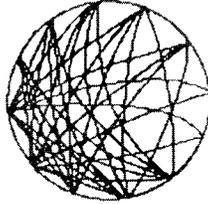# CHAPTER 4

THROUGH THE WORM HOLE

Links for Virtual Teams

Telecommunications and the global economy have arrived for millions of people, bringing with them new partners in daily work. Colleagues can sleep in opposing time zones and still be members of the same team. This is true, but it is not easy. The explosion of links across every conceivable boundary is staggering in its complexity as languages, cultures, governments, distance, and the mysterious nuances of human behavior all play their part.

The Once and Future NCR

"Hey, Gene. I've been meaning to talk to you," Kathy Black, a computer engineer for NCR Corporation, called out, walking into the conference room. "Is this a good time?"

"Just great," her colleague, Gene Young, a computer architect, replied. "I need to talk to you, too. Have a seat."

Kathy, the manager of Scaleable Systems for the project, spotted Gene, an NCR Fellow, "sitting there" as she was going down the hall to get a cup of coffee. Nothing unusual about this scene—one person needs to talk to another, asks if this is a convenient time, and sits down. Then

why are the words "sitting there" in quotation marks? Because Kathy was in San Diego, California, and Gene was in Columbia, South Carolina, and suddenly they were both sitting down at the same table. Is this possible?

Not literally, but almost. Kathy and Gene, both members of the same team, worked together on a daily basis even though a continent separated them. They discussed strategy, argued points, solved problems, made presentations, exchanged documents, used flip charts, and shared files. Nor did they work only with each other. Their project colleagues numbered more than 1000 who worked for more than 11 months in three locations (including Naperville, Illinois) to develop a next-generation computer system.

The three-site virtual team was connected by a high-speed, full-bandwidth continuously available audio/video/data link[1] that they affectionately nicknamed "the Worm Hole." The Worm Hole—think of it as "a portal of instant transport from one place in the universe to another"— comes from the Star *Trek* TV show *Deep Space Nine,* which suggests such an intergalactic phenomenon in its opening credits sequence.

Making Its Mark with WorldMark

Kathy and Gene and their colleagues were all members of Dayton, Ohio, based NCR's new product development team for its WorldMarkTM line of enterprise computer servers. These servers are today what mainframe computers used to be—places that house massive amounts of data and shared software made available to myriad individual users (known in the computer trade as clients).

The WorldMark development process accomplished something that few technology projects do: It met the market four months ahead of schedule. (So frequent are delays in technology development that there is no commonly used word to describe a project which does the opposite of "slip.") WorldMark is a great example of a globally distributed, cross-organizational virtual team. Guided by a clear purpose, the team used the most advanced communication links that we have encountered in the course of our research.

WorldMark's product family spanned, rather than simply filled, major market segments. The product can scale from relatively small computer configurations that link a few processors (the chips that are the computer's brains) to huge ones—very large scale massively parallel processors. Such behemoths can only be meaningfully described to lay people by the weight of the disks they use: In 1996, its 11 terabyte (a million megabytes) version weighed 20 tons. Such "terabrutes," as the NCR people jokingly call them, are used in organizations that manage massive amounts of data, such as banks, large retailers, telecommunications companies, and other organizations with global data infrastructures.

For NCR, the development of the WorldMark line turned into an epic project for the rebirth of the company. Founded in 1884 as the National Cash Register Company, the maker of the first mechanical point-of-sale devices initially got into the computer business in 1952. AT&T acquired the company in 1991, renaming it AT&T Global Information Solutions (GIS) in 1994. When AT&T announced its decision to break up into three separate companies in 1995, it named GIS as one of the units to be spun off. It would become an independent publicly traded unit—as the "once and future" NCR. While renewed independence was appealing to NCR and its newly named chairman and CEO Lars Nyberg, its corporate challenge was considerable. With 1995 losses of $722 million, NCR was looking to WorldMark along with several other initiatives to help return the company to growth and profitability.

It did. By the second quarter of 1996, NCR returned to profitability, reporting operating income of $29 million by the third quarter. The company appeared to be on the upswing. WorldMark's expedited entry into the highly competitive computer server market was a significant contributor to increased revenues. It represented both a process and a product success.

Instant Communication Through the Worm Hole

"We used various communications mechanisms to keep this very, very far flung team together," says Dennis Roberson, chief technology officer and NCR senior vice president. "The activities between San Diego,

Columbia, and Naperville in particular were kept together through the Worm Hole."

Roberson is a veteran of 25 years of doing projects involving people situated in geographically separate locations. "Misunderstandings are always a part of it," he says. "They are something you have to work very hard to fix from a management standpoint. In projects like these, there is always a characteristic lack of trust, particularly when you have groups in different time zones. The boundary lines between groups are not always clear. You've got existing groups and existing emotions and the challenge is to make everyone feel like part of the same organization."

One solution was the Worm Hole, which is, in Roberson's words, "video conferencing taken to its logical next step. It is a continuously open lease line so that you can have a meeting any time you want to. With the high performance of the link, it's just like being there." Because of the quality of the telecommunications connection, there was no strobe light effect and the sometimes not so humorous delays," Roberson says. He refers to the annoying aspects that people associate with what he dubs "traditional" video conferencing. "All of that was overcome by the technology and great bandwidth," he explains.

