Multimedia User Interfaces for Telecommunications Products and Services

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The emergence of multimedia systems, which incorporate media types such as text, graphics, audio, video, and animation, has great potential to change how people interact with systems and with each other. As multimedia technologies and their applications in telecommunications products and services evolve, some critical human factors challenges in designing these systems are emerging. This paper describes how the use of new multimedia technologies, complemented by the proper application of human factors design principles, can enhance the usability of AT&T products and services. Examples of three types of applications — multimedia-based training, multimedia-based performance support, and multimedia conferencing — highlight challenges specific to the design of multimedia user interfaces.

Introduction

"Multimedia is a major part of AT&T's future, and we will work very hard to make that happen." [1]

—Robert E. Allen, AT&T Chairman

In the past several decades, telecommunications and computer technologies have expanded at a far greater rate than many could have imagined. Evolving telecommunications capabilities have led to changes in when, where, why, and how people communicate. Advances in computer capabilities have changed many aspects of our work and personal lives, and will continue to do so. We are on the verge of a revolution in which the boundaries of telecommunications, computing, publishing, entertainment, consumer electronics, and information access are becoming blurred. A "mega-industry" is being created, driven by the emergence of new technologies, the most important of which is *multimedia*.

Multimedia systems incorporate a variety of media types, including voice, image, music, text, animation and graphics, real-time and stored video, and facsimiles. At least two schools of thought exist concerning the definition of multimedia systems.[2] Some believe that the inclusion of multiple media types is enough to categorize a system as "multimedia." In this paper, however, we are referring to multimedia telecommunications products and services that combine some or all of these media *in an interactive computing application*.

This paper describes multimedia systems in which the user actively controls communications. Specifically, the level of control is critical. Users of multimedia systems should be able to do more than start and stop an application. Their actions should trigger different system responses, based on a host of factors (e.g., prior user actions or current system context). The information that the system presents, and even the media through which it is presented, will be influenced by these factors.

Multimedia technologies and their applications in telecommunications products and services are just beginning to evolve. Clearly, these technologies will change the way people interact with computer systems. Much as graphical user interfaces revolutionized human-computer interaction in the 1980s, the maturation of multimedia technologies will fundamentally alter human-computer interaction paradigms in the 1990s, and beyond. There will be more emphasis on developing systems with user interfaces that are interactive, dynamic, and engaging.

Panel 1. Abbreviations, Acronyms, and Terms

ac — alternating current
AM — amplitude modulation
CAD/CAM — computer-aided design/computer-aided manufacturing
CD — compact disk
CPS — Concept Presentation System
CSCW — computer-supported cooperative work
dc — direct current
EPS — electronic performance support
FM — frequency modulation
NOET — AT&T Network Operations Education and Training
NSD — AT&T Network Systems Division
VCR — video-cassette recorder

In addition to changing how people interact with computer systems, multimedia technologies may change the way people interact with each other. Video telephony has already hit the marketplace with products that are certain to affect person-to-person communication.[3] On a grander scale, multimedia conferencing and multimedia computer-supported cooperative work (CSCW) systems undoubtedly will change many meeting, work group, educational, and other communication activities. (See Panel 1 for definitions of abbreviations, acronyms, and terms.)

This paper focuses on how new multimedia technologies, combined with the proper application of human factors design principles, can improve AT&T's products and services. We discuss usability as it applies to multimedia-based products and services, and the design challenges presented by multimedia technologies. Examples are culled from multimedia-based training, performance support, and conferencing.

Multimedia and Usability

Brian Shackel defines usability as "the capability in human functional terms to be used *easily* (to a specified level of subjective assessment) and *effectively* (to a specified level of performance) by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of environmental scenarios."[4] For a system to be usable, its users should be able to:

- Easily learn how to operate the system
- Efficiently complete the task(s) they are performing with the system
- Interact with the system without making errors
- Enjoy interacting with the system.

