

Multimedia—From Vision to Reality

Sandra L. Teger

Technology advances in digitization, networking, and intelligent devices and servers—all supported by software—are enabling expanded choices in our lives. A fundamental shift is occurring—a movement from the physical to the electronic realm and now to the networked domain. This shift is evident in the evolution of such diverse conveniences as home entertainment, telecommuting, telemedicine, desktop collaboration, and electronic home shopping. Multimedia—the integration of multiple media types coupled with interactivity—is a major beneficiary of these trends. This introductory paper provides some perspective on the emergence of multimedia, both in industry and within AT&T. It also introduces ideas and issues that are elaborated on in the papers that follow.

Introduction

The January/February 1993 issue of the *AT&T Technical Journal* reviewed advances in video communications. It discussed enabling technologies and expected applications, and it described early AT&T products, prototypes, trials, and architectures.

The Pace of Progress. Enormous progress has been made in less than three years' time. Later in this paper, some of the many AT&T video and multimedia products and services now in the marketplace will be described. Several examples will provide some context on the pace of progress in this arena.

Price and performance improvements. One paper in that 1993 issue described a first-generation multimedia video-codec chip set from AT&T Microelectronics. Since then, two more generations of chip sets have come to market, and they have been improved in four significant ways:

- The number of chips needed to perform the major functions (video, still-image multiplexing, and protocol control) has dropped from three to one;
- New functions have been added;
- Video quality has improved; and
- The price has dropped by a factor of four.

The effects of this price and performance improvement in components are rapid-

ly dropping prices and increasing shipments for systems, as illustrated in Figure 1.

Multimedia moving to the market. The same January/February 1993 issue of the *AT&T Technical Journal* described viewer-controlled cable television (VCTV), a market test of enhanced pay-per-view and video-on-demand services conducted jointly with Telecommunications, Inc. (TCI*) and U. S. West. Today, AT&T Network Systems, working with Cablevision Systems Corp., is in the process of commercial deployment of such services.

The earlier issue of the *AT&T Technical Journal* also featured *Rapport*, a research prototype for a multimedia conferencing platform. Much of the work from *Rapport* is being integrated into commercial multimedia service offerings, such as AT&T WorldWorxSM Network Services. The paper by Berkley and Ensor discusses the influence of *Rapport* and other multimedia research platforms on several AT&T products.¹

Multimedia Definition. The term "multimedia" is being used to describe the theme of this issue. Thus, it may be useful to clarify three of the term's characteristics, which are the focus of many AT&T multimedia endeavors:

- *Multiple media* (for example, audio, video,

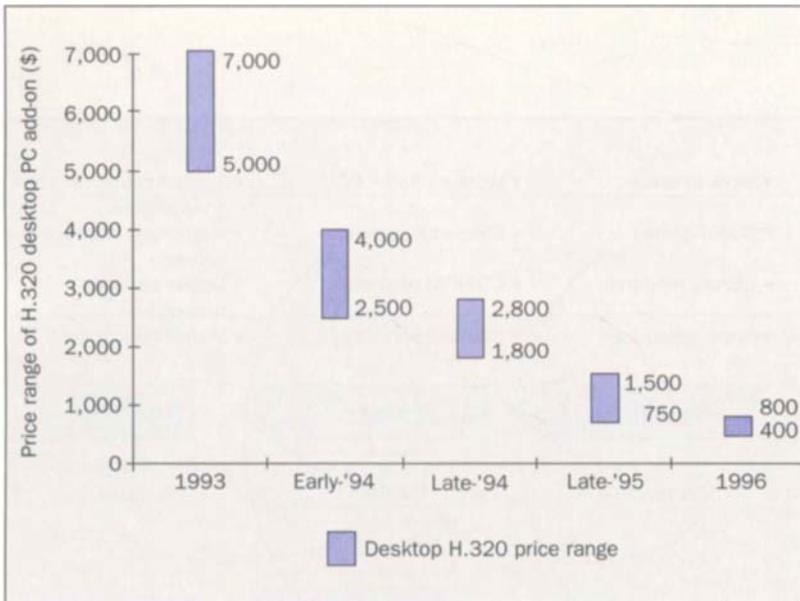


Figure 1. Rapid technology improvements are reducing prices. Since 1993, two additional generations of video-codec chip sets produced by AT&T Microelectronics have come to market, and they have been improved in four significant ways: the number of chips needed to perform the major functions has dropped from three to one; new functions have been added; video quality has improved; and the price has dropped by a factor of four. One of the effects of these improvements is rapidly dropping system prices.