"We did some nice things with the link between Columbia and San Diego. The grain of the wood on the table is the same in both sites so it looked the same," he recalls. By angling the cameras properly—there were two or three in each location along with 32-inch television screens—the desk in one location blends right into the desk in the other location. "It was just a bright engineer who thought of that level of detail," Roberson remembers. "That sort of thing really helps create the feeling of 'being there.' It's the only room of its type that I've experienced where you really do forget that you're not in the same place."

This proved so true to the group that it created its own standing joke. With its three-hour coast-to-coast time difference, one group always seemed to be having lunch while the other was not. "Someone was always saying, 'Can I pass you a sandwich?' People thought they should because they felt like they were in the same room. People couldn't help but make the offer and then laugh about it."

Each of the screens in the Worm Hole served a different purpose. One showed the people at other end. A second was the equivalent of an overhead projector that electronically projects foils onto the screen. The third was a standard PC monitor that facilitated information sharing and distribution.

As important as the Worm Hole was for organized meetings—the system could accommodate up to three sites simultaneously with as many people at each site as could comfortably fit into the 18-by-24-foot conference rooms—"the next step is even more amazing and more desirable," Roberson says. "When the rooms are not being used for meetings, the doors are left open and people do in fact 'meet in the hall.' Someone yells out through the tube and you have meetings that take place on the fly. It's an extremely valuable way to do distributed product development. It keeps people in sync and creates the feeling of one team rather than several teams.

"It {the Worm Hole] lets you feel much more tightly connected. However, it doesn't completely reduce the requirement for travel. You still have some need for being together and sharing meals and for very large meetings where you can't fit everyone into the lens of the camera. But it certainly reduces the frequency of trips."

Network of Partner Teams

The three-site hardware and systems software engineering group was only one team within a network of WorldMark development program partners. It comprised internal groups, external partners, and customers. First, there were the groups that were internal to NCR:

- ? The core development groups in California, South Carolina, and Illinois, which were supported by groups in two locations in India and one in China;
- ? The database development group in El Segundo, California;
- ? A communications software group in Lincroft, New Jersey;
- ? Marketing and administrative groups which were located at NCR's headquarters, Dayton, Ohio; and
  The manufacturing sites in South Carolina and Dublin, Ireland.

Then there were the outside partners:

- ? Intel in California and Oregon, which provided the basic processors;
- ? EMC in Massachusetts, which provided disk arrays that supply the system with memory capacity;
- ? Symbios Logic (which was a part of NCR when the project began but was sold to Hyundai while the product was being designed) in Wichita, Kansas, which also provided disk arrays;
- ? Informix in California and Oregon, which provided database systems for the new line of machines;
- ? Microsoft in Washington State, which provided operating system software support; and
- ? Many others including customers as well as additional suppliers.

Each of these partners had an internal team focused on WorldMark, with its own communications needs, as the system development group did. Sets of different partners then needed different mixes of connections depending on the work they were doing together (i.e., the need to exchange large files). The program as a whole needed to communicate across the many physical and organizational boundaries represented by the network of teams—the WorldMark teamnet.

Many Modes of Communication

Although few organizations today have such communications power available to them, the glimpse of the future that NCR offers carries important lessons for all virtual teams:

> *Use multiple media to offer many pathways for interactions and the development of relationships.*

"You need to carefully blend in and utilize each tool for its intended purpose," Roberson says.

Voice

Because the telephone is so basic to work-at-a-distance, we scarcely reflect on how remarkable this voice-extension capacity is—and how it is continuing to evolve.

The WorldMark project made modifications to its voicemail system to ease the complexity that springs up among multiple players. "Voicemail had been around for a long time and it was a very good capability. But we decided that wasn't really good enough because we were doing team development and our teams were spread around the world," Roberson says. So they enhanced the addressing ability of their voicemail system to create one "virtual site." Usually, people have to dial different codes on the system for different buildings, cities, or countries and leave separate messages for each person. Instead, the enhanced system allowed people to send a single message to any subgroup of the team or, if appropriate, the entire team.

Video

Beyond voice connections that are basic to all virtual teams, video channels also can be interactive. For the WorldMark virtual team, the Worm Hole was not the only type of video link used to bind the disparate project group.

The team used "traditional" video conferences to link project partners, including the Indian and Chinese sites where high-quality telecommunications links are scarce. "This was one of the handy features of having AT&T as a part of us," Roberson observes. With AT&T's global communications infrastructure, the team minimized problems that most companies face in countries where telecommunication is still under development.

The WorldMark program also used desktop video conferencing—where a camera is mounted on the top of a person's computer monitor. Desktop video conferencing allows a small number of people to hear and see one another through small windows on their personal screens, as though they were gathering informally in a colleague's office.