These goals apply to the user interface for any computer-based system, whether or not it employs multimedia technologies. We expect that, when used properly, multimedia technologies will enhance the usability of many products and services. Multimedia systems should create an intuitive environment that minimizes the effort required to learn and use the system. Some studies of interactive multimedia-based training suggest that learning occurs faster and that learned material is understood better and remembered longer than it is with classroom instruction.[5]

People process information using their five senses, especially sight and hearing for communication tasks. Certain types of information are better communicated through one medium than another. For example, full-motion video does a good job of demonstrating complex mechanical procedures.[6] In addition, multimedia-based products and services, such as multimedia-based CSCW applications, can help workers be more efficient in a variety of tasks, including meetings, document preparation, physical design, computer-aided design/computer-aided manufacturing (CAD/CAM), etc., especially for those in widely separated locations.

Multimedia technologies often enhance usability by supporting various input devices (e.g., voice, pens) that allow users to interact more naturally with systems. Finally, multimedia systems promise to be more engaging, more *fun* to use.[7] Multimedia presentation can increase the expressiveness of, and the audience's sense of involvement with, the information presented.[8]

Although multimedia systems may be "richer" than their single-media counterparts, they do not necessarily increase usability. Studies of multimedia teleconferencing have shown that the usefulness of video depends on the specific tasks that users perform during the call.[9,10] Kraut et al.[8] suggest that interaction with or through multimedia systems creates a new *type* of communication. The most usable multimedia systems are those whose user interfaces are designed consistently with, and take advantage of, this premise.

If the benefits of multimedia-based systems are to be fully realized, they must be tailored to the needs, capabilities, and limitations of users. Some critical challenges in building these systems relate to human factors, because they have the potential to change the fundamental nature of human interaction with systems and with other people using these systems. Although multimedia technologies clearly offer benefits, a variety of usability issues should also be considered.

Multimedia Products and Services. Analysts in the telecommunications industry agree that multimedia

