Groupware and Knowledge Management in the Internet Age: Retrospective and Forecast

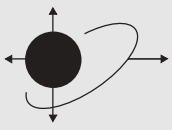
SR-751 December 2001

Since the early seventies, IFTF has been forecasting groupware and other technologies to support collaborative knowledge work. The Groupware Outlook Program was formed in 1984, and Bob Johansen published *Groupware: Computer Support for Business Teams* in 1988. This current report reviews a history of groupware and knowledge management and forecasts where it is headed in an Internet world.

Contents

Authors:
Robert Mittman and Brad Jackson

Published by the
EMERGING TECHNOLOGIES OUTLOOK PROGRAM YEAR 2001



Introduction

We use the term "groupware" advisedly, despite its limited currency today, because it can serve as a point of reference to the technologies that support collaboration.

Here we view both the past and future for groupware:

- In 1988, we wrote that the term "groupware" would disappear as many of the functions then separately identified as groupware would be absorbed into the common infrastructure shared by most applications or stop being used because they failed to demonstrate sufficient value.
- This flow of functionality from application to middleware to infrastructure has continued apace. Screen sharing, instant messaging, e-mail-based workflow, document management, and information filtering and refining have all migrated into the common infrastructure.
- Infrastructure was a key barrier, as we noted the difficulty of justifying the installation of a LAN or other network infrastructure based on the value derived from groupware applications alone. Today, local- and wide-area networking is ubiquitous in business and groupware functionality is readily deployed at the margin of many other applications.
- There were manifold possible applications—yet relatively few "sweet spots." E-mail proved to be a core upon which many applications were built. In contrast, ideas like group decision rooms and shared decision spaces proved less than compelling.

One development unanticipated in the late 1980s was the growth of the Internet as a ubiquitous information and communications platform. The Internet has had four main impacts on collaborative work:

1) Providing enterprises and individuals with the globally-scalable connectivity now a prerequisite for collaboration.
2) Establishing a ubiquitous user interface layer—the browser—now in place for all collaborative applications to use.
3) Offering vendors of collaborative technologies a core infrastructure to build on. Instead of earlier business collaboration models, requiring a separate infrastructure investment, the Internet elevates application deployment.

4) Delivering unanticipated volumes of information on business, technology, and more; as a result, collaborative tools to filter and refine that glut of information are in demand.

We first review two useful models first presented in IFTF's 1991 book, *Leading Business Teams: The 4-Square Map of Groupware Options* and the Team Performance Model/4-Square Map hybrid. The Internet has only accelerated the need for companies to build skills for managing remote work. These models show how team leaders must pull together multiple technologies and social conventions, defining a flow to support the team through its lifecycle.

Next we take a retrospective look, give a present assessment, and make a forecast of how the major categories of groupware and knowledge management concepts, products, and services are changing. Some categories have converged—new types have sprung up; others have disappeared.

Further, we look at provocative research currently underway that, beyond 2005, could have the potential to develop into products with impacts on collaboration. These include technologies for extracting meaning from disparate information sources (be it structured information in a semantic Web or analytic engines from which meaning may emerge); affective computing that relates to, arises from, or deliberately influences emotions (probably first applied in games and educational systems); browseable, searchable video and audio that makes those media as easy to search as text (albeit probably more time-consuming); teleimmersion technologies that enable users to collaborate in real-time in a shared, simulated, hybrid environment at geographically distributed sites; and the broadband Internet infrastructure that will be necessary if bandwidth-intensive applications like these become commonplace.

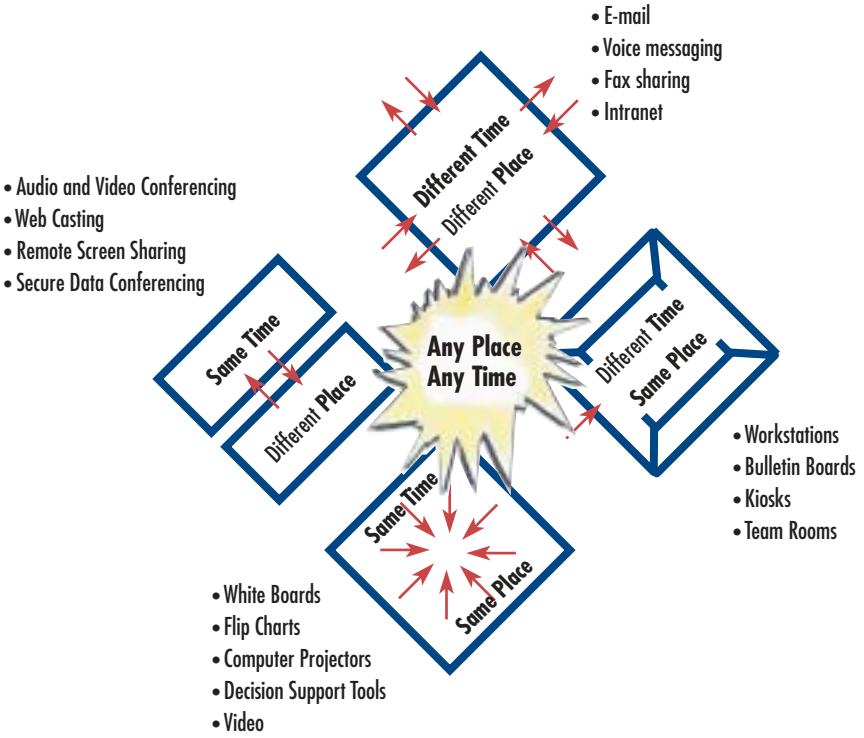
Finally, both currently available systems and future scenarios raise issues—opportunities or threats—that the organization must address. Among those that we identify are:

- *New Leadership Models.* As technologies assist in "flattening" organizational structures and work involves collaborations with partners outside the traditional boundaries of an organization, management will need to develop new models to assist leaders of the networked organization and to engage efficient use.
- *Security of Information*. In flat, distributed, networked organizations, it will be increasingly necessary to pay attention to who gets access to what information.
- *Social Networks*. How do we value (and consider managing) informal social lubrication ("who is talking to whom") since these contacts are undocumented and poorly understood? Good networking is vulnerable to inadvertent management actions, like reorganizations or changes in physical location or environments. Not only is collecting data about these networks expensive and labor intensive, the results could give management intimidating levers.
- *Awareness Technology for Distributed Groups*. Technology to replicate a sense of "mutual awareness," as if physically close, to a widely distributed group. Such tools offer the beneficial support for productive team collaboration at the risk of being used to monitor, or spy on, workers.

Mapping the Groupware Territory: The 4-Square Map of Groupware Options and the Team Performance Model

In the late 1980s, the Outlook Project created the 4-Square Map of Groupware Options as a simple framework to think about team processes in time and place/space. Groupware tools in each quadrant alleviate pains users face working in each mode (see Figure 1).

Figure 1
The 4-Square Map of Groupware Options



Source: Institute for the Future

The emerging technological tools could be placed in the particular quadrant in which they would be applied most often by teams.