Computer

In addition to numerous audio and video links, "the group also used more standard secured computer-based communication connections heavily," Roberson says. They used basic e-mail, available to everyone, with the capability of "embedding information"—the electronic equivalent of attaching multiple packages of any size to a letter. It was not atypical for an e-mail to contain ten embedded files, each containing 25 pages of documentation—marketing plans, service plans, detailed schedules, product specifications, spreadsheets, charts, even near-photographic-quality images. "The extent to which we embedded files probably took the state-of-the-art up a level," he says. The team also used intranet-based discussion groups to keep members updated on the project.

With all of this data and communication speeding around the world, the team naturally built its own knowledge center. It was linked to NCR's corporate information repository (data warehouse) that houses most of the relevant information for the company. The repository is available through conventional file access as well as through the company's internal Web-based intranets.

Face-to-Face

Like most virtual teams, WorldMark members also met face-to-face. Coming full circle, Roberson remarks, "We still met, of course. There were lots of meetings. You still need all-hands meetings. With all this wonderful technology and shared information, they still don't replace the need to get together with the whole team in a particular site and communicate with them on what's going on, on what the direction is, and on the importance of their contributions."

However, unlike many major virtual team projects, this one had no memorable kick-off event nor did the *entire* group ever come together face-to-face. "We didn't have to because we had greatly enhanced other forms of communication," Roberson says.

Communications Is a Process

As exciting and effective as the technology used on this project was, the WorldMark project had something else. It never would have hit the mark

without a comprehensive planning and project management system that kept information flowing to the right people at the right time. Using what it calls its "Global Realization Process," the team was able to track and measure its progress monthly, weekly, and even daily. The process convened cross-functional team leaders for monthly meetings to evaluate where the project stood relative to the plan. They in turn reported their progress to a senior executive team that closely monitored development.

Even though this very large effort successfully combined all the elements of a virtual team—the people, the purpose, and the links—Roberson says that there was "still more to learn and more to do. The engineering side was done in a pretty spectacular fashion but we didn't have as complete a connection to all of the stakeholders as was needed. The people in sales groups particularly outside the United States could have been involved earlier and we had to mount a double-time effort with sales training. When you pull the schedule forward, you don't always pull everyone with you. It was a pretty massive development activity sited around the world and yet we accomplished it in record time."

Overall, links made the difference for the WorldMark virtual team— links of media, interactions, and relationships.

- ? WorldMark paid attention to its need for *physical connections* with face-to-face, audio, video, and computer media.
- ? The program managers set action items, articulated processes, and blazed new pathways for *boundary-crossing interactions* using its Global Realization Process.
- ? They laid the basis for strong *trusting relationships* that developed over time as people worked together.

Four Ages of Media

To operate effectively across boundaries, virtual teams become masters of media. They need to be media savvy in two very important ways. Virtual teams use:

1. "Process media" to run their own organizations, because the actual time the team spends creating, specifying, designing, and managing itself is largely informational work; and

2. "Product media" to deliver results, such as new products, decisions, reports, and plans.

Marshall McLuhan woke people up to the momentous impact of media on human experience with his 1964 book *Understanding Media.*[2] His memorable phrase, "the medium is the message," epitomizes his insights.

Imagine being asked to do something. Your interpretation of the request depends on whether the requester is your boss, subordinate, partner, or competitor. It also matters whether you receive the message in a face-to-face exchange, a handwritten private note, an e-mail, or a printed memo sent to everyone.

Many communications theorists separate the content of a message from its context. They point to the *metamessage—the* relationships, status, and interpretive cues that ride along with the literal symbols themselves. Scientist-philosopher Gregory Bateson called these bells and whistles the "command" part of the message.

McLuhan went a step further. He said that the transmission medium itself powerfully influences the total communications experience. That is, there is (a) the message; (b) the affect that it carries; and (c) the medium by which it travels—a meta-metamessage so to speak.

Perhaps the most basic message that a medium sends is whether it expects, allows, or makes possible a response Virtual teams need to maximize their use of media that enable interaction.

The Evolution of Communication

Just as a signature organization characterizes each great era of human civilization, so does a signature style of communication typify each era. Indeed, the rise of different media have usually been key features in differentiating the big break points in history.

Speaking, writing, and printing are the first three revolutions of human communication.

- ? Speech shaped the Nomadic Era and the formation of small groups and camps.
- ? Writing emerged in the Agricultural Age and made large-scale hierarchies possible.
- ? Printing spread specialized knowledge in the bureaucratic Industrial Age.
- ? In the information era of the Network Age, electronic media have shrunk the planet to McLuhan's famous epithet, the "global village."

Each organizational era—small group, hierarchy, bureaucracy, and network—brings its own capabilities that accumulate over time. Instead of new forms of organization wiping out the old, they incorporate them.[3] Thus, today's emerging network organization benefits from and includes the positive aspects of its organizational predecessors: the specialized functions of bureaucracies, the levels of hierarchies, and the coherence of small groups.

As the new impacts the old, it brings modern variations to recurring themes. The virtual team is a new form of small group made possible and necessary by new forms of communication. While we now have geographically distributed small groups, we still retain access to the variations spawned in each previous era. Command-and-control hierarchical teams such as military units and rule-based bureaucratic groups such as executive committees are still with us.