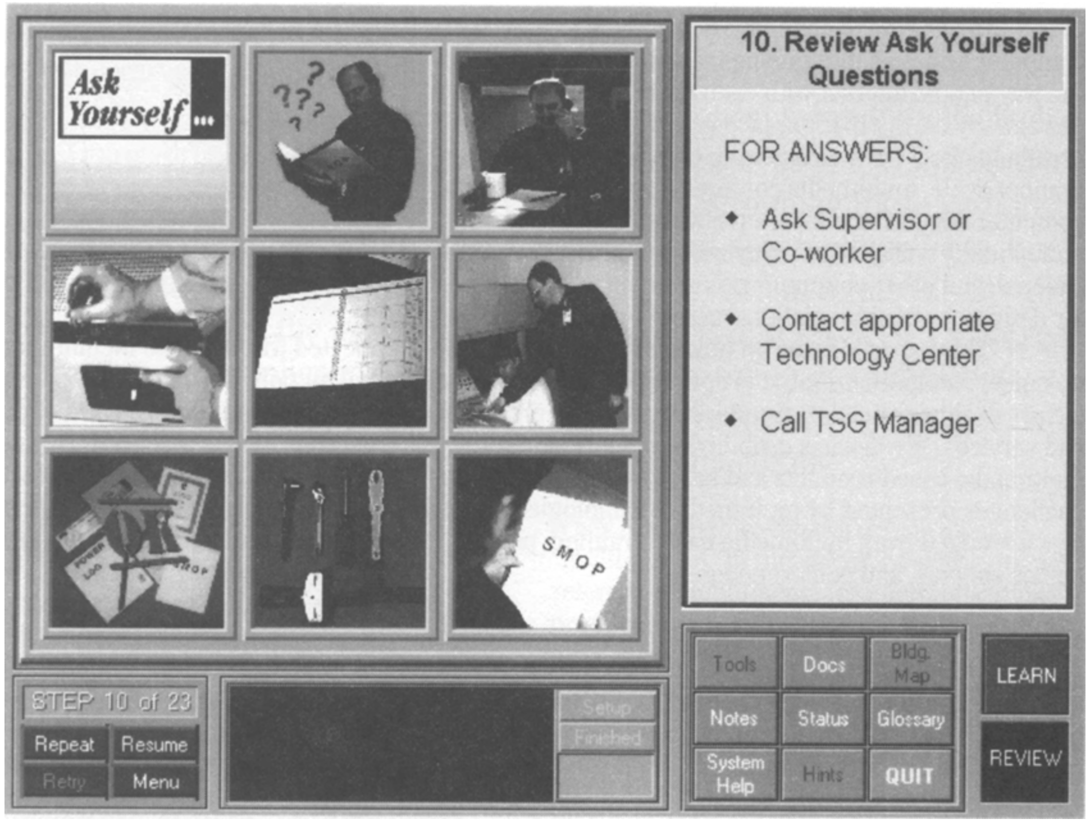

Figure 1. Sample screen from the Advantage℠ multimedia training system. The presentation window, at the left, displays photographs, graphics, animation, and video. The text window, at the right, presents text that complements the audio narration. Function buttons and other controls are at the bottom of the screen.

capabilities will be a cornerstone of telecommunications network and product development in the next decade.[11] AT&T is committed to offering products and services that allow people to communicate efficiently and expressively. An opportunity now exists to provide useful new capabilities based on multimedia technologies, such as multimedia conferencing; interactive information services; entertainment services; and education, training, and performance support.

For instance, the Rapport multimedia conferencing system,[12] developed at AT&T Bell Laboratories, allows people in widely separated locations to share voice, video, data, and other applications in real-time. AT&T is also cooperating with Pacific Bell, California State University at Chico, and the Chico public school system to offer *distance education*, which allows students to "attend" a course from a remote location using a multimedia workstation. Each student can enroll in individually paced courses and attend at his or her preferred time and place. The NCR 3331 Multimedia Learning Station delivers multimedia-based education courses in business, retail, and manufacturing environments. The AVP 4000 video-compression chip set, produced by AT&T Microelectronics, makes possible reliable and cost-efficient storage and transmission of multimedia data. The AT&T/EO Personal Communicator 440 allows users to combine multiple input (e.g., touch screen, handwriting) and output media (e.g., audio, text, fax) to perform a wide variety of tasks (e.g., record notes, access bank records, place a phone call). Even the AT&T VideoPhone 2500,™ the world's first color video telephone that operates over conventional copper telephone lines, is based on multimedia technologies.

AT&T is incorporating human factors principles into its multimedia products and services to ensure their usability. The sections that follow focus on examples drawn from multimedia-based training, performance support, and conferencing. These examples illustrate the potential that multimedia technologies have to enhance the usability of many *existing* products and services and to engender entirely *new* classes of products and services.

Multimedia-based training. Multimedia technologies are revolutionizing how training simulations are used. Until recently, complex simulations were prohibitively