- *Same Time/Same Place:* support for face-to-face meetings including presentation systems and agenda management and meeting support tools. Much of the early work on groupware focusing on room-based decision support tools carried out at places like EDS in Ann Arbor, the University of Arizona, and the IBM Decision Conference Center would fit in this quadrant. Presentation support applications like Persuasion and PowerPoint would fit here also.
- *Different Time/Different Place:* group archives/ repositories, e-mail, voice mail, and threaded discussion applications. In the early days of groupware, most development was applied to this quadrant. These tools now support increasingly media-rich documents. Development of indexing and retrieval technologies (particularly applied to unstructured information) and decreasing storage cost has increased the value of group repositories and archives. Groups with evolving memberships can experience "emergent learning" without being forced to file information in predetermined taxonomic categories.
- *Same Time/Different Place:* support for meetings at a distance such as teleconferencing, chat, and application sharing tools. Instant Messaging tools have become recent additions to this quadrant.
- *Different Time/Same Place:* support for team rooms including bulletin boards and kiosks.
- *Any Time/Any Place:* with experience in specialized tools and the growing pervasiveness of supporting infrastructure, this became the environment in which, for better of worse, we all work. Conceived originally by Stan Davis, teams have ever increasing flexibility in opportunities for and tools to support teamwork at any time and from any location. The ubiquity of the Internet, as well as wireless connectivity, lower prices, higher performance, and more convenient form factors for a variety of devices including cell phone, PDAs, and laptop computers have made this possible.

A second framework, the Drexler/Sibbet Team Performance™ Model, proved useful in talking about group processes over time. This model, created by Allan Drexler and David Sibbet, divides the life of a team into seven recurring stages ranging from the establishment of a team and the mutual development of trust through implementation, high performance, and renewal. The "V" shape of the model reflects the movement of a team toward constraints as they form and establish commitment and the subsequent movement to freedom as the constraints are mastered (see Figure 2, page 5).

Stages of Team Performance

Creating Stages

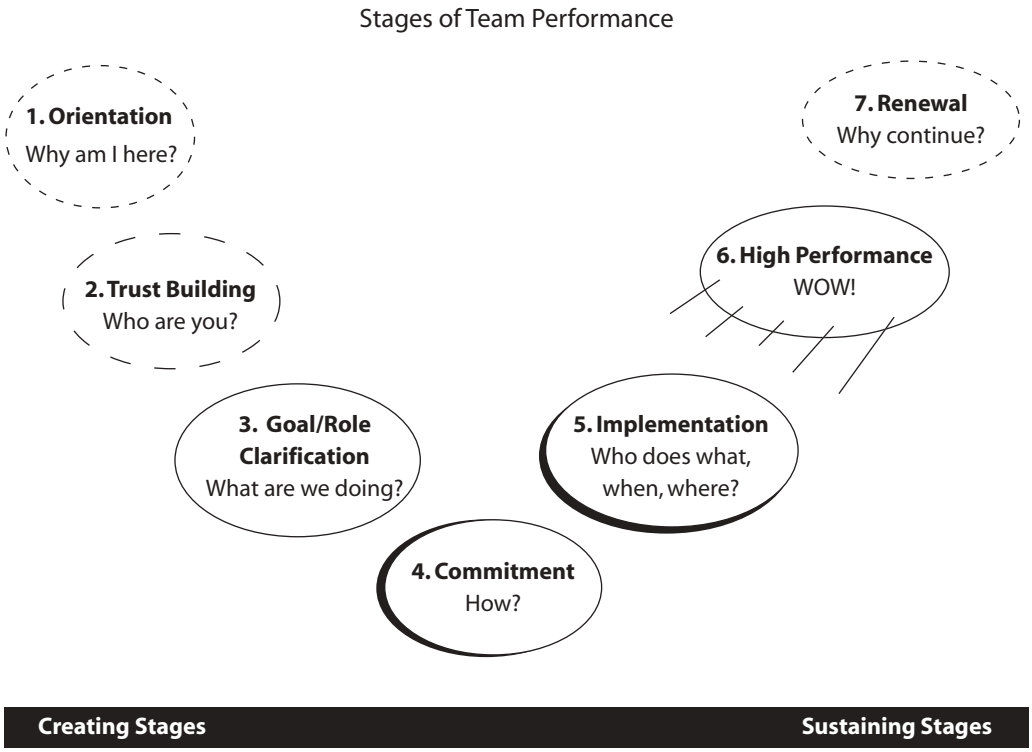
Stage 1: Orientation. Anything is possible. Why is the team being formed? What is the purpose of the team?

Stage 2: Trust Building. Who is on the team? What will be expected of each team member?

Stage 3: Goal/Role Clarification. What must the team do? Without clear goals and roles, the team can't progress effectively.

Stage 4: Commitment. Decisions are made about structure, resources, and budgets. The team agrees how to proceed.

Figure 2
The Drexler-Sibbet Team Performance™ Model



Source: Institute for the Future; Allan Drexler/David Sibbet, Team Performance™ Model.

Sustaining Stages

Stage 5: Implementation. Once commitments have been made, the team answers questions involving who does what, when, and where. The timing and sequence of work must now be managed.

Stage 6: High Performance. If methods are mastered, a team can act intuitively and flexibly respond to fast-breaking conditions. This results in occasional WOW!

Stage 7: Renewal. High performance isn't a steady state. Team membership changes. Tasks are accomplished and new tasks arise. "Why continue?" The team must transition to a new process.

Each stage builds on the prior ones. Attempts to shortchange early stages and immediately jump into implementation result in backsliding into the earlier, incomplete activities. Thus, trust and goal clarification are integral to having good implementation and are even more important for high performance.

In the hybrid of the 4-Square Map of Groupware Options and the Team Performance Model, we suggested which groupware options (as outlined by the 4-Square Map on page 3) would help yield the greatest group performance (when applied to the stages of the Team Performance Model.)

Thus Orientation, Trust Building, and Renewal would optimally take place in face-to-face meetings (Same Time/Same Place). Groupware could help facilitate and capture the results of these meetings for further reference and evolution over time, but there is no optimal technical substitution for interpersonal contact.

In the later stages of Goal/Role Clarification and Commitment, same time meetings could effectively take place at a distance, supported by technologies in the Same Time/Different Place square. Implementation and High Performance can be supported asynchronously (Different Time/Different Place).

Since the creation of these models, technologies have become more interdependent and have, as we shall see, moved from the domain of separate applications into a common infrastructure. Thus a complementary suite of tools are available for the life of a team.

The post-Internet world has accelerated the need for companies to build remote work skills. Team leaders need to weave together the appropriate set of tools for their group. This is analogous to determining and organizing a physical space in which a co-located team would work. For a distributed team, the online Project Space is their “home” because there is no single physical place an individual team owns.

In the next section we examine the past and possible future evolution of these collaboration tools.

