Connectivity of Heterogeneous Environments

Part 1: Communication

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Abstract

In this paper we identify the incongruous nature of virtual environments and, relying on well-established standards, propose a communication architecture to facilitate the merging of heterogeneous systems. This is accomplished by relying on a standard system used by hundreds of thousands of Internet users every day, Internet Relay Chat (IRC).

Key words: Virtual Reality, Mixed Reality, Virtual Communities, Chat Worlds, Heterogeneous Environments

1. INTRODUCTION

This paper is the first in a series that identifies the problem of disjointedness found in today's virtual environments and offers a proposal for unification through unobtrusive implementation of standard and simple protocols. The goal of this stage of our research is to provide developers with the concepts needed to integrate a communication architecture within their virtual environments that will enable them to communicate with other environments that are very different in nature. Not all environments have identical requirements, and it is true that not every feature of the proposed system is necessary for a successful implementation. Therefore we attempt to offer different solutions for various environments by explaining some of our experimental developments. We believe these examples cover a majority of the needs of most of today's virtual environments. However, before we can propose methods of amalgamating these heterogeneous systems, we must first identify the requirements and characterize the diverse forms of virtual environments.

1.1. What is a Virtual Environment?

Examining the combination of dictionary definitions for each word reveals that a "virtual environment" with invisible efficacy, that is to say without the agency of the sensible part, fabricates surrounding conditions. While this may suggest that a virtual environment must envelope the user in visuals to overcome sensory requirements and produce "surrounding conditions", it does not specifically state that visuals must be represented by computer graphics nor displayed on a computer monitor. It is this very reason we find some non-graphical systems, such as text based multi-user dimensions (MUD), which predate 3D computer graphics and host virtual spaces vastly larger than their 3D counterparts, fulfilling the definitional requirements of a VE. The phrase "virtual environment" (VE) has largely become thought of as the computerized rasterization of 3D space projected on a 2D computer screen. This is certainly one instance of a VE, but additional types of environments such as a MUD are equally implicit (if not more so), and it is not uncommon for enthusiasts to claim having greater immersive virtual experiences over traditional 3D computer generated environments.

1.2. Imagination and Reality Gaps

The participant in a virtual environment has a tremendous amount of control over the quantitative and qualitative aspects of their immersive experience. It is the subject's willingness to become involved and their ability to suspend disbelief that ultimately decides how much immersion they experience [1,2]. Imagination plays an important role in today's virtual reality as even the highest quality VR systems produce experiences that are far less detailed than our own natural world, causing gaps in the suggested reality. Using our imagination, we are able to fill in these "reality gaps" and become enveloped in a virtual experience. In short, virtual environments exists when the user reaches a level of immersion that enables them to believe the artificial objects perceived, by whatever sensory device being targeted, are real. They facilitate presence for a user in a mental or physical place other than their corporeal location, or suggest to the user the existence of objects not otherwise residing in their physical proximity. It could be considered that environments such as real-time 3D rendered worlds, text-based MUD systems, or even chat rooms are all instances of virtual environments, but they exist in different "mental dimensions".

2. FRAGMENTED CYBERSPACE

It is curious that even with the vast number of VE servers available on the Internet today, from 3D games to chat rooms, there is currently no system that binds them together in any manner. Our cyberspace is fragmented and the three primary factors contributing to the fragmentation are identity, visualization, and communication. While each problem is discussed briefly here, each paper in this series will thoroughly address one. This paper will focus on the current state of communication systems in networked virtual environments and propose methods for interconnectivity.

2.1. Identity

The lack of identity users possess in today's virtual environments is remarkable. Only a few types of populated virtual environments such as MUD/MOO, Blaxxun, and Active Worlds offer any sort of avatar persistence. Even on servers hosting 3D first-person perspective games like Quake II, Tribes, or Unreal we find that players do not even have avatar continuity from one server to the other in these practically homogeneous environments. A player may enter such a world, compete for a few hours, log off and leave no evidence of previously being there. Similarly, when they connect to another server of the same type, there is no guarantee they will maintain the same identity. Because there is no identity key or authentication method, their avatar properties are not carried over. Although this problem is less prevalent in the MUD communities, it is still uncommon to find two systems that will share avatar information. This lack of identity only contributes to the feeling that these worlds are disjointed.

