Being there

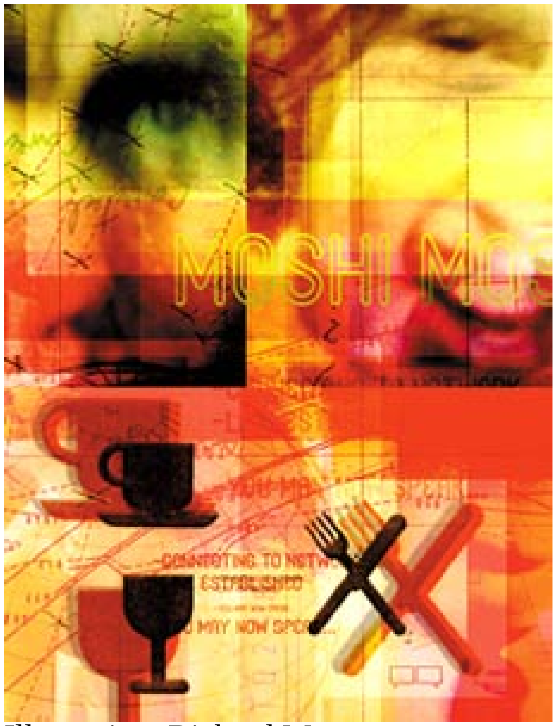

Illustration: Richard May

Imagine seeing and touching your first grandchild in a New York hospital--from Sydney. The smart 3D behind tele-immersion will make it feel just like the real thing, predicts Anil Ananthaswamy

NOT MUCH gets past the eagle-eyed sentries who guard the Internet gateway at the University of North Carolina at Chapel Hill. You'd be ultra-vigilant too, if you were watching over Internet2, the prototype next-generation Net. So when, on 9 May, the electronic traffic suddenly surged to more than four times its normal level, alarms began to ring and panic set in. Someone, somewhere was driving juggernaut-sized wodges of data over the Net. This was big . . . really big.

A swift investigation revealed that the culprits, led by UNC computer scientists Henry Fuchs and Greg Welch, had just opened a pair of portals connecting Chapel Hill with Philadelphia and New York. Through these portals, they could peer into the offices of colleagues hundreds of miles away, in life-sized three dimensions and real time. It was as if they had teleported distant chunks of space into their laboratory.

The experiment was the first demonstration of tele-immersion, which could radically change the way we communicate over long distances. Tele-immersion will allow people in different parts of the world to submerge themselves in one another's presence and feel as if they are sharing the same physical space. It's the real- world answer to the *Star Trek* Holodeck, the projection chamber on the Starship Enterprise where crew members interact with projected images as if they were real. "We call it 'being there'," says Welch.

May's experiment was the culmination of three years' work by the National Tele-Immersion Initiative (NTII), a project led by virtual reality pioneer Jaron Lanier. The test linked three of the members of the group: UNC Chapel Hill, the University of Pennsylvania in Philadelphia, and a non-profit organisation called Advanced Network and Services in Armonk, New York, where Lanier is chief scientist.

At Chapel Hill, there were two large screens, hung at right angles above a desk, plus projection cameras and head tracking gear. The screens were flat and solid, but once the demo was up and running they looked more like windows. Through the left-hand screen, Welch could see colleagues in Philadelphia as if they were sitting across the desk from him. The right-hand screen did the same for Armonk. When Welch changed his point of view, the images shifted in a natural way. If he leaned in, the images got larger, if he leaned out they got smaller. He could even crane his neck to look round the people.

To make it work, both target sites were kitted out with arrays of digital cameras to capture images and laser rangefinders to gather positional information. Computers then converted the images into 3D geometrical information and transmitted it to Chapel Hill via Internet2. There, computers reconstructed the images and projectors beamed them onto the screens.

The images were split and polarised to create a slightly different image for each eye, much like an old-fashioned 3D movie. Welch wore glasses with differently oriented polarising lenses so his left eye saw one image and his right eye the other, which his brain combined to produce 3D images. A head-mounted tracker followed Welch's movements and changed the images on the screens accordingly.