Retrospective and Forecast

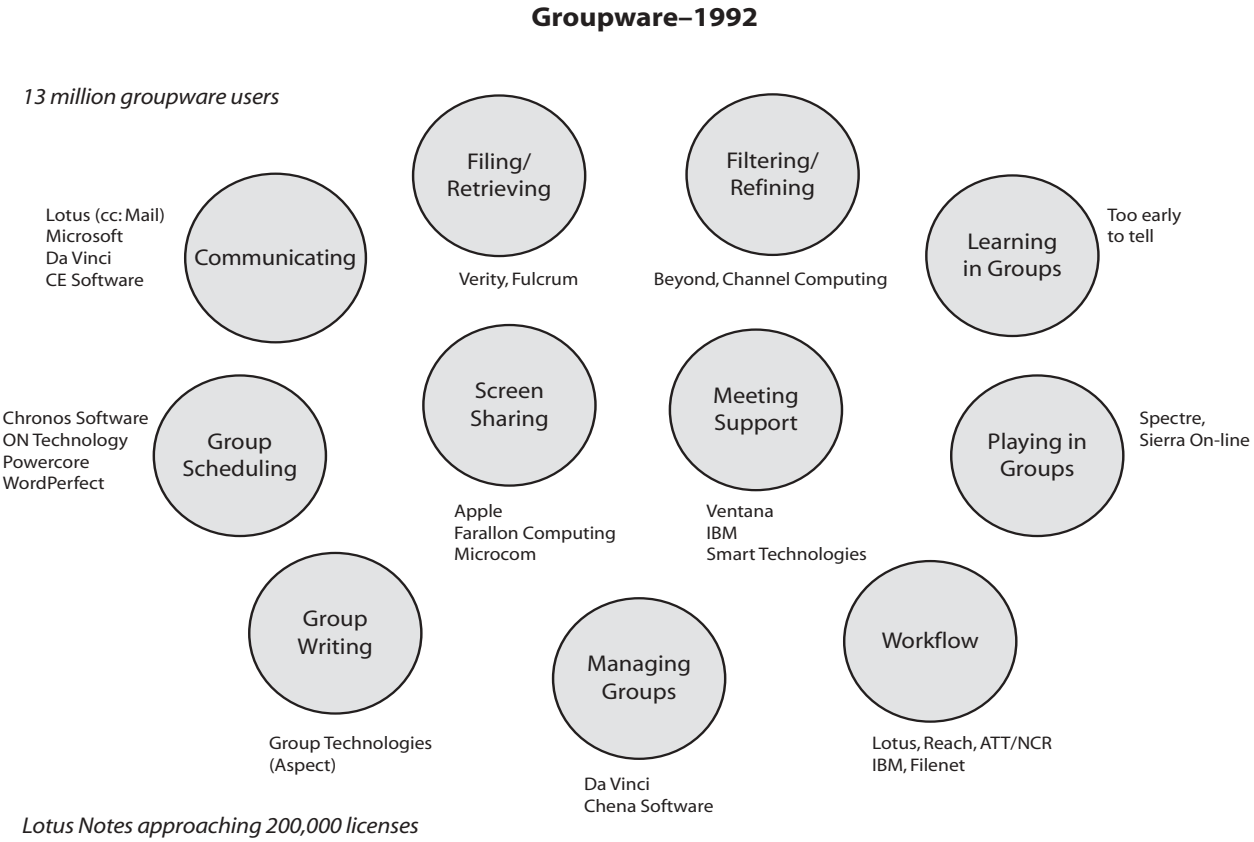
"...it will become obvious that groupware is not just a new class of products...[It] is a temporary term or banner, signaling the transition from the personal computer to interpersonal computer and eventually the collaborative computer…[and] is what all of us will expect our computers and telephones to do for us within the next 5-10 years."

—Bridging Distance and Diversity: Navigating the Challenges of Distributed and Cross-Cultural Business Teams, Groupware Outlook Project 1992-1993.

RETROSPECTIVE AND FORECAST: 1992

To evaluate how groupware has changed and where it is going, we use the taxonomy that we created in the early 1990s to serve as a baseline for comparisons of 2001 and 2005. Figure 3 is a graphical representation of IFTF's 1992 groupware taxonomy. Each category—communicating, group scheduling, filing/retrieving, filtering/refining, managing groups, learning in groups, playing in groups, workflow, meeting support, group writing, and screen sharing—is represented as a circle of equal size indicating that each was relatively new and equally small in terms of market size. Sample product names from 1992 are listed beside each category. In 1992, the categories floated, as if isolated, with little connection to each other. For example, e-mail was separate from calendaring. Information filtering/refining were separate, stand-alone applications. Furthermore, most applications had their own proprietary client interface and access.

Figure 3
The 1992 Groupware Taxonomy



Source: Institute for the Future

GROUPWARE TODAY: 2001

By 2001, driven significantly by the Internet, there have been dramatic changes that are illustrated in Figure 4 below.

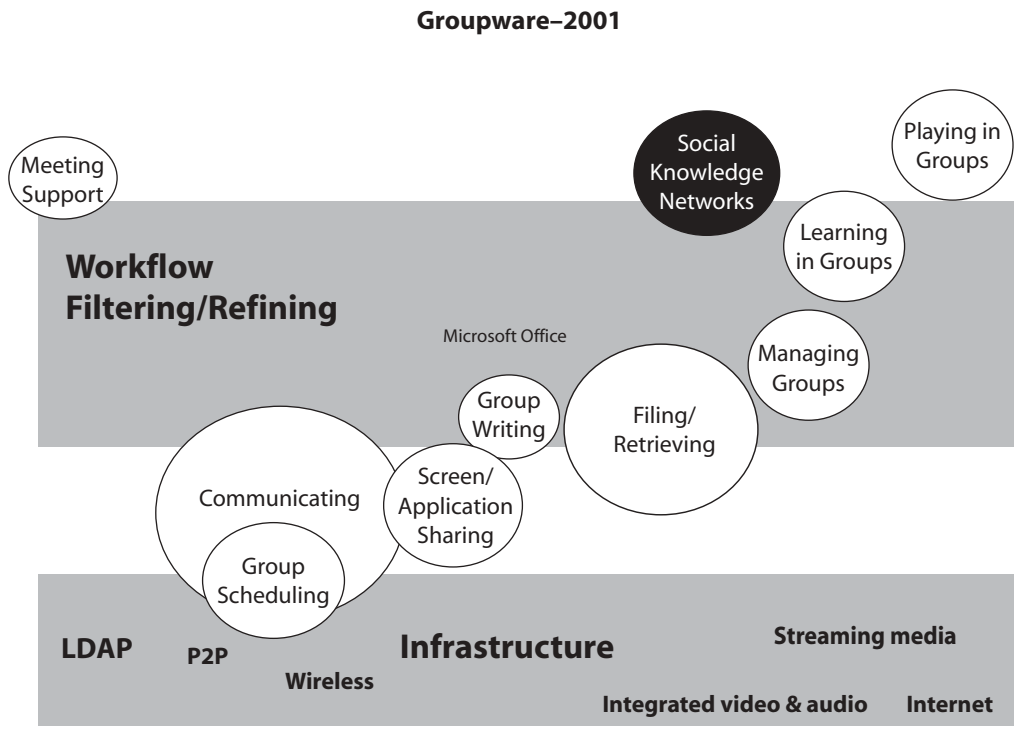
Growth and Shrinkage of Categories

Relative to the 1992 baseline, the size of each circle indicates the growth or shrinkage of the market for that category.

E-mail has become ubiquitous, fueling the explosion of the "Communicating" category. The growth of e-mail has come both from corporate buyers as well as free Internet e-mail for consumers, such as Hotmail. Another growth category is the "Filing/Retrieving" category driven by the increased usage of document management systems.

On the other hand, and despite much media attention, meeting support software, which typically required a special purpose room and a facilitator to support brainstorming and the "rating/ranking/voting" of ideas never took off.

Figure 4
2001 Groupware Map



Source: Institute for the Future

GROUPWARE TODAY: 2001 (CONT.)

Functions like tracking changes, comparing documents, and merging documents support group writing. Many of the capabilities of special-purpose applications supporting group writing have become embedded within conventional productivity tools, with Microsoft Office being the de facto standard. Version management, however, remains problematic in many organizations.

Categories Are Clustering

The desire to work seamlessly across different applications is driving closer integration of products, for example, storing a word processing document directly into a document management system. The browser has become a standard interface for many applications, creating a network effect similar to that created by the widespread availability and use of the graphical user interface standard for personal computer applications.

