other players, an advantage moreover of which they may be unaware. Habitat is such a multiplayer game. When we were designing the software, our “prime directive” was, “The backend shall not assume the validity of anything a player computer tells it.” This is because we needed to protect ourselves against the possibility that a clever user had hacked

around with his copy of the frontend program to add “custom features.” For example, we could not implement any of the sort of “skill and action” elements found in traditional video games wherein dexterity with the joystick determines the outcome of, say, armed combat, because we couldn’t guard against users modifying their copy of the program to tell the backend that they had “hit,” whether they actually had or not. Indeed, our partners at QuantumLink warned us of this very eventuality before we even started—they already had users who did this sort of thing with their regular system. Would anyone actually go to the trouble of disassembling and studying 100K or so of incredibly tight and bizarrely threaded 6502 machine code just to tinker? As it turns out, the answer is yes. People did. We were not 100 percent rigorous in following our own rule. It turned out that there were a few features whose implementation was greatly eased by breaking the rule in situations where, in our judgment, the consequences would not be material if some people “cheated” by hacking their own systems. Darned if some people didn’t hack their systems to cheat in exactly these ways.

Care must be taken in the design of the world as well. One incident that occurred during our pilot test involved a small group of players exploiting a bug in our world database that they interpreted as a feature. First, some background. Avatars were hatched with 2000 Tokens in their bank account, and each day that they logged in they received another 100T. Avatars could acquire additional funds by engaging in business, winning contests, finding buried treasure, and so on. They could spend their Tokens on, among other things, various items for sale in vending machines called Vendroids. There were also Pawn Machines, which would buy objects back (at a discount, of course).

In order to make this automated economy a little more interesting, each Vendroid had its own prices for the items in it. This was so that we could have local price variation (a widget would cost a little less if you bought it at Jack’s Place instead of The Emporium). It turned out that in two Vendroids across town from each other were two items for sale whose prices we had inadvertently set lower than what a Pawn Machine would buy them back for: Dolls (for sale at 75T, hock for 100T) and Crystal Balls (for sale at 18,000T, hock at 30,000T!). Naturally, a couple of people discovered this. One night they took all their money, walked to the Doll Vendroid, bought as many Dolls as they could, then took

them across town and pawned them. By shuttling back and forth between the Doll Vendroid and the Pawn Shop for hours, they amassed sufficient funds to buy a Crystal Ball, whereupon they continued the process with Crystal Balls and a couple orders of magnitude higher cash flow. The final result was at least three Avatars with hundreds of thousands of Tokens each. We only discovered this the next morning when our daily database status report said that the money supply had quintupled overnight.

We assumed that the precipitous increase in "T1" was due to some sort of bug in the software. We were puzzled that no bug report had been submitted. By poking around a bit we discovered that a few people had suddenly acquired enormous bank balances. We sent Habitat mail to the two richest, inquiring as to where they had gotten all that money overnight. Their reply was, "We got it fair and square! And we're not going to tell you how!" After much abject pleading on our part they eventually did tell us, and we fixed the erroneous pricing. Fortunately, the whole scam turned out well, as the nouveau riche Avatars used their bulging bankrolls to underwrite a series of treasure hunt games that they conducted on their own initiative, much to the enjoyment of many other players on the system.

### Keeping "Reality" Consistent

The urge to breach the boundary between the infrastructure level and the experiential level is not confined to the players. The system operators are also subject to this temptation, though their motivation is expediency in accomplishing their legitimate purposes rather than gaining illegitimate advantage. However, to the degree to which it is possible, we vigorously endorse the following principle:

#### **Work within the system.**

Wherever possible, things that can be done within the framework of the experiential level should be. The result will be smoother operation and greater harmony among the user community. This admonition applies to both the technical and the sociological aspects of the system.

For example, with the players in control, the Habitat world would have grown much larger and more diverse than it did had we ourselves not been a technical bottleneck. All new region generation and feature implementation had to go through us, since there were no means for players to create new parts of the world on their own. Region creation was an esoteric technical specialty, requiring a plethora of

obscure tools and a good working knowledge of the treacherous minefield of limitations imposed by the Commodore 64. It also required much behind-the-scenes activity of the sort that would probably spoil the illusion for many. One of the goals of a next generation Habitat-like system ought to be to permit far greater creative involvement by the participants *without* requiring them to ascend to full-fledged guruhood to do so.