Successive waves of change may have reduced the globe's Nomadic Era populations to vanishingly small numbers. Yet the echo of communications in that age still reverberates distinctly in all human life at the turn of the 21st century.

Time has not diminished the importance of oral communications.

Writing, the second great leap in communication, incorporates the message contained in speech into a newly enduring, transportable

medium. When written down, words persist and can move independently of the writer. Printing in turn incorporates writing while electronic media incorporate all previous media. The inventions of the new include the innovations of the old.

The One, the Many, and the Few

A fundamental distinction about a medium—whether it is one-way or two-way—shapes virtual team communication at every scale.

One-way media broadcast actions.

Two-way media enable interactions.

Because virtual teams must produce products and interact across distances fractured by delays in time, this distinction is crucial. One-way media are great for delivering products (and orders), but they do not enable the interaction (and good will) required for people to work in virtual teams.

Researchers typically characterize media by another distinction important to virtual teams: the ratio between the number of senders and the number of receivers. Broadcast television and the daily newspaper are one-to-many (1:M) media. Generally speaking, one entity produces the communication and many receive it. CNN cablecasts to you, but for all intents and purposes, you have no genuine ability to respond (even if a fax number or e-mail address appears on the screen). Contrast this with the telephone that people most frequently use in its one-to-one (1:1) form—just you and me. Interactive media also have their many-to-many (M:M) mode—such as the discussion and "schmooze" time at a conference or any large social event.

The range from one to many (1:M) senders and receivers is too broad to properly identify the media most important to small groups. Thus we add the category of the "few" modes of communication.

Virtual teams interact extensively in the world of the few.

Organizational life is replete with events that involve one sender with a few receivers—workshops, seminars, and briefings. Photocopiers, fax machines, and e-mail distribution lists are technologies that support one-to-few (1:F) communication.

Most important to the internal workings of all kinds of teams, but of particular import to virtual teams, are the media that connect a few senders with a few receivers (F:F). This is the communications venue for small group interaction, including the all-important medium of the face-to-face meeting. Virtual teams make frequent use of few-to-few conference calls, and of video conferencing, which is becoming more prevalent in both its room-based and desktop modes.

Online conversations, meetings, and conferences provide a new array of interactive digital media. They open abundant possibilities for communication among many senders and receivers—from groups of a few too vast numbers of participants.

Communication Media Through the Ages

Each type of media has certain common characteristics that influence effectiveness, cost, and accessibility of communications, the very stuff of virtual group life.

For virtual teams, the conditions for communicating across space and time boundaries are intimately involved with the nature of the technology they use and how interactive it is. Technology has moved the human world of small groups from the assumed state of collocation in place and time to the option of working together at a distance. This change is thousands of years in the making.

Virtual teams are the beneficiaries of this long evolution of communications technology. Media, once developed, do not go away. Although we no longer use stone tablets to communicate, it is generally true that we do not lose older forms of communication as we acquire newer ones.

Virtual teams today have access to a wide array of media and are able to choose among them for specific purposes.

It is also important to review past communications revolutions in order to put the digital difference of the 1990s in context—and to give direction to the onrushing future of virtual teams.

All the communication that people and organizations send and receive can be placed somewhere in the Communications Media Palette (Figure 4.1). Make your own matrix from the media available to you, or add in other media you know about.

Oral Media

Oral media encompass a full range of one-to-few-to-many channels that are both one-way and two-way. Speeches, workshops, seminars, and

Figure 4.1 Communications Media Palette

	Oral	Written	Printed	Analog Electronic	Digital Electronic
Nomadic	**Agricultural**	**Industrial**		**Information** →	
1-Way Active **1 : M**	Speech Conference Briefing	Tablet Proclamation Manuscript	Book Film Newspaper Magazine	Broadcast TV Broadcast radio Videotape Audio cassette	Online broadcast Internet video Internet radio Online publication Digital packaging (disk, CD)
1 : F	Workshop	Graffiti	Newsletter Memo	Photocopy Fax	E-mail list
2-Way Interactive **1 : 1**	Dialogue	Letter	Greeting card	Telephone Mobile Ham radio	E-mail File transfer Internet phone chat
F : F	FTF meeting	Flip chart		Voice mail Audio conference Video conference	Online meeting Online conference Intranet
M : M	Social event				WWW Internet

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briefings are all one-way, sender-based; conversations, meetings, and social events are all two-way and interactive.

To speak to someone else without the aid of technology, both sender and receiver need to be in the same place (collocated) at the same time (synchronous). Consequently, a speaker can only reach as many people as the voice will carry to.

The physics of sound carries voice through the air. The receiver's capacity to hear and comprehend speech rule reception. Given the requirement of shared space and time, speaking offers a medium with no appreciable delay between sender and receiver.

People retain what they hear only in the private places of their individual memories, not in the communication medium that links them. Unlike e-mail, for example, which records all communication, speech evaporates. Reconstructing a remembered conversation has caused more than one argument. People interpret conversations privately, separate from the medium itself. In short, real-time oral communication has little inherent storage, recall, modification, or reprocessing features. Continuity persists through an oral tradition passed from memory to memory.