Categories Collapse into Others

Group scheduling has largely been absorbed into the "Communicating" category. Microsoft combined its Schedule+ and e-mail client into Outlook while Lotus added calendaring to its Lotus Notes product.

Workflow and Filtering/Refining are now features across all product categories. Although a few standalone workflow systems and web-based services still exist, e-mail and document management systems support automated workflows. They are used, for example, to route documents for approval and to signal responses to critical alerts. Increasingly sophisticated searching is available in almost all applications.

Categories Shift down from "Applications" to "Infrastructure"

The "Communicating" category (including group scheduling), once a separate application, is now submerged into the standard business infrastructure. E-mail, for example, is expected to be available 24/7 and applications are built on top of it. A critical transaction system will automatically generate an e-mail to confirm the transaction to the consumer or notify a support person about a problem. The ubiquity of e-mail based on standard protocols has necessitated the development of filtering tools to block unwanted messages.

Document management (filing/indexing/retrieving) and application sharing systems are becoming commonplace, though typically only standardized at a departmental or functional level. They are not yet as ubiquitous as e-mail across the enterprise. Corporate functions heavily dependent on timely document access, e.g., legal, training, or quality, have been early adopters of document management systems that provide document registration and storage along with version control.

Products in the "Managing Groups," "Learning in Groups," "Marketplace for Talent," and "Playing in Groups" are still separate applications, with those categories higher up in the diagram since they are further away from being incorporated into the infrastructure.

Infrastructure Capabilities Expand

The infrastructure includes support for wireless connections, access to the Internet, peer-to-peer protocols, and the Internet Engineering Task Force's lightweight directory access protocol (LDAP), gaining wide acceptance by vendors providing directory-based products. LDAP was designed for browser based applications that need to access an X.500 directory without incurring the resource requirements of the X.500 Directory Access Protocol (DAP).

Since groupware by definition involves collaborating human participants, each product needs to manage data about those participants. Without a common directory, organizations face a proliferation of independent directories for each installed system, thus increasing support costs and reducing the seamlessness of the user experience.

Managing Groups Moves to the Browser

Browser-based software to support project teams will continue to grow. The primary features in these systems are:

- Project management
- Issue tracking
- Threaded discussion
- Document management
- Group calendar
- Real-time chat

With the exception of real-time chat, the main uses of this type of application are asynchronous. The Internet, and more specifically browser-based software, such as Intraspect (www.intraspect.com), e-Room (www.eroom.com), Lotus Quickplace (www.lotus.com), Andromeda2001 (www.cogos.com), eProjects (www.eprojects.com), and Buzzsaw (www.buzzsaw.com) is driving a significant portion of the usage. Most of these applications may be "rented" from an Application Service Provider (ASP) or licensed for internal implementation. For situations where multiple organizations are involved, the ASP is attractive for several reasons. First, they provide a subscription service on a per user basis, thus avoiding high upfront hardware or software costs. Second, the organization has immediate use because there is no hardware or software to deploy. Third, the management of the server is done by a third party and not hosted by one of the user companies. For example, during the process of a merger, an ASP can host a space for the project teams that can be easily accessed by the two companies and their consultants without having to create additional user IDs and access privileges on pre-existing, perhaps incompatible, corporate servers.

While businesses are using these types of applications from ASPs that provide secure workspaces (id/password, Secure Socket Layer), many will still prefer to install these systems inside a corporate 'firewall' for sensitive internal projects.

Meeting Support Remains a Niche

Face-to-face (Same Time/Same Place) meeting support systems remain a small niche. They are another element in the facilitator's tool bag along with the flipchart and sticky notes. Meeting support software requires planning work prior to the meeting to determine where and how the technology will be used. While planning for a meeting is a positive habit, in general business people don't find the time. In a same-time setting additional overhead (from set-up and running the technology) is a further barrier to widespread use. Less-rich, less-complex meeting support capabilities, such as brainstorming and rating/ranking ideas, will be part of products providing general project team support ("Managing Groups"). Effective tools have to be simple to use and not require a facilitator, thus allowing the team to draw upon them as needed.

The underlying technology (e.g., brainstorming, rating, ranking) in meeting support systems may prove most valuable as tools for marketers collecting customer opinions in focus groups.

Enterprise Information Portals

Enterprise information portals (EIPs) are intended to be gateways to fragmented information systems: business intelligence, documents, project systems. To the user, an EIP is a "one-stop shop" for corporate information. For developers, they provide toolkits to create and maintain the corporate Intranet. EIP vendors include IBM, Plumtree, Hummingbird, SAP, Broadvision, and Oracle. Poorly implemented EIPs can add to employees' information clutter. They rarely satisfy all information needs, and often turn out to be

GROUPWARE TODAY: 2001 (CONT.)

yet another format and place to look for information. Further, users can become frustrated if the information available in legacy applications was not converted to the new portal environment resulting in new tools with less usefulness than their predecessors.

Learning in Groups

Learning in groups includes e-learning (training, courses) and polling. The simplest e-learning systems are sites hosting the syllabus of a topic and associated reading/presentation materials along with a threaded discussion area. More elaborate systems incorporate multimedia (digitally recorded lectures), interactive simulation exercises and learning management tools for registration, testing, and grading. Internal corporate e-learning and learning management systems will also tie into human resource systems to track the types of courses completed and certifications attained by each employee.

The near term adoption of these tools will occur in regulated areas (e.g., safety training) or where certification or continuing education is required (e.g., CPAs, attorneys). E-learning will be used to reduce expenses, with the added convenience of fitting the student's time schedule and reducing travel time. Vendors will continue to provide online training for their customers.

Universities will also continue to explore what e-learning means for them. Gerry DeSanctis, who teaches in a global executive MBA program at Duke University, identified two major issues in this environment:

- Sense-making is extremely difficult because of the large volumes of text. In a class of 90 students, there are subspaces of five people in a team. The students, however, do not like segmentation. They want to learn what everyone is saying, but they find it difficult to process all the material—read everything and make sense of it.
- Relationship overload—because everything is online, students find the numerous interactions with so many people difficult to sort out and manage. They cope by learning to scan material and by using interaction protocols, such as "don't type more than a screen" and "don't say things like 'I agree'".

In May 2001, IBM held a three day internal online session called "WorldJam" to poll ideas from employees. They invited all of IBM's 320,000 employees to an internal site that facilitated posting, commenting, and voting on ideas. By the end of the three days, 52,600 people had logged into the site and generated more than 6,000 proposals and comments and viewed on average at least five postings each. The discussion was initially seeded with 10 broad topics, such as how to retain valuable employees and how to work faster without compromising quality.

Converging Areas: Instant Messaging, Screen- and Application-Sharing, Peer-to-Peer

The major shifts in communicating in 2001 include the growth in Instant Messaging (IM), the availability in the infrastructure and on the Web of screen- and application-sharing environments, and peer-to-peer business applications.

Instant Messaging

Although e-mail will remain the dominant mode of communication, expanding along with Internet growth, the use of Instant Messaging (IM), will grow rapidly, especially in the corporate setting. While young people first adopted IM, older workers initially began to use it for similar social purposes and are now using it in business.

IM is primarily consumer and socially-oriented and the users have largely been young people. College students often use IM to communicate with their friends and family in other locations. As a synchronous peer-

to-peer technology, IM facilitates faster communication than e-mail. Its popularity relies on use of the Internet, thus avoiding long-distance charges. Not surprisingly, IM's adoption in business settings is occurring most frequently at high-tech companies. The three largest IM vendors (AOL, Yahoo!, MSN) have over 50 million users.