A further example of working within the system, this time in a social sense, is illustrated by the following experience:

One of the more popular events in Habitat took place late in the test, the brainchild of one of the more active players who had recently become a QuantumLink employee. It was called the "Dungeon of Death." For weeks, ads appeared in Habitat's newspaper, *The Rant*, announcing that the Duo of Dread, DEATH and THE SHADOW, were challenging all comers to enter their lair. Soon, on the outskirts of town, the entrance to a dungeon appeared. Out front was a sign reading, "Danger! Enter at your own risk!" Two system operators were logged in as DEATH and THE SHADOW, armed with specially concocted guns that could kill in one shot, rather than the usual twelve. These two characters roamed the dungeon blasting away at anyone they encountered. They were also equipped with special magic wands that cured any damage done to them by other Avatars, so that they wouldn't themselves be killed. To make things worse, the place was littered with culde-sacs, pathological connections between regions, and various other nasty and usually fatal features. It was clear that any explorer had better be prepared to "die" several times before mastering the dungeon. The rewards were pretty good: 1000 Tokens minimum and access to a special Vendroid that sold magic teleportation wands. Furthermore, given clear notice, players took the precaution of emptying their pockets before entering, so that the actual cost of getting "killed" was minimal.

One evening, one of us was given the chance to play the role of DEATH. When we logged in, we found him in one of the dead ends with four other Avatars who were trapped there. We started shooting, as did they. However, the last operator to run DEATH had not bothered to use his special wand to heal any accumulated damage, so the character of DEATH was suddenly and unexpectedly "killed" in the encounter. As we mentioned earlier, when an Avatar is killed, any object in his hands is dropped on the ground. In this

case, said object was the special kill-in-one-shot gun, which was immediately picked up by one of the regular players who then made off with it. This gun was not something that regular players were supposed to have. What should we do?

It turned out that this was not the first time this had happened. During the previous night's mayhem the special gun was similarly absconded with. In this case, the person playing DEATH was one of the regular system operators, who, accustomed to operating the regular Q-Link service, had simply ordered the player to give back the gun. The player considered that he had obtained the weapon as part of the normal course of the game and balked at this, whereupon the operator threatened to cancel the player's account and kick him off the system if he did not comply. The player gave the gun back, but was quite upset about the whole affair, as were many of his friends and associates on the system. Their world model had been painfully violated.

When it happened to us, we played the whole incident within the role of DEATH. We sent a message to the Avatar who had the gun, threatening to come and kill her if she didn't give it back. She replied that all she had to do was stay in town and DEATH couldn't touch her (which was true, if we stayed within the system). OK, we figured, she's smart. We negotiated a deal whereby DEATH would ransom the gun for 10,000 Tokens. An elaborate arrangement was made to meet in the center of town to make the exchange, with a neutral third Avatar acting as an intermediary to ensure that neither party cheated. Of course, word got around and by the time of the exchange there were numerous spectators. We played the role of DEATH to the hilt, with lots of hokey melodramatic touches. The event was a sensation. It was written up in the newspaper the next morning and was the talk of the town for days. The Avatar involved was left with a wonderful story about having cheated DEATH, we got the gun back, and everybody went away happy.

These two very different responses to an ordinary operational problem illustrate our point. Operating within the participants' world model produced a very satisfactory result. On the other hand, taking what seemed like the expedient course, which involved violating the world model, provoked upset and dismay. Working within the system was clearly the preferred course in this case.

## Current Status

As of this writing, the North American incarnation of Lucasfilm's Habitat, QuantumLink's Club Caribe, has been operating for almost three years. It uses our original Commodore 64 frontend and a somewhat stripped-down version of our original Stratus backend software. Club Caribe now sustains a population of some 15,000 participants.

A technically more advanced version, called Fujitsu Habitat, has been operating for over a year in Japan, available on NIFtyServe. The initial frontend for this version is the new Fujitsu FM Towns personal computer, though ports to several other popular Japanese machines are planned. This version of the system benefits from the additional computational power and graphics capabilities of a newer platform, as well as the Towns' built-in CD-ROM for object imagery and sounds. However, the virtuality of the system is essentially unchanged and Fujitsu has not made significant alterations to the user interface or to any of the underlying concepts.