Panel 1. Abbreviations, Acronyms, and Terms

API—Application Program Interface
 ARPA—Advanced Research Projects Agency
 ATM—asynchronous transfer mode
 CATV—cable television
 DAVIC—Digital Audio Visual Council
 DSP—digital signal processor
 EIA—Electronic Industries Association
 FCC—Federal Communications Commission
 HDTV—high-definition television
 IEC—International Electrotechnical Commission
 IEEE—Institute of Electrical and Electronics Engineers
 IETF—Internet Engineering Task Force
 IMA—Interactive Multimedia Association
 IMTC—International Multimedia Teleconferencing Consortium
 ISDN—integrated services digital network
 ISO—International Organization for Standardization
 ITU—International Telecommunications Union

LAN—local area network
 LEC—local exchange carrier
 MMCF—Multimedia Communications Forum
 OMG—Object Management Group
 OST—Office of Science and Technology
 POTS—“plain old telephone service”
 Rapport—an AT&T multimedia, desktop virtual conferencing research system
 RISC—reduced instruction-set computer
 SLC—AT&T fiber-optic subscriber loop carrier system
 TI—Telecommunications Industry
 TIA—Telecommunications Industry Association
 VCTV—viewer-controlled cable television
 Vistium—an AT&T multimedia platform
 WorldWorx—an AT&T multimedia service offering
 XIWT—Cross-Industry Working Team

data, text, and graphics), which center on including such types as audio or video for which time is crucial;

- *Interactivity*, rather than simple one-way broadcasting; and
- *Networked offerings*, as contrasted with those that stand alone.

AT&T’s particular focus is on *networked* interactive multimedia solutions.

The Trend Toward Networking

As shown in Figure 2, the overarching trend of the past 30 years has been to increase user options—first

by adding electronics to the physical domain, and then by adding networking capabilities.

The evolution of games serves as an example. Historically, they were limited to the realm of the physical, such as a Monopoly set. Electronics provided alternatives, such as Game Boy.* Then, networking provided a further enhancement: the ability to interact with distant players, as on the ImagiNation™ Network.

Additionally, office workers who migrated from typewriters to word processors or PCs over the past ten years are now moving even more rapidly to electronic mail and shared electronic documents.

Figure 2. User options are expanding. The overarching trend of the past 30 years has been to increase user options—first by adding electronics to the physical domain, and then by adding networking capabilities. For example, some new options in electronic games have become available. Also, office workers who migrated from typewriters to PCs over the past ten years are now moving even more rapidly to electronic mail and shared electronic documents. The result of this migration is the advent of new choices for how we work, play, and learn.