Like the first transcontinental phone call, the quality was scratchy. It was also jerky, updating around three times a second rather than 10, the minimum speed needed to capture the full range of facial expressions. And it only worked one-way: the people in Armonk and Philadelphia couldn't see Chapel Hill. Nevertheless, it moved UNC video services manager Thomas Cox to say: "It looks like somebody took a chainsaw and cut a hole in the wall and he's on the other side."

All this may sound like conventional videoconferencing. But tele-immersion is much, much more. Where videoconferencing delivers flat images to a screen, tele-immersion recreates an entire remote environment. "The person is projected life-size in 3D around you, and you can look behind them," says Kostas Daniilidis of the Pennsylvania tele-immersion team.

It's easy to dream up applications for such a technology. Business people on different continents could conduct face-to-face meetings. Schoolchildren in China, Australia or Britain could walk beneath massive dinosaur bones in a museum in New York. Patients in remote areas could see a doctor. And once haptics--touch simulators--are built in, people could use tele-immersion to come together in even stranger ways. A woman in Europe could reach out and touch her newborn grandchild in the US.

But not yet. Problem is, today's Internet can't ship data fast enough. To look anything like reality, tele-immersion will have to be able to move mountains of data--spatial and visual information about people and their environments--across the Internet in a trice. Today's 56-kilobit-per-second connections can't do that. Even the bare-bones demonstration at Chapel Hill needed 60 megabits per second. High-quality tele-immersion will require even more--around 1.2 gigabits per second.

Pioneering spirit

Fortunately, that kind of capacity is on its way. Leading the charge is Internet2, a consortium of American universities, government agencies, private companies and international organisations that is trying to recreate the collaborative spirit of the early Internet. The group is building high-speed networks and developing software with the aim of transmitting data at speeds an order of magnitude faster than the Net does now. The project's leaders say it is a unique test bed for Internet applications of the future, including tele-immersion.

In addition to high-speed networks, tele-immersion will require supercomputers to perform the trillions of calculations that are needed to portray environments in 3D. This kind of computer power would have to be on tap over the Internet. Something like that is on the way, too, in the form of a network called the Grid (see "Power sharing").

Illustration: Richard May

In the next tele-immersion experiment, the teams will open two-way portals so that all three locations can see and hear one another. They will then try out a dummy collaborative project: rearranging the furniture in a doll's house.

Eventually the researchers would like to make tele-immersion even more naturalistic, perhaps by jettisoning the headgear and glasses altogether. One possibility is to use a screen that transmits different information to each eye, using swivelling pixels that track either the left or right eye. Another idea is to turn the entire tele-immersion room into a screen. Walls, tables, curtains, even floors could be coated with special light-sensitive material. Cameras would photograph the surfaces, computers would calculate their shapes in 3D, and projectors would shine pre-warped images, making it seem as if they filled the room.

Tele-immersion may seem like another kind of virtual reality, but Lanier says it's something different. And he should know: he coined the term. Virtual reality, he says, allows people to move around in a pre-programmed representation of a 3D environment, whereas tele-immersion is more like photography. "It's measuring the real world and conveying the results to the sensory system," he says.

But that doesn't mean there's no place for virtual reality within tele-immersion systems. The NTII researchers are working on incorporating virtual objects that can be seen, manipulated and altered by all the participants. "We might want to look at the design of a product together," says Welch. Meanwhile, Tom Defanti and his colleagues from the University of Illinois at Chicago are taking the marriage of tele-immersion and virtual reality a step further. In their systems, people share a virtual environment and each is visible to the others as a computer simulated entity, or "avatar". People could choose the way they look in a tele-immersion session--from changing their hair colour to looking like a film star.

Defanti thinks that such technology would enable researchers to collaborate in fields such as architecture, medicine, astrophysics and aeroplane design. The beauty of it is that it allows widely separated people to share a complex virtual experience. "You might be testing a vehicle," says Defanti. "You want to smash it into the wall at 40 miles per hour and put your head by the cylinder block. Say there's a guy from Sweden and you have to prove to him that it doesn't move by 3 centimetres or more. That kind of stuff works."