The key features of IM are:

- Real-time messaging with another user
- "Buddy lists" that allow users to more easily contact correspondents they IM (yes, it's also a verb!) frequently. Users can track the availability status of their friends and colleagues (e.g., disconnected, online, away), and immediately communicate with them if they are available.
- File exchange
- Webcam (on Yahoo!'s service)

For some business settings, IM can be socially more efficient than phone calls because there is less setup and shut-down in conversations. Phone social etiquette ("How was your weekend?" or "How are the kids"?) precedes work. With IM, users report they pose their question immediately, get an answer, and finish. When a work process involves a few people who may not normally work together and engages them for a brief duration, connecting synchronously using an Instant Messaging tool requires less setup than is the case with an asynchronous workspace because the basic tools are already installed and ready to use.

Screen Sharing & Application Sharing

Screen sharing software has moved beyond its initial application facilitating remote technical support. It is a synchronous tool providing application sharing; text creation; group annotation; and collaborative brainstorming. Microsoft NetMeeting is free PC client software widely used in small groups. However, when working across companies, there can be "firewall" problems with this application. Browser-based products, such as WebEx, Latitude, and Centura, available on a per use basis from Application Service Providers (ASPs), support many users and do not require separate applications. These are commonly used for larger events (e.g., sales training) and when the users are from different companies.

The growth of screen and application sharing software will continue, and it will move close to becoming part of the infrastructure. There will be tighter integration with project support software ("Managing Groups") so that after an online meeting, the outcomes can be stored in the team's space.

Peer-to-Peer (P2P)

Peer-to-peer architectures move beyond the centralized architecture of mainframes or client-server systems to a new model in which networks of peers—typically desktop or notebook computers, but also conceivably PDAs, mobile phones, and other devices—share information according to a set of common protocols. Put simply, peer-to-peer (P2P) computing is a user-level, distributed system architecture that makes independent file-sharing and communication easy. Users with similar interests can link with one another and search each other's computers for desired information. In a peer-to-peer architecture, computers that have usually functioned as clients of shared servers, instead communicate directly among themselves, acting as both clients and servers, assuming whatever role is needed at a particular time. The lack of a central server creates a fundamentally decentralized network, which provides fault tolerance while also reducing the ability to control the flow of information and resources within the network.

GROUPWARE TODAY: 2001 (CONT.)

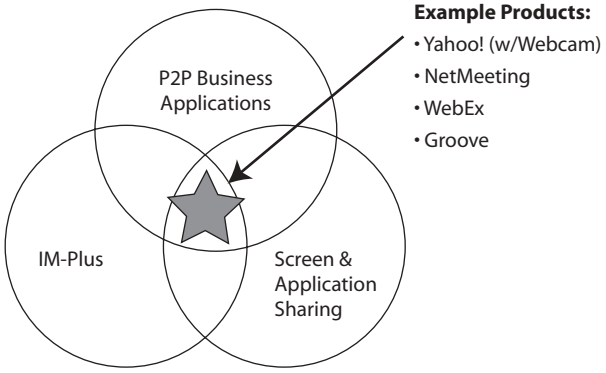
Examples of peer-to-peer architectures are instant messaging programs, (e.g., AOL IM, Yahoo!, MSN Messenger), Groove, and JXTA.

Ray Ozzie, father of Lotus Notes, started Groove Networks in late 1997. He says he selected P2P technology as the basis for the Groove operating environment because "it was the best way to solve the problem of getting self-organizing groups together in a fast and secure fashion." In October 2001, Microsoft invested $51M in his company. Groove is an example of what might be described as "IM with Memory". While supporting instant messaging, Groove lets colleagues share a discussion space, take a web tour together, share files, and view documents together at the same time. Unlike AOL, Yahoo!, or MSN, Groove retains a record of the collaboration. If users connect with Groove at the same time to work on a document, it will remain available (stored on each person's PC) and may be worked on after they disconnect.

Convergence of the Three Segments

Between now and 2005, there will be a convergence of functionality at the core infrastructure among IM-Plus (IM with additional capabilities), screen- and application-sharing programs such as NetMeeting and WebEx, and peer-to-peer (P2P) business applications, such as Groove. Figure 5 illustrates this trend.

Figure 5
Three Applications Converge



Source: Institute for the Future

FORECAST: 2005

Figure 6 forecasts where groupware will be in 2005. There is the continued trend of categories getting larger and moving into the infrastructure. Workflow and Filtering/Refining connect to the infrastructure, with increasingly standardized development frameworks enabling workflow across different applications while offering a more seamless user experience.

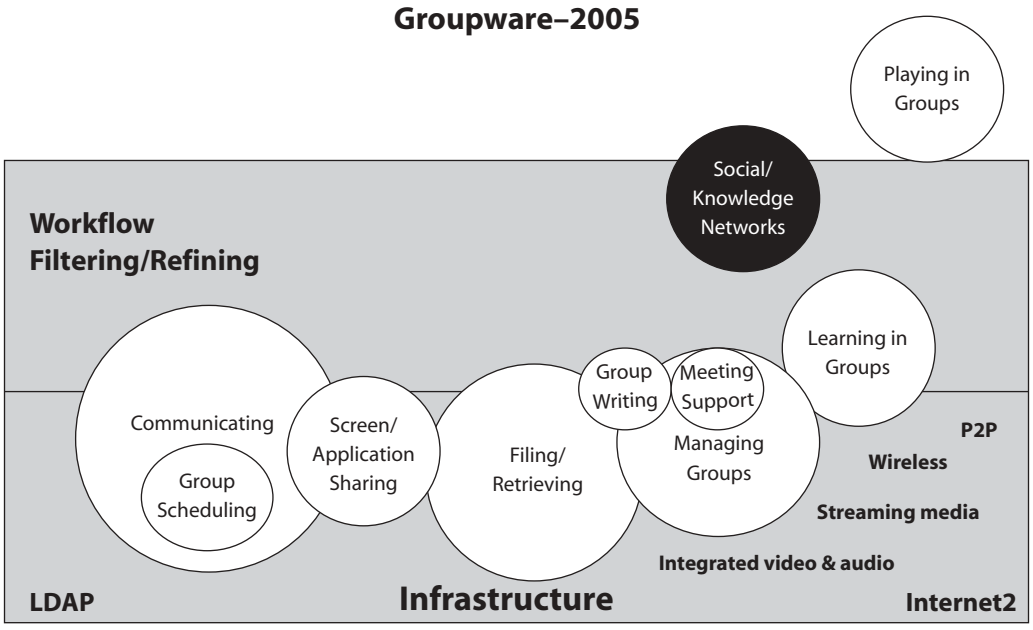
Communicating: Project-Based Calendaring on the Web

In the communicating segment, E-mail and calendaring (group scheduling) have combined. Will business users share calendars across the Web as easily as they do e-mail? Calendaring has come into common use to schedule meetings within companies. With e-mail, coordination, and workflow applications already blurring company boundaries, calendaring across companies will follow. However, such integration will more likely occur in a web-based calendar that is part of the coordination software, than directly with the user's personal calendar. Internal users will not want their calendars accessed directly by outside people, even if they are on the same team. They will share calendar information relevant to a particular project and synchronize it with their personal calendar.