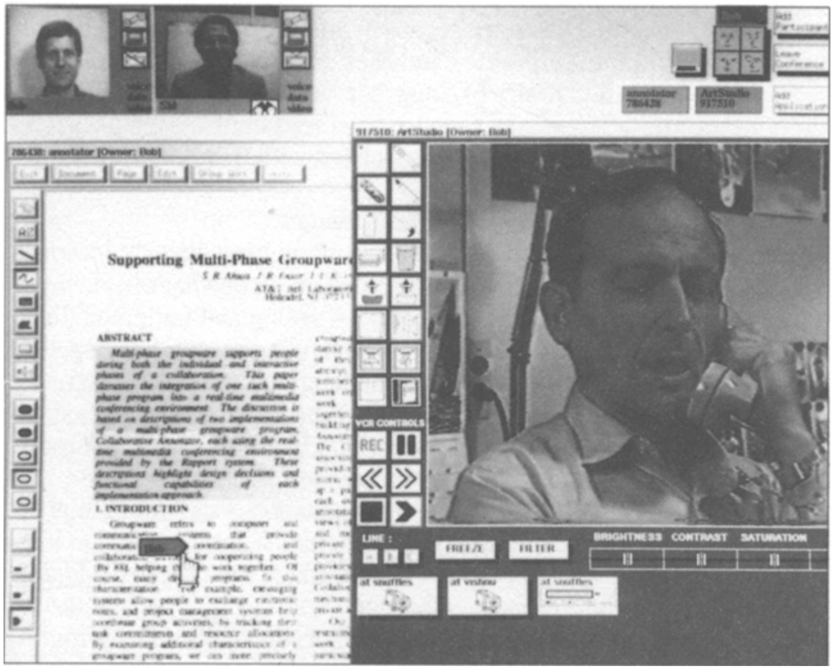

Figure 2. Sample screen from the Rapport multimedia conferencing system. Individual attendees, conference status, and conference controls are displayed along the top. Two separate, shared applications — in this figure, a text document and a stored videotape segment — are open for all attendees to view and manipulate at their own workstations.

expensive to develop and deliver. In only a few fields, such as aviation and nuclear power (where a single mistake in the real world might be catastrophic), has the expense of simulations been justified. One of the most important benefits of multimedia technologies, therefore, is its ability to deliver low-cost, medium-fidelity simulations on desktop computers. While these desktop simulations may not be as realistic as a Boeing 747 flight simulator, they are realistic enough to give students the freedom to experiment and to practice individual steps in a sequence repeatedly until they get them right.

Many jobs performed by AT&T technicians lend themselves naturally to training by simulation. For example, small, unattended buildings, called *regen huts*, are located approximately every 30 miles along a lightguide route to regenerate the fiber-optic signal. At each regen hut, AT&T technicians perform an annual power review that involves 23 major steps that must be completed in a specific order. Because the power review is performed only once a year per regen hut, even experienced technicians may run into problems. During the procedure, the technician must transfer the power in the regen hut from normal commercial ac power to backup dc power. This procedure puts technicians under stress, because a mistake can result in the failure of a segment of the fiber-optic network. By practicing with a simulation of the annual power review before performing it, the technician can become familiar with each step in the procedure and how these steps fit together.

The AT&T Network Systems Division/Network Operations Education and Training (NSD/NOET) Power Technology Institute is producing a hardware and software platform, called the Advantage℠ multimedia training system, to develop and deliver multimedia training. The first course provides multimedia-based demonstrations, practice simulations, and tests for the annual power review of a regen hut. Figure 1 shows a screen from the annual power review course on the Advantage multimedia training system. Future Advantage courses will teach students about power-related equipment (such as batteries, rectifiers, and tools) and other technologies (such as alarms, outside plant, and lightguide). Photographic images, audio, and animation all play central roles in the Advantage instruction and simulations.

Multimedia-based performance support. Training ensures that workers have achieved a minimum level of proficiency before attempting to perform a job in the real world. But many instructional technologists are adopting the view that training alone may not enable workers to do their jobs effectively and efficiently. *Electronic performance support* (EPS) integrates training, documentation, and on-line help and delivers it to the worker as needed at the work site. It emphasizes performance, rather than learning, and is delivered to the worker with minimal interruption of the normal job flow.

EPS systems do not necessarily include multimedia capabilities, but designers are finding that these capabilities make their systems more effective. Several versions of the Concept Presentation System (CPS), developed in AT&T Bell Laboratories, have supported technicians who perform network management and provisioning activities or who diagnose and repair troubles in switches.

CPS functions with applications the worker normally uses to do the job. In the 5ESS® switch version, the worker can "toggle" to CPS by pressing a single key on his or her workstation. The user receives instructions from CPS at several different levels, ranging from an overview of the current procedure, through detailed step-by-step instructions, to a listing of valid entries for a specific field on a recently changed screen in the on-line system. CPS presents information using text, graphics, and motion video, with accompanying narration. As soon as the user gets the information needed from CPS, he or she can toggle back to the on-line system, which remains in the same state it was in before the user left it to access CPS. If more performance support is required later, the user can return to CPS.

Multimedia conferencing. Multimedia conferencing systems, an important application of multimedia technologies within AT&T, allow individuals at widely separated locations to perform meeting-related tasks and other activities as if they were in the same room. They can see one another, talk privately with someone, present viewgraphs, share images, write on a blackboard, point to items on the blackboard, etc. Figure 2 shows a sample screen for one such system — the Rapport multimedia conferencing system — developed at AT&T Bell Laboratories.