2.2. Visualization

Also contributing to the incoherence of networked virtual environments is the inability to travel seamlessly between different types of worlds hosted on different servers. There is no visualization of the "virtual space in between" nor is there a standard method for navigation among various worlds. The web browser has been targeted as the platform for media integration in the future, and we believe we will see it to possess stronger connectivity with virtual environments. The fact that a standard web browser can directly or indirectly provide access to a VE, through VRML or a proprietary system respectively, suggests a relation between the VE and the web browser that demonstrates the potential for all content to be presented in a VE. However, the role and responsibility of the web browser, as well as its interface, can cause added confusion in trying to accommodate seamless world travel.

2.3. Communication

Most virtual reality systems are proprietary and only facilitate communication among participants in one environment. In the rare cases where two worlds are able to intercommunicate it is also accomplished in a proprietary manner. We also find that of the few virtual environments that do offer communication facilities, they are limited to 1-to-1 or 1-to-all communication. We believe that providing an architecture for intercommunication among heterogeneous environments, as well as methods for applying communication techniques found in other community driven environments, is an apposite foundation for convergence and thus a suitable starting point for this series.

2.4. The Need to Unify

These concepts are obvious, but are they necessarily problems that are in need of rectification? Our shared vision of Cyberspace is more classical in the literary sense than what exists today; our ultimate goal being a *Gibsonian* Cyberspace. Originally, author William Gibson coined the term *Cyberspace* as a "consensual hallucination experienced daily by billions of legitimate operators…" The key phrase in this definition is *consensual hallucination*, which implies both that Cyberspace is a communal or shared experience and that imagination is relevant. We are certainly not bound to keep the definition of a science fiction author, but we believe the concept to be meaningful. Moreover it is such a system that most research into collaborative virtual environments hints to, but has not yet been able to achieve.

Addressing each fragmentation point will allow us to not only create a seamless virtual universe, but also add depth, character, and most importantly the sense of community. It is proven that multi-user environments in which participants can communicate among each other tend to be more immersive [1]. Our research focused on the communication aspects, as it is an ideal starting point for bringing a greater sense of community to isolated environments.

3. UNIFICATION VIA COMMUNICATION

3.1. IRC as a Standard Communication Protocol

In this paper we propose a communication architecture that does not enforce a proprietary protocol or implementation method upon developers. This is accomplished by relying on a standard communication system used by over one hundred thousand Internet users every day, Internet Relay Chat (IRC). The IRC protocol provides a distributed method for disseminating messages among thousands of users connected to different servers in different channels [3]. Figure 1 shows how an IRC network can consist of one or many servers connected in the form of a spanning tree. The protocol requires all servers to possess the ability to send a message in exactly one direction to reach any node on the network, thus the message delivery path is always the shortest route between two nodes on the spanning tree.

While voice chat is more likely to be the communication method of choice for VE systems of the future, there currently exists no widely accepted standard for Internet based voice communication. Text based chat was chosen as a least common demoniator solution for supporting the vastly different environments targeted.

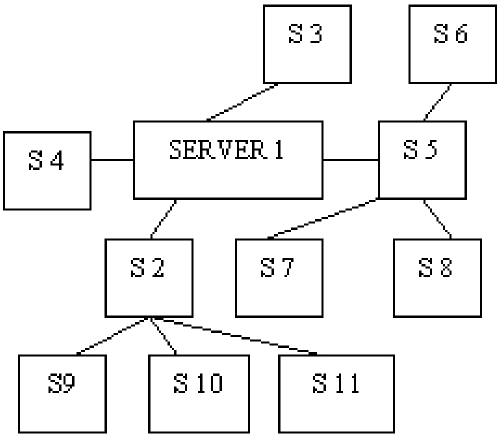

Figure 1: Format of IRC server network

3.1. A Brief History of IRC

IRC has been in existence since 1988 and the protocol began standardization in 1993 when RFC 1459 was made available to the public. Today more than 100,000 people use IRC as a communication protocol daily via various IRC client software packages and networks. In fact, it is not uncommon to see 50,000 simultaneous users on the larger networks. In August 1990, a historical dispute transpired that forever changed the IRC world. The "A-Net" (Anarchy Network) ironically proposed that a certain IRC server at Berkeley, named *eris*, was to be used as a central connecting point for all servers. A strong opposition arose and a new network called "EFnet" (Eris Free Network) was born, which remains the largest IRC network to this day.

In 1991 the Gulf War broke out and IRC immediately became a prominent platform for real-time discussion of breaking news and communication with those at the scene. Peak usage rose by a factor of 3 during this time [4]

In October of 1992 a small group of programmers set up a private IRC server with the intention of adding features to address the security and stability issues unforeseen in the original protocol design. Thus the Undernet IRC network was born and is today the second largest IRC network on the Internet [5]. The developments of the Undernet are relevant to this paper as they increase the viability of IRC being used as a backbone for mixed environment communications.