New Function: "Dribble-Synch"

As teams of people, each with a multiplicity of devices (cell phones, PDAs, notebook and desktop computers) collaborate over time and across diverse networks, work flows can get out of synch, including directories and document versions. Rather than enforcing major synchronizing episodes, "dribble-synch" updates directories and versions on an as needed basis. The highest priority applications will be updated more frequently with other applications and devices updated

Figure 6
Groupware in 2005



Source: Institute for the Future

FORECAST: 2005 (CONT.)

less frequently. They will be "well-enough synched for the job."

Filing/Retrieving: From Lightweight Document Management to Emergent Knowledge Repositories

Document management functions will become part of office application suites and "lighter" in nature than previous document management systems. Users will store directly from their productivity tool into group repositories. These systems will provide corporations with a trustworthy location for documents that are important corporate assets. The document management system will be reinforced with back-up and recovery capabilities, adding reliability beyond users' local hard drives.

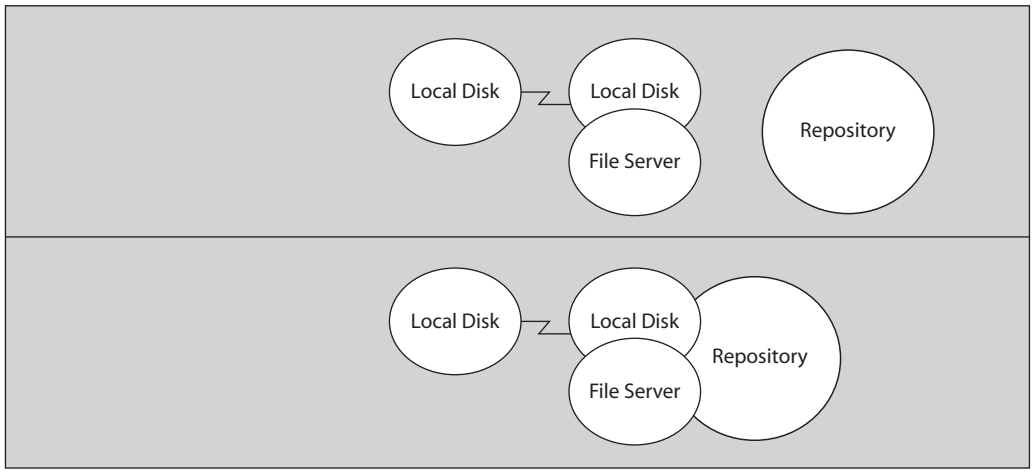
There will be tighter integration of document management systems ("Filing/Retrieving") with project team support systems ("Managing Groups"). Combining repositories of formal documents with the informal working materials of a group (e.g., e-mail exchanges, instant messages), which are equally important in evolving a group history, creates a solid foundation of "intellectual capital".

In viewing the document management system as the repository for knowledge, companies still face the challenge of motivating users to store their documents in these systems and not on their local hard drive (see Figure 7). Businesses also face difficulties in maintaining a passive repository as a living knowledge management system. Cheap storage in which documents are stored redundantly and automatically, along with more powerful indexing and retrieval software will lead to "emergent" knowledge in ways that older knowledge management systems (requiring conscious contribution and categorization) did not.

Social/Knowledge Networks

Increasingly, the war for talent—finding, attracting, and retaining the best employees—is driving the need for new tools to meet personnel needs. At the same time, a more fluid and mobile work force needs to connect with potential employers. As a result, there is a

Figure 7
Where are Files Stored?



Source: Institute for the Future

plethora of online jobsites. Over the next five years companies will move away from HR and upper management controlling the movement of employees into assignments to a more open marketplace for talent through the use of online job posting systems.

Expert locator software and talent mapping systems support this trend. Expert locators typically have two parts: 1) the biography or profile developer and 2) the searcher.

The "'biography" developer requires active participation by the subject, who enters his evolving experience, interests, and skills. This procedure is most effective where knowledge can be very clearly classified and categorized and where there are strong incentives to keep it up to date, for example, when one is essentially advertising to attract customers. However, the implementation of these systems often fails because information is incomplete and stale. An "automatic profiler" passively builds a more detailed picture based on one's e-mail, writings, web browsing, etc., and usually allows some commentary by the subject. A team leader searches the system for particular knowledge or skills. The potential for abuse of the privacy of workers should be obvious.

Tools like these may be deployed inside a corporation or externally to find contractors.

A few of the challenges to these systems involve how to get people to "opt-in." Employee concerns may include: 1) being labeled an expert and thus getting barraged with requests; 2) being forced to document expertise or the lack of it implicitly ("Am I identifying information or skill sets that the company may use to get rid of me?"); 3) additional overhead populating the expert database; 4) keeping the information about people current; and 5) privacy (who gets to see what?).

Reputation systems involving peers, not just the individual, will be used in conjunction with these systems to help establish trust for ad hoc or distributed groups.

BEYOND 2005

In 1967, a time when keypunch machines were state-of-the-art, Doug Engelbart, then at Stanford Research Institute, demonstrated a prototype interactive system for knowledge workers using what were then the non-standard monitor with windowed hypertext and a keyboard supplemented by the mouse cursor controller, which he invented. This prototype used live video, audio, and screen sharing in real time. Silicon Valley companies exploited parts of Doug's vision for decades by commercializing the flashy technologies that spun out of his lab. Other, more subtle, parts of that vision are only now moving into the mainstream. These include the use of group repositories, data mining, and filtering tools to create emergent knowledge from a collaborating team's information flow and communication.

There are many ambitious technology research projects underway today that hint at a very rich technology future just as Engelbart's demonstration of over thirty years ago. While it is not clear what parts of them will become widely adopted or what forms these adoptions will take, the projects can offer glimpses into the future. The sampling of current projects discussed here involve harvesting meaning, sensing emotions, browsing/searching audio and video, and living in highly interactive virtual reality environments.

Sense-Making Technologies

An increasing challenge in an era of information overload is making sense of the high volume of content from the Web, in data repositories, in corporate and personal storage media, in e-mail, and, increasingly, in large accumulations of IM sessions. In 1997, we proposed a distinction between "knowledge by emergence" and "knowledge by design." That distinction is equally valid in 2001 and will be, we believe, still relevant in 2005. Table 1 below summarizes the essential differences between the two approaches. These two schools of thought will continue to be in tension beyond 2005. This distinction will extend far beyond knowledge management and sense-making technologies to include mapping of social and knowledge networks and systems that help groups to maintain mutual awareness of each others' work.

From the knowledge by design school, the Semantic Web is a multinational effort to augment Web pages with information about the structure and meaning of the material on them so that material may be used and manipulated by software agents. Technologies developed under the rubric of "artificial intelligence" are being extended onto the Web in conjunction with:

- XML, the eXtensible Markup Languge, that is the follow-on to HTML, the Hypertext Markup Language that defined the first generation of the World Wide Web.

Table 1
Knowledge By Design vs. Knowledge By Emergence

Design	***Emergence***
• Context is predefined	• Context is undefined
• Categories are predefined	• Categories emerge
• Categories are human-generated	• Categories are machine generated

Source: Institute for the Future

- RDF, the Resource Description Format, that provides the technology for expressing the meaning of terms and concepts in a form that computers can readily process.
- Ontologies, collections of statements written in a language such as RDF, that define relations between concepts and specify logical rules for reasoning about them.

The successful implementation of the Semantic Web depends on solving some hard implementation problems, including agreeing on a common, formally organized symbology. If implemented, the Semantic Web could result in a wide variety of software agents for negotiating, searching, and scheduling services as well as for other currently unanticipated uses.