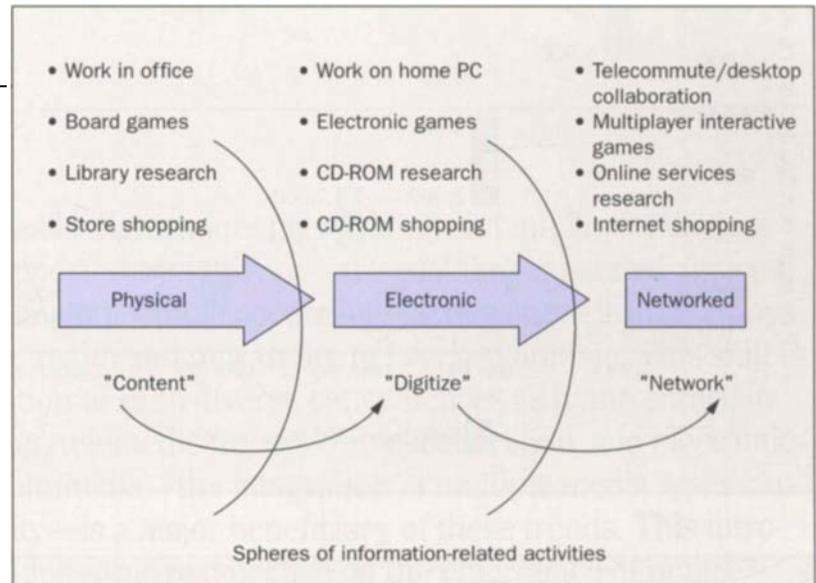
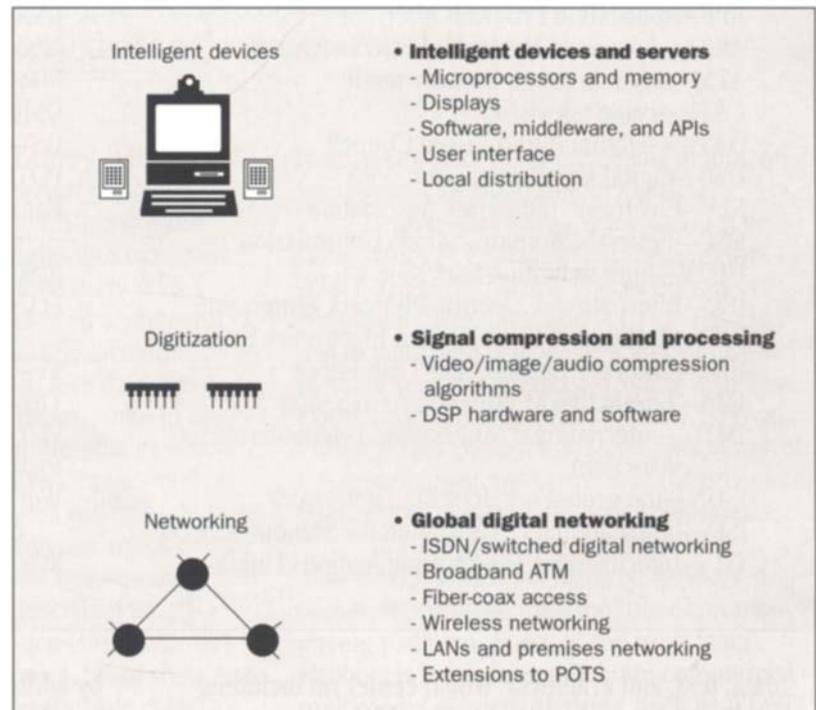


Figure 3. Technology enablers—Intelligence, digitization, and networking—are driving the continuing evolution of multimedia. Software and microprocessors underlie intelligence, which in turn forms a foundation for both digitization and networking.



Communications—changed and enhanced through users’ rising expectations—enables such migration. Individuals accustomed to retrieving large files and images rapidly in the office through local area networks (LANs) crave comparable bandwidth to “surf the Net” from home. The result of this migration is the advent of new options for how we work, play, and learn.

Multimedia Technology Enablers

As shown in Figure 3, the continuing evolution of multimedia is being driven by three major technology enablers: “intelligence,” digitization, and networking. Software and microprocessors underlie intelligence, which in turn forms a foundation for both digitization and networking.

Intelligent Devices. Progress in intelligent devices and servers is driven by technology advances in microprocessors, memory, and displays. The continuing improvement in microelectronics—especially in computer “horsepower” and memory capacity—has followed the well-known Moore’s Law, which predicts that any microelectronic functionality will double in performance or halve in cost within 18 months.

Software—particularly middleware and Application Program Interfaces (APIs) that isolate applications from underlying communications—enable application developers to create solutions once that will work over multiple networks. Navigation tools and user agents help users find the right information.

Intelligence may reside in end devices, premises servers, or network servers accessed widely on a shared basis. Although intelligence may be distributed through-