Written Media

The development of written languages, both ideographic and alphabetic, co-evolved (very roughly speaking) with the agricultural economy and the rise of hierarchical organization. (Egyptian hieroglyphics and calendars developed 5000 years ago setting the stage for the Early Dynasty period and the rise of the first great cities.) Writing offered message-senders options—from inscriptions on stone that have lasted for ages, to painstakingly produced and reproduced manuscripts, to the remarkably flexible medium of paper documents.

Writing represented a profound break with the limitations of the spoken word. Senders and receivers were no longer required to be in the same place at the same time; they could be in different places (distributed) at different times (asynchronous). The number of people reached by writing, while in principle virtually unlimited, was in fact quite small. The costs of production and transportation together with the literacy required for individual use capped the number of possible writers and readers.

Slower and more cumbersome than speaking, written interaction occurs when people exchange letters and notes. Delivery depends on the transport technology, which in the Agricultural Era included domesticated animals, wheeled vehicles, and boats as well as fleet-footedness. An individual's capacity to read governs the speed of reception. These characteristics add up to a general delay between sender and receiver, dependent mainly on the distance between them.

Writing freed communication from the constraints of space and time because of its most important quality in memory terms, the ability to be stored. Suddenly, human beings had a way to capture communications and make messages explicit, public, and permanent. While a great way to store ideas, writing-on-paper is still a limited medium in terms of its ability to help people recall or modify communications. (Witness how much time you spend rifling through files and piles looking for a particular piece of paper.)

Printed Media

Historians always cite the invention of the printing press and the production of the Gutenberg Bible in 1456 as key early developments of the Industrial Era. Printing is primarily a one-way medium, whereby single senders can reach great audiences of receivers through proclamations, books, and other printed materials. Newspapers, magazines, and newsletters are examples of print media in which a few senders (publishers, writers, and advertisers) reach large audiences of generally passive readers. Monographs or limited run publications offer some small-scale options, but until the advent of desktop publishing, the cost of production had been so relatively high that printed media have had limited value for interactive communication.

Like writing by hand, printing breaks the bonds of space and time. Unlike writing, print reproduction is comparatively easy; the time and cost differences between a print run of 1000 and 10,000 are marginal. Very large numbers of people are reachable through printed media.

Print production, however, is much more complicated and slower than writing. It involves not only the time required for writing, but also the time of transferring writing to the print mechanism and the time of

printing the product itself. Speed of delivery is again dependent on the transport technology, which greatly increased in the Industrial machine era. Speed of reception, however, remains constrained by the speed of reading. These factors create what is usually a substantial delay between sending and receiving, rendering print media almost useless for sustained interaction.

Like writing, printing provides storage integral to the medium. Its recall, however, is still limited to remembering the location of the information and then physically combing through material to find it. Modification is, if anything, more difficult in printing than in writing.

Electronic Media of the Information Age

The paradigm-shattering concepts of relativity and quantum mechanics that announced the end of Newtonian absolutes and the coming of a new age of science are now almost a century old. Most of us point to the mid-20th century as the practical point of transition from the Industrial to the post-Industrial era. At the end of the century, it is a mainstream idea that humanity is now going through fundamental transformations in technology, culture, economics, and social organization.

We are now deep enough into the Information Era to begin to recognize major stages within this overall period of time. In 1964, McLuhan described the media of our time as "electric," remarkable by the almost instantaneous nature of communications based on principles of electromagnetism. Writing in 1995, Nicholas Negroponte, director of MIT's Media Lab, drew a fundamental distinction between *Being Digital*[4] and *being analog*. From Negroponte's point of view, analog TV shares more with analog books than it does with computer-based digital media.

In the analog world, "atoms" deliver information. We move molecules in the air, ship paper around, or modulate the structure of electromagnetic waves. In the digital world, "bits" deliver information. Bits are pure information, representations of on-off switches. They deconstruct the analog world into ephemeral strings of binary relationships and reconstruct them wherever. An analog book deteriorates over time, but a

digital book is potentially timeless. An analog book Occupies physical space, while a digital one occupies none the eye can see.

This very big difference between atoms and bits has a profound impact on virtual teams and their future development. Accordingly, we separate electronic media into analog and digital eras.

Analog Electronic Media

Broadcast TV and radio, videotapes, audio cassettes, and the like are all one-way analog electronic media. They allow senders to reach groups of receivers at virtually any scale, from local to global. Analog electronic reproduction extends to print through media such as photocopies and fax.

The extraordinary innovation of the telephone has made possible a new species of interactivity. It is the most important addition to the human repertoire of one-to-one communication since the evolution of speech. Audio teleconferencing and voicemail are group-oriented log media. The same is true of "traditional" video conferencing and its offspring, Video mail and desktop video conferencing.

People often remark on the distributed, aspatial nature of electronic media. However, this feature does not distinguish them from earlier non-oral forms. Senders and receivers of writing and print can be just as far apart as the people who communicate via electronic media.

In terms of time, however, there is an enormous difference. Electronic media completely fracture the constraints of time, offering synchronous or asynchronous connections, or even both together, such as recording a broadcast for replay. These media extend to virtually unlimited scales, reaching billions of people at the same time, such as during Olympic broadcasts.