From the knowledge by emergence school, search engines like Google show the way. They manifest increasing power, speed, and selectivity in bringing sense to information from disparate sources. Beyond 2005, we expect to see these types of engines tuned in many different ways—for searching the web, for gathering documents from within a corporate peer-to-peer network, for answering natural language queries, or for extracting transaction profiles and histories from across databases.

Affective Computing

MIT's Media Lab is conducting research on affective computing, described as computing that relates to, arises from, or deliberately influences emotions. Its research focuses on creating personal computational systems endowed with the ability to sense, recognize and understand human emotions, together with the skills to respond in an intelligent, sensitive, and respectful manner toward the user and his/her emotions. MIT is also exploring the development of computers that aid in communicating human emotions, computers that assist and support people in developing their skills of social-emotional intelligence, and computers that "have" emotional mechanisms, as well as the intelligence and ethics to appropriately manage, express, and otherwise utilize these "emotions."

We do not anticipate that affective systems will be in widespread use in common business applications. Like many edge technologies, they will develop first in entertainment, in the form of user interfaces that make games even more engaging. From there, they may spread to e-learning systems. Initially, affective computing will be used in tools for individuals to monitor the emotional response and receptivity of the student to the instruction. Affective models of groups could be useful in group learning environments.

Browsable, Searchable Video and Audio

The focus of browsable, searchable video and audio is to make them as versatile as print. Areas of experimentation include low-cost capture of audio and video, multimedia browsing and skimming, tele-presentation, and collaborative annotation of multimedia content.
Microsoft Research is looking at compressing streaming video information captured in seminars and classes. Mechanically removing gaps and doing basic acceleration (with pitch adjustment) can already reduce a one-hour lecture to a half-hour. However, they are going further by making use of heuristic cues (e.g., pitch inflection changes or changes in slides) to tag key points in a lecture. They then use these cues to reduce the presentations to even shorter highlights in order to make possible the type of browsing and skimming of multimedia material currently only possible in print. Note that this work would not be possible without ever increasingly inexpensive storage media, processing power, and network bandwidth.

Even with these improvements, video will not be as efficient to scan and browse as text, but the dropping cost and increasing use of video content make it an important area of research.

BEYOND 2005 (CONT.)

Tele-immersion

Tele-immersion enables users at geographically-distributed sites to collaborate in real time in a shared, simulated, hybrid environment, as if they were in the same physical room. It is the ultimate synthesis of media technologies:

- 3D environment scanning,
- projective and display technologies,
- tracking technologies,
- audio technologies, robotics, haptics (touch feedback interfaces), and
- powerful networking.

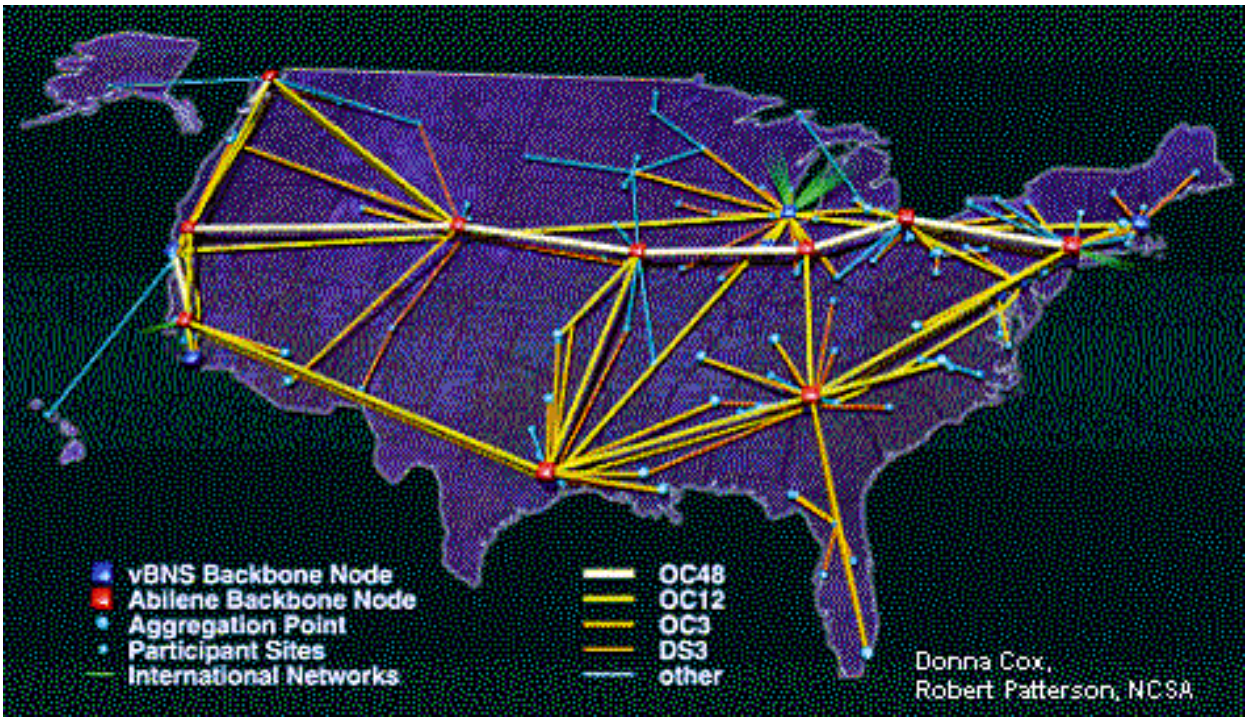
In a tele-immersive environment computers recognize the presence and movements of individuals and both physical and virtual objects, track those individuals and objects, and project them in realistic, multiple, geographically distributed immersive environments on stereo-immersive surfaces.

Tele-immersive environments will therefore facilitate not only interaction among users themselves, but also between users, their environment, and computer-generated models and simulations. For example, a group of designers will be able to collaborate from remote sites in an interactive design process. They will be able to manipulate a virtual model starting from the conceptual design, review, discuss, and refine the design, perform evaluations and simulations, and even finish off the cycle with the production of a physical part on automated milling machines.

Internet2

In order to make collaborative, tele-immersive environments work, substantial upgrades will be required in the communications infrastructure. Internet2 is a consortium led by over 180 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet (see Figure 8). The current Internet handles millions of users: Web, e-mail, low-quality audio and video; and interconnects PCs and servers. Internet2 is designed to support billions of users and devices, providing convergence of current applications with multimedia (telephony, video-conference, HDTV); and communicating intelligent devices. These include not just today's PCs and servers, but also a wide variety of intelligent appliances. Ted Hanss, director of Internet2 application development in Ann Arbor, MI, suggests that Internet2 will become mainstream in three to five years; others suggest it will be longer, especially in upgrading the so-called "last mile" of slow, dial-up connections. Important elements of Internet2 that affect groupware are vastly increased bandwidth, important for high-quality audio and video, and Internet addressing in the IPv6 protocol, important in handling the ever-increasing number of devices being added to the network.

Figure 8
Internet2



Source: Donna Cox, Robert Patterson, NCSA.