## Future Directions

There are several directions in which this work can be extended. Most obvious is to implement the system on more advanced hardware, enabling a more sophisticated display. A number of extensions to the user interface also suggest themselves. However, the line of development most interesting to us is to expand on the idea of making the development and expansion of the world itself part of the users' sphere of control. There are two major research areas in this. Unfortunately, we can only touch on them briefly here.

The first area to investigate involves the elimination of the centralized backend. The backend is a communications and processing bottleneck that will not withstand growth above too large a size. While we can support tens of thousands of users with this model, it is not really feasible to support millions. Making the system fully distributed, however, requires solving a number of difficult problems. The most significant of these is the prevention of cheating. Obviously, the owner of the network node that implements some part of the world has an incentive to tilt things in his favor. We think that this problem can be addressed by secure operating system technologies based on public-key cryptographic techniques (Rivest, Shamir, and Adelman 1978; Miller et al. 1987).

The second fertile area of investigation involves user configuration of the world itself. This requires finding ways to represent the design and creation of regions and objects as part of the underlying fantasy. Doing this will require changes to our conception of the world. In particular, we don't think it will be possible to conceal all of the underpinnings to those who work with them. However, all we really need to do is to find abstractions for those underpinnings that fit into the fantasy itself. Though challenging, this is, in our opinion, eminently feasible.

### Conclusion

We feel that the defining characteristic of cyberspace is the sharedness of the virtual environment, and not the display technology used to transport users into that environment. Such a cyberspace is feasible today, if you can live without head-mounted displays and other expensive graphics hardware. Habitat serves as an existence proof of this contention.

It seems clear to us that an object-oriented world model is a key ingredient in any cyberspace implementation. We feel that we have gained some insight into the data representation and communications needs of such a system. While we think that it may be premature to start establishing detailed technical standards for these things, it is time to begin the discussions that will lead to such standards in the future.

Finally, we have come to believe that the most significant challenge for cyberspace developers is to come to grips with the problems of world creation and management. While we have only made the first inroads into these problems, a few things have become clear. The most important of these is that managing a cyberspace world is not like managing the world inside a single-user application or even a conventional online service. Instead, it is more like governing an actual nation. Cyberspace architects will benefit from study of the principles of sociology and economics as much as from the principles of computer science. We advocate an agoric, evolutionary approach to world building rather than a centralized, socialistic one.

We would like to conclude with a final, if ironical, admonition, one that we hope will not be seen as overly contentious:

### Get real.

In a discussion of cyberspace on Usenet, one worker in the field dismissed Club Caribe (Habitat's current incarnation) as uninteresting, with a comment to the effect that most of the activity consisted of inane and trivial conversation. Indeed, the observation was largely correct. However, we hope some of the anecdotes recounted above will give some indication that more is going on than those inane and trivial conversations might indicate. Further, to dismiss the system on this basis is to dismiss the users themselves. They are paying money for this service. *They* don't view what they do as inane and trivial, or they wouldn't do it. To insist this presumes that one knows better than they what they should be doing. Such presumption is another manifestation of the omniscient central planner who dictates all that happens, a role that this entire chapter is trying to deflect you from seeking. In a real system that is going to be used by real people, it is a mistake to assume that the users will all undertake the sorts of noble and sublime activities that you created the system to enable. Most of them will not. Cyberspace may indeed change humanity, but only if it begins with humanity as it really is.

### Acknowledgments

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## Notes

1. One of the questions we are asked most frequently is, "Why the Commodore 64?" Many people somehow get the impression that this was a technical decision, but the real explanation has to do with business, not technology. Habitat was initially developed by Lucasfilm as a commercial product for QuantumLink, an on-line service (then) exclusively for owners of the Commodore 64. At the time we started (1985), the Commodore 64 was the mainstay of the recreational computing market. Since then it has declined dramatically in both its commercial and technical significance. However, when we began the project, we didn't get a choice of platforms. The nature of the deal was such that both the Commodore 64 for the frontend and the existing QuantumLink host system (a brace of Stratus fault-tolerant minicomputers) for the backend were givens.
2. Habitat contains its own fully-fledged economy, with money, banks, and so on. Habitat's unit of currency is the Token, reflecting the fact that it is a token economy and to acknowledge the long and honorable association between tokens and video games. Incidentally, the Habitat Token is a 23-sided plastic coin slightly larger than an American quarter, with a portrait of Vernor Vinge and the motto "Fiat Lucre" on its face, and the text "Good for one fare" on the back; these details are difficult to make out on the Commodore 64 screen.

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