Multimedia conferencing provides advantages over more limited forms of conferencing. For instance, by using technologies that enable participants to see and hear one another at the same time, and to use network-based blackboards and other communication devices, multimedia conferences attempt to restore the "naturalness" of in-person communication to individuals communicating electronically. Moreover, multimedia conferencing can increase the productivity and efficiency of meetings. Participants have the flexibility to present or manipulate information using whichever media best suits their needs. They have access to information sources, such as internal corporate databases, external public resources like the Library of Congress, and so on. Multimedia-based meetings can also produce tangible savings, such as the cost and time associated with travel.

Multimedia User Interface Issues

Designing a successful multimedia user interface is a challenging task, because much of what people do "naturally" in everyday life — seeing and understanding objects and gestures, understanding each other's speech, etc. — is a tremendous challenge for the field of computing.[13] A good user interface for an interactive application must fit the user's motor skills,[14] problem-solving strategies,[15] and cognitive organization.[16] User interface design for a single-media application is difficult; the prospect of designing for multiple media and the need to integrate different types of media make the task of designing user interfaces even harder.

As we discussed earlier, the application of multimedia technologies creates exciting opportunities for new products and services. But these new opportunities also present challenges to the human factors specialist. These challenges, listed in Table I, are detailed in the sections that follow.

Appropriate Use of Media. What tasks are best served by the various media now at our disposal? What are the development and delivery cost tradeoffs of different media types? Can we identify the different types of information delivery tasks and communication situations and recommend appropriate media?

User Control over Multimedia Environment. To what extent should users be allowed to customize their own multimedia environments? During a multimedia conference, for example, should users be able to reposition windows that display other attendees? If these windows are moved, will all attendees know to whom each of them is speaking?

Information Navigation. How should information be organized in a multimedia system to make it easy to use? How can system designers help users find the information they need? Do navigation devices used in hypertext systems, such as information structure maps, guides, default paths, and backtracking, benefit multimedia systems?

Control of Time-Based Information. By what means should users control the presentation and flow of time-based information in the system? Are user interface

Table I. Multimedia User Interface Challenges and Problems

Human factors challenges	Typical problem
Appropriate use of media	Which applications require full-motion video, still-image graphics, or animation?
User control over multimedia environment	Should users be allowed to customize how multimedia objects are arranged on their screens?
Information navigation	Can users access the next piece of information in a database?
Control of time-based information	Is there a universal set of on-screen controls to start, stop, pause, resume, replay, etc.?
Tools for multimedia authors	How can multimedia authors decrease the time it takes to script, edit, and integrate media objects for an application?
Media fidelity	What are the minimal audio and video requirements for various applications?
Social psychological and human behavioral issues	Which characteristics of face-to-face meetings should multimedia conferencing include?
User acceptance of multimedia-based products and services	How can non-computer-literate people benefit from multimedia products and services?

Problem-solving strategies
Iterative rapid prototyping
Usability testing
User-centered design
Knowledge gathered from many disciplines

metaphors, such as compact disk (CD) audio controls or video-cassette recorder (VCR) controls, the best ones? Is there a "universal" set of controls, or do different tasks demand different controls? What tradeoffs in control features are necessary because of functions not supported by the current level of multimedia technologies? And more generally, in the absence of industry-wide standards, how can we create user interfaces that are consistent in important aspects with others in the industry?

Tools for Multimedia Authors. What help can be provided to the people who are developing multimedia systems? What tools for idea generation and script writing can help them be more creative and productive? Are there ways to shorten the time required to develop and edit media elements (individual graphics files, audio files, etc.)? How can media elements be most efficiently assembled and integrated into a coherent application?