3.2. IRC Advantages

It would be mayhem if so many users communicating on the same network could see every message sent by every user. Not only would it be a tremendous flood of text, but also every message would be heard regardless of content or its intended privacy. To accommodate this, the IRC protocol defines a channel system for all communication. This allows groups of people to convene on a particular channel to communicate with more efficiency. Because IRC also regards each user as a channel, messages may be sent directly to users for private communications. This fact along with the security and management features, discussed below, makes for a robust protocol; IRC serves as a competent platform for cross environment communication.

3.3. Security and Moderation

The IRC protocol has the option of requiring password connections for all server-to-server connections. In fact, this is strongly recommended and is the primary point of dispute that led to the the split between the A-Net and EFnet networks, as A-Net proposed an open network where no server passwords were required. This in effect would have been chaotic and the "Anarchy Net" would have earned its name.

Server operators have all of the abilities of a channel operator, discussed below, as well as the ability to remove and/or ban troublesome users from the entire IRC network.

IRC channels are dynamic in the sense that they are created when the first user attempts to join them and they are destroyed when the last user leaves. The IRC protocol provides many useful mechanisms for moderating channel communication. It allows the channel operator(s) (creator of the channel) to not only control who on the channel has the ability to speak, but to remove or ban troublesome users, create invitation only channels, and grant or revoke operator privileges to other users.

3.4. Problems with the Standard IRC Protocol

Some of the major problems currently plaguing the EFnet are collision of nicknames and channels when two servers split, or drop connection between each other, attempt to rejoin. Due to this, some aggressive users are able to occasionally "take over" channels or knock other users off the system. The additional Undernet developments have improved the IRC servers adding more security features addressing these problems directly. It is for this reason, we chose to use IRC servers enhanced with the Undernet developments for our research.

4. OBJECTIVE

For our research we conducted an experiment whose objective was to use IRC to enable various modes of communication among selected heterogeneous environments. This required extending the existing communication subsystems of the assorted environment servers and clients to act as simple IRC clients. To demonstrate the potential of the architecture, we intentionally chose very diverse, but highly accessible, environments. Each one implemented a small subset of IRC commands, leaving the existing communication subsystems intact as a contingency plan against interruption in VE server to IRC server network communications. The following virtual environments were selected as candidates for initial testing:

- Standard IRC Client
- Quake II
- MUD
- Unreal
- Cold (MOO)

To allow for more immersive experiences, we chose to implement 5 distinct communication modes in each environment.

- Private: “1 to 1” communication whereby any two participants may send and receive messages privately.
- Channel: “1 to many” communication whereby any participant may send a messages that are received by all members of the same channel.
- Global: “1 to many” communication whereby a participant of a given environment may send messages to all users of the same environment.
- Zone: “1 to many” communication whereby a participant of a given environment may send messages to all users within the same “zone”.
- Ambient: An environmental communication technique that filters messages in such a manner that only users in a given proximity can hear them.

Real-time 3D game engines generate the Quake II and Unreal environments, whereas MUD and Cold are text-based environments of different natures. The game engines are proprietary and only facilitate communication among participants in the same world (on the same server). There are no methods to communicate to others residing on different servers, nor are there methods for private or ambient communication. The text-based environments are more equipped for handling all forms of communication, except for cross server, as they come from the MUD or MUD Objected Oriented (MOO) background. The IRC client does not require additional development and simply allows the existing users to communicate with the inhabitants of other virtual environments given that they are all communicating on the same network of IRC servers.

Obviously the channel paradigm does not correspond directly with ambient communication concepts, so it was compulsory to develop new techniques for implementing such features without encroaching the periphery of the IRC protocol specification.

4.3. Channel Mapping in Virtual Space

The goal of this research is to add simple IRC support to each of the selected virtual environments and their viewing clients, and then provide various types of communication with the ability to send messages from one environment to another. Each user logging into the VE server is automatically logged into an IRC server by their VE client, and the VE client attempts to use the same name on IRC as the one selected for the avatar. If a nickname collision occurs, the VE client intelligently picks variations (by appending numbers to the name) until it finds a unique version. The VE server is then responsible for maintaining a table of relations between actual IRC names and names used in the environment. Figure 2 illustrates name mapping in multiple environments. Note that it is possible to have multiple users using the same name on different VE servers, however each VE server does require unique names for each inhabitant of the world instance. Some VE systems may not require or guarantee unique nicknames and consequently additional development is required.