Electronic communication effectively travels at the speed of light, a distribution speed that has no parallel in nonelectronic media. For production and reception, however, analog speed slams into real-time barriers. An hour's worth of information broadcast or viewed on a tape still takes an hour to meaningfully view (fast forward aside). How quickly people can speak and listen limit the speed of the telephone connection. This is the real-time limitation of the analog world.

In memory terms, analog electronic media offer little in the way of fundamentally new capabilities. Like writing and printing, electronic media can store communications, but provide limited support for recall and modification without additional digital capability.

Digital Electronic Media

ENIAC, the first electronic computer, was unofficially turned on at the end of World War II in early 1945 to help with some last minute calculations for the first atomic bomb. Thus, the birth of the digital era is linked with the nuclear explosions in August of that year that irrevocably sundered human time into "before" and "after."

Despite their dramatic entrance, computers stayed in the background for the next quarter-century, generally supporting the centralized, routine bureaucratic needs of the Industrial Era, fueling the rise of IBM to the pinnacle of global companies. Computers then shrank from mainframes to minis, led by then new companies like Digital Equipment Corporation. But it was not until the computer-on-a-chip escaped from the labs in the mid-1970s that the digital revolution began to flower and directly affect everyday working life. It gave rise to the now-ubiquitous personal computer (PC) and companies like Apple ("computers for the rest of us").

Somewhat simultaneous with the rise of the PC was the development of computer networks, initially created to spread out use of the incredibly expensive mainframes through time-sharing systems. These trends converged in the 1980s, heralded by the Macintosh, a PC with built-in networking. Networks are now the central computing paradigm. They link computers of every size and capacity, from massively parallel supercomputers to mainframes, minis, workstations, desktop PCs, portables, palmtops, and chips embedded in all manner of appliances. More than one company has used the slogan that Sun Microsystems has made famous: "The network is the computer."

The total computing facility available to society consists of both the computing capacity of individual devices and the network connections among them, what some call "the matrix."[5] This combination has given

rise to "computer-mediated communications" in the parlance of early researchers in the field of *digital media.*

Like their analog counterparts, electronic digital media offer an array of one-way options, although many are only now being deployed as we approach the millennium, such as digital TV. Internet audio and video provide both one-way and two-way capabilities, although temporary limits of bandwidth are slowing growth. The transmission of graphics, audio, and video requires bandwidth that is vastly greater than that needed for transmitting simple (ASCII) text like e-mail, which is almost instantly replicable and can reach millions or a few. Digital content can also be packaged in CDs, for example, and documents can be posted for retrieval from online databases. The new media also offer something else: interactivity.

> *The digital media really shine in interactivity, exploding the limits to human organization and allowing a vast expansion in virtual group capability and variety.*

The options of one person communicating with another, of a few communicating with a few, or of many communicating with many others flow almost seamlessly from one digital variety to the next. E-mail ranks with the telephone and face-to-face dialogue as a powerful personal medium. Digital technology also allows the point-to-point exchange of files (including digitized print documents) and even replicates the telephone system through Internet phone. Small groups have a growing list of digital media available that allow a few people to communicate with a few others—from synchronous online chat and electronic meetings to asynchronous computer conferencing and topical discussions.

The scale of interactivity continues to expand beyond shared data-bases like Lotus Notes, where participants are both senders and re-ceivers, to intranets, the World Wide Web, and the Internet as a whole. Digital media and especially the ubiquitous Internet represent an his-torically unparalleled expansion of interactive capability. Just what is different?

Digital Is Different

As with every media developed since writing, digital media support communications across space. Like analog electronic media, digital communication may be synchronous or asynchronous, and is effectively unlimited in terms of the numbers of people it can reach.

All computer-based media take full advantage of the speed of light. This is especially true at the nanoscale of the chips themselves, a level of functioning imperceptible to our natural senses. Production and reception speeds are not limited to real-time. They may vary enormously according to the type of data being prepared and communicated. A database instantly produces information at processor speeds while you spend real time typing an e-mail note.

The big difference in computer-based media, what makes it so effective for interaction, lies in its vastly increased memory capabilities. This pertains not simply in storage, which all post-oral media share, but also in memory's other aspects. Recall is integral to digital media. One can peruse vast quantities of information in moments, needles picked instantly out of the proverbial haystacks of data. Modification is unlimited; it is easier (and incomparably faster) to turn bits on and off than it is to retype a page. (Take a stroll down memory lane to compare the act of editing a document in a word processor with retyping pages on a typewriter.)

Reprocessing is unique to digital media.

No medium other than the computer-based one can reprocess its own stored information. Computer-based media can compress, split apart, and recombine information in infinite varieties. The medium itself makes possible computer enhanced images, data compression, packet-switching, language translation, content filtering, and morphing, to name just a few capabilities.

It is not just what you can do with the bits that is so exciting, but what you can do with the content itself. Of special interest are the digital

connections that can link concepts, data, pictures, diagrams, and all manner of media. We have barely scratched the surface of the cognitive capabilities that digital media offer virtual teams and the organizational networks they undergird.