Media Fidelity. What types of audio and video quality needs do users have, and how do these needs change for different applications? Is CD-quality audio required, or would frequency modulated (FM) quality, or even amplitude modulated (AM) quality, suffice? Is full-motion video, or even full-screen video, necessary? What levels of color rendition, contrast, image resolution, and screen refresh rate are necessary? What degree of audio-video asynchrony is perceptible, and at what point does it hinder usability? If a window in a multimedia conferencing environment provides person-to-person eye contact, how can we ensure that all important nonverbal information (e.g., head-shaking, facial expressions, etc.) is communicated while using as little screen space as possible? How important is full-duplex audio, and how does it affect system usability?

Social Psychological and Human Behavioral Issues. How do face-to-face meetings differ from electronically mediated ones? What are the important qualities and by-products of both face-to-face and electronically mediated meetings, and how can multimedia conferencing systems be designed to maximize their advantages? What are the important nonverbal feedback mechanisms people use in conversation? How is the character of a meeting affected by its multimedia nature? What assumptions do participants make about what other participants are doing and seeing, and what are the effects of these assumptions? How can multimedia conferencing improve group dynamics and decision-making processes?

In summary, it is not sufficient merely to provide systems with multimedia capabilities. Instead, we must understand how and why individuals will be using the system, and we must design the user interface accordingly, with the set of interaction techniques best suited to the given media.

Potential Solutions

As the previous section illustrates, there are many user interface design issues that relate specifically to multimedia systems. However, the prospects for designing usable multimedia systems are not as overwhelming as this list might imply. Some of what we know about good design for graphical user interfaces can be applied to multimedia user interfaces. Information structure maps, guides, etc., should help the user navigate through information, whether text-based or multimedia in nature. Sometimes, design decisions can be modeled on well-known user interface metaphors. For example, users seem to have little problem learning, understanding, and controlling on-screen motion video using a design that resembles a VCR remote control device.

We can also use results gathered from well-run empirical studies. For instance, increasing the audio quality of a multimedia phone call has been shown to have a positive effect on users' perceptions of the call's video.[17] Phenomena such as this can be used to formulate design decisions that improve usability while minimizing resources.

Solutions for unsolved multimedia user interface design issues will come from many sources. Methodologies such as iterative rapid prototyping, usability testing, and user-centered design that have been proven successful in systems design will continue to be critically important.[18,19] Iterative rapid prototyping refers to building a model of the user interface, before formal development of the system, that looks and behaves as the system will when it is completed. This prototype shows a system's functionality and user interface and is iteratively updated to reflect user and project team feedback, new system requirements, etc. Usability testing, in a specially designed laboratory or, sometimes, at the user's work site, can uncover design flaws that project team members might miss. Based on what is learned during this phase, design changes are made in the next iteration of the prototype, ensuring that the final system meets user needs in an efficient, pleasing manner. Iterative rapid prototyping and usability testing, which work hand-in-hand to improve the design of any user interface, are core methodologies of user-centered design.

Knowledge gathered from other fields, such as cognitive and social psychology, computer science, graphic arts, broadcasting, and instructional technology, will also help solve future problems in multimedia user interface design. Successful multimedia system development requires diversity among project team members. The ideal project development team includes members who have most, if not all, of these skills.

Conclusions

In the future, multimedia technologies will affect the ways in which people interact with systems and with each other. The inevitable development of powerful multimedia products and services, and the broadband network infrastructure to support them, will make multimedia communications as ubiquitous as today's telephone or personal computer. John Sculley, Chairman of Apple Computer, Inc., foresees a convergence of previously diverse industries — computing, consumer electronics, communications, broadcasting, and publishing — all integrated in hand-held devices that will be ubiquitous.[20] Nicholas Negroponte, founder and director of the Media Laboratory at the Massachusetts Institute of Technology, envisions a future in which machines will see, hear, talk, and, in a sense, think, all to "know" and serve their human masters.[21] The speed with which this future is realized depends on several factors, including the continued development of better hardware (e.g., computers, chips, transport equipment) and software (e.g., video compression and decompression algorithms, development tools). To be successful and ubiquitous, however, these products and services must be designed to fit users' needs. How close we come to achieving this will directly affect our ability to realize this vision.

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