As mentioned previously, even IRC channels (chat rooms) can be regarded as simple virtual environments if the user is able to achieve an adequate degree of immersion. Thus, if an IRC channel is thought of as a small virtual space, it is easy to extend the same philosophy to a region of a 3D virtual world or a textually described room in a MUD. However, because of their simplicity, IRC clients need not implement all communication techniques discussed here, as some of them are virtually impossible to achieve as a result of the lack of environmental descriptors. We will therefore focus on the implementation techniques for 3D and text-based MUD/MOO VE systems. Again, even in such cases it is not important to implement all of the communication modes we describe hereafter, but they have been provided for demonstrative purposes.

The following subsections describe the various techniques we used to map channel concepts to virtual environments. The IRC protocol allows users to participant in many channels at once and also allows, under certain circumstances, a user to send a message to a channel they do not belong to. These features are important to consider when examining our methods.

4.3.1. Private Communication

“1-to-1” communication is easily accomplished through IRC since every message must be directed at a user or channel. Private communication implementation requirements for any VE are minimal as such type of communication need not necessarily be world aware. It is enough to simply provide the user with an interface to type a message to a selected user. If a straightforward command line style is used, the user can use standard IRC client syntax, such as: *`/msg Bill Hello World`*.

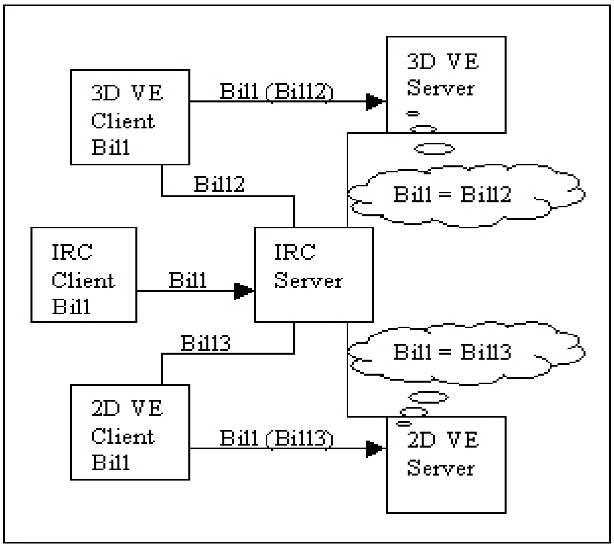

Figure 2: VE/IRC Name Mapping

4.3.2. Channel Communication

Because IRC is by nature channel oriented and the following techniques all incorporate communication through channels, it is not necessary to expound greatly on the details of implementation. Again, as in the case of private communication, providing a simple interface for the user to perform basic channel operations is sufficient. These operations include joining (creating) and leaving channels, viewing a list of members of the channel, and performing operator commands if the user has such privileges. In such cases where the user has operator status, it is important to provide an interface for performing basic channel maintenance commands such as removing or banning troublesome users, setting channel modes (invite only, secret, etc), and granting operator and voice privileges (for moderated channels).

For some of the following techniques to function properly, it is occasionally necessary to limit the user's control over certain IRC operations. However, allowing the user to have full control, as we will see, will not affect the VE communication systems negatively for the server nor participants, but only for the user if they wish to do so.

4.3.3. Global Communication

To accommodate a global communication system whereby a user is able to send a message to all participants in the same virtual environment, the virtual environments also connect to the IRC servers as clients on startup. Similarly, all clients when connecting to the VE server are added to the server's channel. This enables the server to send messages to all participants via one channel and correspondingly allows users to send messages to the server channel for dissemination among all participants.

As mentioned previously, it is possible to give the user full control over whether or not they are members of the server's channel, but doing so could have negative affects. For instance, if a system utilizes the channel count as a means of determining the number of participants in a system where the user has control over their participation in the channel, erroneous results could be returned. In such cases, it is easier to restrict the user's access based on the needs of the virtual environment. Although the protocol does not provide a mechanism for ignoring messages from users or channels, most IRC clients are foresighted enough to provide the user with a feature to "ignore" the messages sent on the channel usually through a command such as */ignore <channel>*, which generally directs the client to suppress the messages for the specified origin. This can often be a cleaner implementation when a VE requires users to be in certain channels. The VE IRC client can simply intercept channel joining and leaving commands and pass them on, or translate them to ignore commands unbeknownst to the user.