The digital medium is the ultimately flexible one. It can take on the shape and contour of any of the others, from a highly centralized mass medium to a completely decentralized interactive one. Most remarkably, it can be all forms at once, available to match the right medium to the right need. For a virtual team that is working anywhere at any time, digital technology dramatically expands its communication bandwidth— professionally, organizationally, educationally, intellectually, emotionally, and socially.

Media Characteristics by Age

Media vary by key characteristics. As we have seen, each great era of communication carries a common set of advantages and constraints summarized in Figure 4.2 along these dimensions:

- *?* *Interaction.* How far apart people are in space and time and how many people the medium can reach influence interaction, the back and forth, or lack of it, of communication.
- *?* *Speed.* The pace of message production, the speed of its transmission, and the rate of its reception govern the swiftness of communication.
- *?* *Memory.* The ability to hold and use a message depends upon its storage, its ease of recall, its difficulty in modification, and its reprocessing capability.

Multiply Communication Options

Virtual teams need to know what their options are across the range of one-way and two-way media. Particularly, they need to distinguish between the communication required for their work internally and the media they need to communicate their work externally.

Figure 4.2 Media Similarities and Differences

	Oral	Written	Printed	Analog Electronic	Digital Electronic
Interaction					
Space	Collocated	Distributed	Distributed	Distributed	Distributed
Time	Synchronous	Async	Async	Sync/Async	Sync/Async
Size	Small	Small	Mass	Unlimited	Unlimited
Speed					
Produce	Speaking	Writing	Write and Print	Real-time	Variable
Deliver	Sound	Transport	Transport	Electronic	Electronic
Receive	Hearing	Reading	Reading	Real-time	Variable
Delay	None	Some	Lots	None	None
Memory					
Store	None	Integral	Integral	Integral	Integral
Recall	None	Limited	Limited	Limited	Integral
Modify	None	Limited	Limited	Limited	Unlimited
Reprocess	Separate	Separate	Separate	Separate	Integral

Virtual teams need both one-way "product media" as well as two-way "process media."

"I don't know what kind of maturity it takes to realize that you can't rely on just one medium to establish communication," says Bernie DeKoven, author of *Connected Executives.*[6] DeKoven believes that each medium is appropriate to a different kind of message.

"E-mail is the middle step between fax and phone," he says. "It's still informal but I am as accountable as if I'd written something down. I can misspell, and even be a little incomplete but whatever I've said can come back to me, and can be redistributed. E-mail has a certain viability but it's not as concrete as a fax. When I send a fax, there's a sense of permanence and formality that comes along just because of the

medium of paper. It's a less tenuous form of communication than e-mail. It allows you to check, 'Is this what you wanted? Is this what you meant?' For you to sign off on it means we've achieved an understanding. E-mail is a longer term, less formal exchange—I say something and expect something back, then you add and so on. The point is to use each of the media for what they do the best."

One example of a long-lived virtual team that came to rely on a variety of media is at Hewlett-Packard (HP).

"What it really comes down to is massive communication," says Larry Banks, HP's Technical Education manager in its Medical Products Group. Banks is referring to the magic required to make virtual teams work. Like many others, he believes that "you can't beat collocation" and that the trick comes in making people "feel as if they are collocated."

Banks spent five years working as Research and Development section manager at HP on a project that crossed all the boundaries—organization, discipline, distance, time, and culture. Its purpose is to develop a product that makes it easier for HP's virtual teams to work together. The worldwide distributed product information management system (PIM System) that this geographically and organizationally separated project team works on allows HP engineers to manage schematics and mechanical drawings from design through manufacturing. Not all the engineers who work on a project sit next door to each other. Nor are all of HP's manufacturing sites in the same place. Thus, the PIM System project is key enabling technology for the company's virtual teams in the future.

Like the WorldMark program, the PIM System project is a good example of how many different kinds of links a virtual team needs to use:

- ? E-mail, which is continuous;
- ? Telephone conference calls, also frequent;
- ? Voicemail, which became pervasive and indispensable in the company during the life of the project;
- ? Face-to-face meetings (which always include an "element of cel-ebration—food and fun," Banks says) that they hold three times

a year alternating locations between HP's headquarters in Palo Alto, California, and one of the other seven lead sites that are involved (including Germany);

? Real-time video conferencing, which allows people to sit at their desks and display what is on their computer screens to one another regardless of where they are; and

? An internal World Wide Web site.

While not every organization has the technology capacity of HP, most organizations, even cash-strapped nonprofits, have access to telephones, fax, and usually some e-mail. To work at a distance, over time, and across organizations, virtual teams must link copiously and variously.

Communication Pulled Apart

While communication has been critical to group life since the beginning of human time, today connective technologies are exploding exponentially. They enable small task-oriented groups to perform in extraordinary new ways.

"Links" is a short word for communication, the wonderful, vital term riding the global wave sweeping in the Information Age. Key elements of the future are wrapped up in multiple meanings of the word communication that pull in different directions.