Issues

As more and more people go online, issues that were raised early in the IFTF Groupware Outlook research program become more pronounced. These issues include:

- *New Leadership Models*—as technologies assist in "flattening" organizational structures and work involves collaborations with partners outside the traditional boundaries of an organization, management will need to develop new models to assist leaders of the networked organization and to engage efficient use.
- *Security of Information*—In flat, distributed, networked organizations, it will be increasingly necessary to pay attention to who gets access to what information.
- *Social Networks*—How do we value (and consider managing) informal social lubrication ("who is talking to whom") since these contacts are undocumented and poorly understood? Good networking is vulnerable to inadvertent management actions, like reorganizations or changes in physical location or environments. Not only is collecting data about these networks expensive and labor intensive, the results could give management intimidating levers.
- *Awareness Technology for Distributed Groups*—technology to replicate a sense of "mutual awareness," as if physically close, to a widely distributed group. Such tools offer the beneficial support for productive team collaboration at the risk of being used to monitor, or spy on, workers.

New Leadership Models

As organizations flatten and evolve into more porous network structures, the need for new leadership forms and new behavior arises. Leaders must confront multiple contexts for work based on the many relationships and patterns of interdependence in these new organizations. The military-style, command-and-control leadership in the early 20th century is not designed for boundary crossing and information sharing. In command and control systems, information is power. There is an incentive for gathering information and pushing it up the pyramid to decision makers at the top. Leadership in the new organic organization is less about control and more about enabling information flow and knowledge creation to occur as needed at all levels of the network and about acting as a catalyst for growth and creativity across the organization.

Organizational knowledge in a networked structure implies an integration and synthesis of viewpoints and ideas that must come from multiple decentralized points to be useful. In dispersed organizations, key resources and ideas are located at different sites, and various tasks require different groupings of members and different leadership functions. A network-style organization demands leadership from many individuals.

In such a distributed network, it's important to identify paths or domains of leadership. Though the term distributed uses location as the lens, it's becoming more useful to think of leadership in terms of conditions, relationships, processes, or crossroads. To collaborate and communicate successfully across boundaries, there must be a shared belief and commitment. Leaders will empower workers to innovate based on shared values and trust. (For additional work on new leadership models, see "Understanding Work and Supporting Workers in the 21st Century: Shifts, Shadows, and Guideposts," Special Report SR-605, Institute for the Future, June 1996.)

Security of Information in Distributed Work

In these distributed network organizations, work is increasingly decentralized and distributed, not only within the boundaries of the company, but also beyond. The model for this collaborative work has evolved beyond a "piece work" mentality in which the outside collaborator is responsible for a well-defined and relatively independent deliverable to a more fully collaborative model in which people from across many organization boundaries work in interdependent teams. A free flow of information, even information that previously would have been considered confidential, is necessary for the collaboration to succeed.

This organizational shift is not new, but is magnified by the free flow of information through groupware and other collaborative technologies. Information that, in the past, would be passed in single copies on paper, stamped "Confidential" and accompanied by a stringent nondisclosure contract now is flowing more freely across networks. Companies must address a range of security issues, including:

- Identification of participants. As organizations take on relationships that span corporate boundaries, they must carefully manage access to their core information bases. As projects begin, evolve, end, change participants, and so on, it will become increasingly difficult to distinguish legitimate access to corporate information resources from illicit ones.
- Managing multiple roles and identities. Individuals will have a parallel issue of managing the information they obtain as they participate in diverse projects. There will be product opportunities for tools that help individual contractors manage confidential information.
- Intellectual property ownership. The rights to intellectual property (IP) developed by a group may be

difficult to determine, especially as participants may contribute IP they have developed in other projects and whose ownership may be confusing to begin with. There will be extensive service opportunities for IP lawyers.

Social Networks

Social networks are about "who is talking to whom" in contrast to knowledge networks that are concerned with "who is talking about what". Social networks exist everywhere, and are crucial to the way knowledge and information flow within an organization, but they are usually informal, undocumented, and poorly understood. As a result, important social networks can be easily disrupted by inadvertent management actions, like reorganizations or changes in physical location or environment.

Social network analysis is a set of tools and methods designed to quantify and analyze the patterns of interaction within an extended group. Because gathering the data is still expensive and labor intensive, such analysis is usually used to diagnose major organizational problems. The analysis can reveal who the key "connectors" are within an organization, where the communications bottlenecks are, and how the informal organization differs (sometimes dramatically) from the formal organization. It can also help identify where managers, or even whole departments, are "out of the loop".

As it becomes easier to collect and analyze such data (for example, by analyzing patterns of email and voice communications), social network analysis could become a valuable tool for improving organizational and individual performance. It could help people improve their communications strategies and identify where relationships need to be strengthened. Of course, it could also be used in very threatening ways by management, such as identifying candidates for lay-offs or using it to suppress unsanctioned contacts and activities. Because of this double-edged character, people are likely to resist many forms of social network analysis unless a strong foundation of openness and trust has been established.

Awareness Technology for Distributed Groups

The purpose of presence and activity sensors is to provide members of a group with the same sense of "mutual awareness" when members are physically separated as when they are located right next to each other—to establish "casual proximity" for distributed groups. For example, one can look into a team member's cubicle and know not only whether they are physically there, but also whether they are in a meeting, concentrating heavily on some task, or available for interruption. This kind of awareness, although we usually take it for granted, is extremely important in encouraging spontaneous interaction and collaboration.

It would be possible to restore a high level of mutual awareness to a distributed group through a combination of web cameras, presence sensors ("Is he in his chair?" or "Are there other people around the table?"), and activity sensors ("Is he talking on the phone?" or "Is he typing furiously at the keyboard or just reading his email?"). Tools such as instant messaging and voice intercom could facilitate casual, spontaneous interaction among team members.

Of course, there are issues of privacy and social protocols to work out, fundamentally different from those that existed among co-located team members. The key is to treat the technology as a valuable aid to team members who want to collaborate with each other, rather than as a way of spying on people or monitoring their activities.

Conclusion

Much of this report was prepared before the World Trade Center terrorist attacks on September 11, 2001. In fact, we conducted an expert workshop to refine our forecast on September 10. The aftermath of those tragic events only reinforces our conclusion that collaborative technologies will only expand in scope, capacity, and use for the next five years. Organizational trends toward more global, decentralized, and cross-company work continue to make collaborative work imperative. A gathering global recession insures that controlling costs will be a priority in most companies. Groupware applications that prove cost-effective will find receptive markets.

As companies upgrade and enhance their collaborative toolkit, managers increasingly will learn the art of media choice—figuring out when to work together and when to work remotely. They will learn to make the most effective use they can of the technology.

Small businesses, too, will be able to employ collaborative technologies. The advent of simpler groupware systems and "rentable" applications on the Web will open collaboration to organizations that can't afford a sophisticated IT department.

As individuals and groups chose their own preferred tools for collaboration, there will be inevitable tensions with approved corporate standards. User-driven adoption is powerful and may well increase team efficiencies at the risk of leaving the larger organization with the need to support a grab-bag of products that do not work well together. Expect conflicts over which IM platform companies use, directories and buddy lists, and screen- and application-sharing systems.

Finally, the use of teleconferencing and groupware to substitute for travel—long a myth that promised tempting benefits, but delivered little in actual savings—is likely to be a short-term result of the events of September 11. Just as the Gulf War and the California earthquakes of 1989 and 1994 reduced travel and increased demand for teleconferencing, current use is up sharply. We expect more of these uses to "stick" this time because of the current ubiquity of common, underlying infrastructure based on the Internet. However, the fundamentals of group work—the need to meet face-to-face to build trust and avoid misunderstanding—will ensure that once corporate travel restrictions are relaxed, business travelers will take to the skies again.