The VE global channel automatically sets the invitation only, no topic change, and no external messages channel modes. When a user enters the VE, the engine generates an event that instructs the VE operator (the server connected as an IRC client) to invite the user into the channel. The VE client processes the invitation and automatically submits a join request for the user into the particular channel. The invitation only mode is optional and can be used to prevent users in other environments from broadcasting messages.

4.3.4. Zone Communication

Zones are usually defined at world creation time for both 3D VE and MUD/MOO systems. They section off a portion of the world to either enhance display efficiency or organize the world by theme respectively. For example, a typical zone in a MUD would be "The Dark Castle", where all room descriptors that compose the castle reside in the same zone. We call this process "landmarking" and use it as a means for providing more specialized zone communication. Figure 4 illustrates a virtual world landmarked by the two prominent features of the world, the "city" and the "country".

In our Quake II and Unreal worlds, we landmarked the world by assigning zones around prominent features. Each world was zoned entirely, so that there were no empty spaces from one zone to another. Each zone is then assigned an IRC channel, and upon the VE connecting to the IRC server, each zone joins its assigned channel. For example, the restaurant in the virtual world is zoned off and assigned the channel "restaurant". As a user travels in the environment, moving from one zone to another, they also join and leave the communication channels designated by the zones. When a user sends a message to the zone, all other users residing in the same zone naturally receive it.

The zones automatically set the invite only, no topic change, secret, private, and no external messages channel modes. When a user enters the zone, the engine generates an event and that instructs the zone to invite the user into the channel. The VE client processes the invitation and automatically submits a join request for the user into the particular channel. This method easily allows users to completely turn off zone communication if the VE provides them with an option to toggle automatic joining of zone channels.

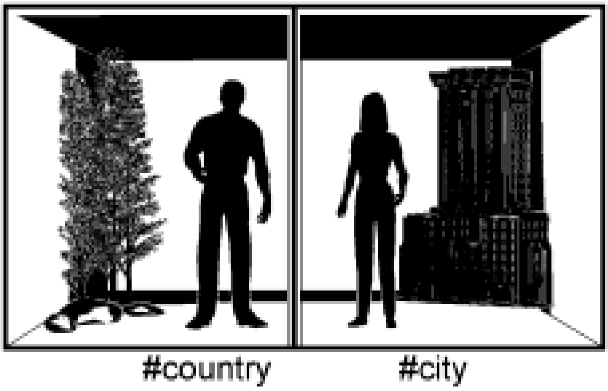

Figure 3: Landmarks (# denotes an IRC channel)

4.3.5. Ambient Communication

Ambient communication involves defining avatar proximities in which they can "hear" other avatars talking. In such cases as MUD and MOO environments, the proximity can be interpreted as being one textually described room. Because some MUD environments are known to have over 10,000 rooms, it would be inefficient to assign each room to an IRC channel. The technique we developed is identical to that method we used for proximity communication in 3D VE environments. Each user is assigned their own IRC channel at login. When two avatar communication proximities, which determine their "virtual hearing" ability, intersect or a user enters the same room as another, in the case of a text-based environment, each user automatically joins the other's channel. Likewise as the users move away from each other, they automatically leave the user channels. From our experience, the effects of this technique are a greater feeling of atmosphere among the participants. Figure 4 demonstrates proximity communication among users in a 3D VE.

It is practical for the user to have complete control over their personal channels, apart perhaps from leaving it. In our experiment we instructed the clients to automatically set invitation only modes and upon generating proximity intersection events, sent the appropriate invitations to each user. We also provided the users with an interface to toggle automatic joining upon invitation to user channels as well as whether or not to automatically invite others into their channel. By allowing users complete control over their personal channels, they can effectively control how they wish to communicate.