? Communication means, first of all, a medium. If you hear people talking about the "Communication Industry," most likely they mean the collection of businesses that provide the technology and channels of communication—from hardware manufacturers to phone and cable companies to the broadcast industry. A "Communication Engineer" understands and applies the physics of communication. This is the meaning of the word we use in the Communication Media Palette.

? Communication also means interactions. A school of communication prepares you to be the intermediary between media and people in broadcast radio or television, or as a newspaper or

magazine journalist, editor, or publisher. More generally, every interaction "communicates a message" in the course of specific transactions.

? Finally, communication is a process of developing relationships. If people say they are "not communicating," most likely they do not mean that they have a technical transmission or message delivery problem. Rather, they refer to difficulty in their relationship. Psychologists recognize communication as the means of forming and maintaining relationships, involving deep issues of trust, reciprocity, and intimacy.

Communication has quite a diverse set of dictionary definitions in current usage. The word works, however, because there is an essential interdependency among all the different meanings.
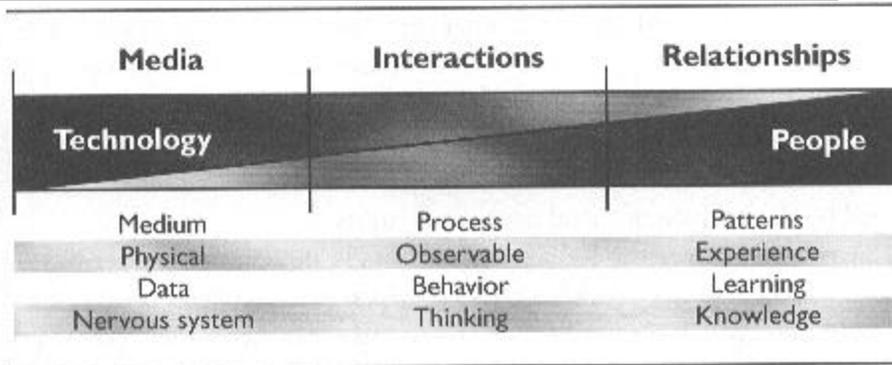
Flowing from Concrete to Abstract

Like purpose, the concept of links spans a range of abstraction. At one end are concrete physical media like wires and telephones and even conversational airspace; at the other end are the often difficult-to-grasp relationships between people. While purpose flows from abstract vision to concrete results (see Chapter 3), communication links flow in the opposite direction. They move from the concrete tangibility of connections to the abstract intangibility of human bonds. Between physical connections and human relationships lie interactions, the moment-by-moment, blow-by-blow stuff of daily social life (Figure 4.3).

> *Links are physical* media *that enable* interactions *that spawn and maintain* relationships.

Media provide the communication channels, the means of interaction. Channels exist quite separately from people or what they want to communicate. As technologies, they are passive and only offer the potential for communication, not the act itself.

Figure 4.3   **Communication   Links**

Media	Interactions	Relationships
Technology		People
Medium	Process	Patterns
Physical	Observable	Experience
Data	Behavior	Learning
Nervous system	Thinking	Knowledge

Interactions, on the other hand, are all about process. To communicate is to interact; to interact is to communicate. Interactions are not separate from the people involved and how they interpret experience. They are also behaviors that generate public information for observers. Researchers study interactions to understand the dynamics of groups and teams.

Relationships represent the cumulative effects of interactions, however few or brief. They are the patterns that simplify the complexity of human interactions, the learning and emotions retained from the intensity of direct experience and fed back into future interactions. Over time, relationships develop among people in a group because of their interactions with one another, eventually enabling them to become a team.

Mapping Relationships

One day early in the life of Apple Computer's new global software engineering organization, vice president Steve Teicher called a small meeting of senior staff. He wanted to map the web of relationships that already enmeshed the fledgling group. He went to the white board, which covered a 15-foot-long wall, and started to draw circles with names as people kept up a steady stream of suggestions. By the time he was done, dozens of interconnected circles ringed the board.

Relationships among all the people and organizations involved with a virtual team can add up to a staggeringly large number of possible permutations. They comprise every combination of the people in the group plus innumerable linkages outside the team—the whole web of the team. Mapping detailed relationships inside and outside even a small group of people can become frightfully complex, a task that is marvelously managed by the science of social network analysis.

A relationship never belongs to one single person or another but to both people together. Although relationships exist between people, they do not occupy any physical space. They grow over time, may span years of inactivity, and yet may fracture in a moment. Our relationships are at once the most durable, the most fragile—and the most rewarding— parts of our lives. Relationships among the members are the bonds that enable virtual teams to do their work across boundaries.

Massive linking begins to suggest that cognitive metaphors point to real opportunities for smarter organizations.

- ? Media provide the nervous system for the virtual team.
- ? Interactions along these pathways by members of the virtual team constitute the team's "thinking," the shared communication that is audible and public to the group.
- ? Relationships are patterns of interaction where a virtual team accumulates its long-term learning. The fabric of relationships and shared knowledge are the internal stabilizing forces of virtual team life. As one virtual team leader says, "It's one part technology and nine parts context." He is stressing the importance of the environment of relationships in which the virtual work takes place.

With relationships, we move from the domain of technology to the realm of people.