But tele-immersion is not just a research tool. The fast-food chain McDonalds showed interest at one early workshop, says Defanti. McDonalds envisioned fitting tele-immersion booths in its restaurants so people away from home could have dinner with their family. "The technology for that is not that far off," says Defanti. The gaming industry is another potential user. Players could tele-immerse themselves in a virtual reality environment, chasing monsters or firing phasers at each other.

All of this, of course, relies on other emerging technologies. Most important is the ability of the Internet to ship vast amounts of data across continents without delay. Luckily for the developers of tele-immersion, their needs are at the forefront of Internet2's thoughts. In fact, the two projects go hand in hand. Internet2 needs a raison d'être for its increased capacity, and in tele-immersion it seems to have found one. The experiment at Chapel Hill in May was made possible by UNC's Internet2 link. "There is simply no other known application that would push the network to its limits," says Lanier.

Further reading:

- see a photograph of the demo at www.cs.unc.edu/Research/stc/Pics/May2000Demo/Demo/DCP_1707.JPG

Power Sharing

HAS YOUR COMPUTER run out of processing power? Wouldn't it be great if you could just tap into someone else's. Anyone else's. This is the idea behind the Grid. The name is borrowed from the US electricity grid, and the goal is to make it as easy to access processing power over the Internet as it is to plug a TV into the wall.

Once the Grid is up and running, users will be able to call on undreamed-of resources simply by switching on their PC. Processing power, software and data from computers across the world--all this will be at their fingertips. And just like the electricity grid, it won't matter where the juice actually comes from.

"A tremendous amount of computing power is sleeping when the US is sleeping, and when Europe is sleeping," says computer scientist Fabrizio Gagliardi of CERN, the European particle physics lab near Geneva. "If we could tap into that, we could do very powerful things."

Gagliardi is head of the Datagrid project at CERN, a grid that links computers at 21 science and industry centres throughout Europe. Scientists at CERN need the grid because in 2005 when they start smashing particles together in their new accelerator, the Large Hadron Collider, raw data from the collisions will pour out at a rate equivalent to a million feature-length movies a second. Processing this data would swamp the CERN computers, so the researchers need a way to share the burden. The Grid will help them to distribute the data to computers across the continent.

Computer scientists in the US are working on a Grid of their own. The Grid Physics Network (GriPhyN) links 16 universities and will be used to crunch data from four major physics projects, including two Large Hadron Collider experiments. Last month, the National Science Foundation awarded $11.9 million to the universities of Chicago and Florida to pursue the project. GriPhyN should be up and running by 2005.

Managing shared resources isn't easy, and the developers' immediate task is to develop a layer of software called "middleware" to keep order on the grid. "The middleware is the guts of it. It is the broker that goes out and finds what is available," says Chris Jones, head of technology transfer at CERN. This software also ensures that all the computers are speaking the same language. "It allows me to identify myself," says Gagliardi. "It establishes a secure connection, so I can be charged. It asks: where are the resources? It looks for the best way to do the job. It will also predict how long the job will take, and how much it will cost."

It is possible to gain access to other computers at the moment, but incompatible systems and languages, bureaucratic rules and suspicious network administrators make it complicated. A pervasive Grid would change all that. "All the authentication, looking for appropriate data, software, space and payment will happen automatically, without us seeing it," says Carl Kesselman from the University of Southern California in Los Angeles. Kesselman, along with Ian Foster from the University of Chicago, introduced the concept of the Grid in 1996. Both are now working on GriPhyN. In ten years, they say, we will all be part of one giant, global Grid.

If they're right, it won't be long before we can access the Grid at home, simply by installing middleware on a PC and linking up to an ultra-fast network. But what would we use it for? "We are still trying to realise what the technology is really good for," Kesselman admits. Foster sees working or playing together as the killer applications. "What people really like to do is communicate," he says. "It is those applications, for example interactive gaming or tele-immersion, that will really take off." Such activities require huge amounts of processing power and will only be possible if you can siphon it off the Grid. Joanna Marchant

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