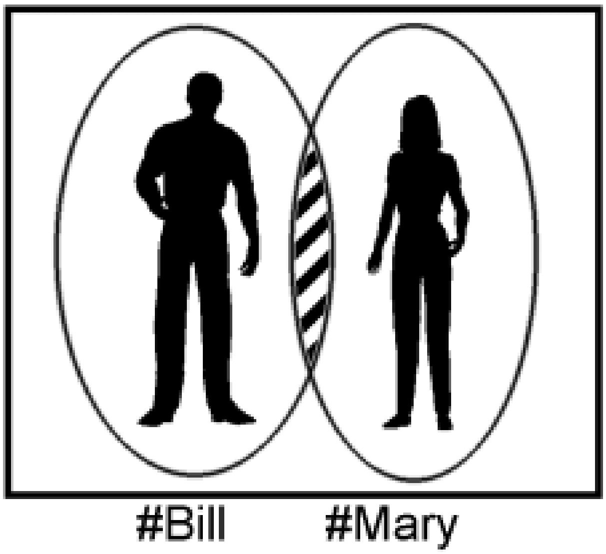

Figure 4: Ambient Communication

4.5. Applications

A primary application and aim of this architecture is to connect various different environments to eliminate the feeling of isolation when visiting one particular environment. While it is still possible to simultaneously visit a VE and communicate with other users through external programs, we feel that by incorporating a global communication system within the environment we can achieve a greater sense of community and immersion. It is certainly possible to take these concepts much further and in different directions, but if VE designers agree upon a standard protocol, it is possible to unify the environments regardless of the client side interface and implementation. Games would greatly benefit from the ambient communication techniques, as well as cross-server messaging. Collaborative VR devices such as the CAVE or Immersadesk systems could imbue participants with a greater sense of connectivity in their applications. By using a standard communication protocol, simultaneous collaborations between heterogeneous environments are more feasible.

5. CONCLUSIONS

5.1. Community

As several of the VE systems chosen for this experiment were games, we allowed a small group of users that were accustomed to, and daily played, each game to use the framework we developed on a test-bed of servers. Our developments allowed a player to communicate with not only the people sharing the same environment, but also with others in different environments. Friends were able to play different games or work on different projects, and still maintain communication regardless of their environment. Users reported having a greater sense of community and depth in those systems utilizing ambient communication techniques, and some reported that zone communication enhanced the social atmosphere when applied to appropriate landmarks.

It was largely due to the fact that the majority of the settings experienced by users of this system were game environments that the feeling inspired was usually one of community. We believe, however, that unifying communication systems of networked virtual environments can also increase efficiency of collaboration as well as eliminate the need for swapping between e-mail, chat, and instant messaging programs.

5.2. Future Work

We found that having VE servers act as IRC clients was not as elegant of a design as would have been to develop them as simple IRC servers. Part of our future work will lie in creating small libraries to easily incorporate IRC communication within all types of new and existing virtual environments, further enhancing their connectivity. We believe this will ease the burden on developers who are interested in the process of unification.

As mentioned previously, IRC was chosen as the least common denominator for these environments. Some of our other research has involved using this same architecture with real-time voice communication systems. As the average home-user's communication bandwidth continues to increase, this form of communication will increase in popularity and be more feasible for lower end networked virtual reality systems.

5.3. Virtual Reality in Mixed Dimensions

Using this well-established standard we have successfully connected a wide variety of environments including 3D game worlds, MUDs, and MOOs allowing them to intercommunicate in real-time while existing in different "dimensions". Other complex and rare environments such as the CAVE and Immersadesk systems were considered, but we preferred to focus on environments that were more accessible to the masses. It should be noted that including support for such environments is not difficult and we have plans to employ them in future research. We believe that identifying a set of standard protocols (IRC, POP3, FTP, etc) that are already in acceptance and commonly used, and integrating them with new and existing virtual environments, we can create a truly unified cyberspace. We call this unification "virtual reality in mixed dimensions" (Figure 5).

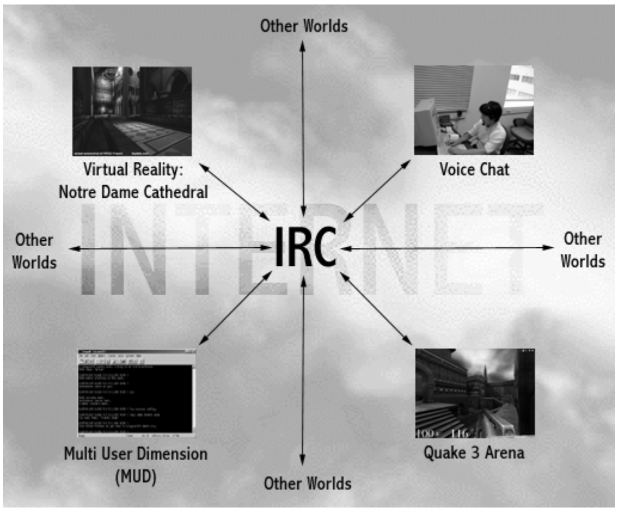

Figure 5: Virtual Reality in "Mixed Dimensions"

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