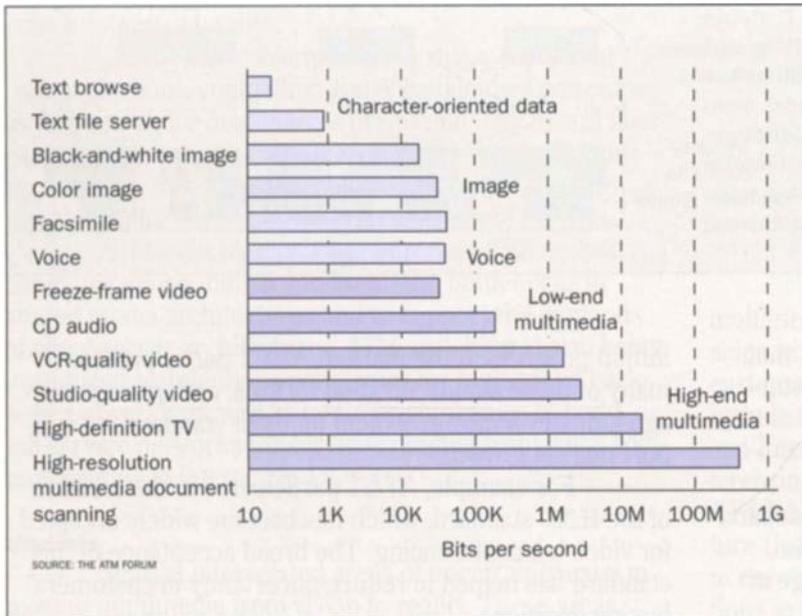


Figure 4. The increasing availability of networks having the required amount of bandwidth enables a wider range of applications. Furthermore, different kinds of information and media have distinct bandwidth requirements. Text has the lowest bandwidth requirement and high-resolution video has the highest. The bar chart shows the bandwidth requirements for a range of media types.

out a network, its visible manifestation is at the user interface. Thus, the success of all systems rests heavily on creating user interfaces that are both easy to learn and easy to use.

The “softer” technologies of human factors and interface engineering are still as much art as science. The papers by Berkley and Ensor¹ and Beacken et al.² discuss some of the human factors issues in designing multimedia services.

The paper by Sterling, Cariño, and Boss discusses multimedia databases and servers and their role in creating innovative information processing solutions.³

Digitization. Signal compression and processing are included in digitization. Algorithms have been defined and standardized that compress images and motion video by factors of 10 to 50 with good quality. When applied to video conferencing (with lower quality requirements), such algorithms produce compression ratios of 100 to 3,000. They run on digital signal processors that have become progressively more powerful. The paper by Jayant et al. further explores audiovisual signal processing.⁴

Networking. Another key technology enabler is the emergence of new networking capabilities to transport information. One limitation to higher speed networks exists in the capability of the “last mile”—the local loop

between a customer’s terminal equipment and the network. ISDN digitizes the existing POTS network, resulting in significant performance improvement.

Broadband introduces next-generation techniques for efficiently carrying a variety of media over fiber-optic cable. Cable

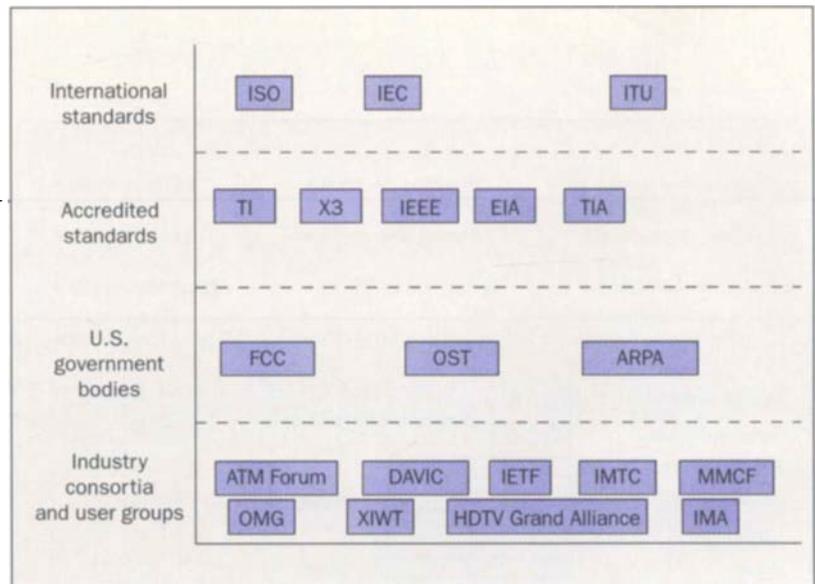
television (CATV) companies and some local exchange carriers (LECs) are deploying hybrid fiber-coax systems at costs that are competitive with copper-based systems. Other LECs are deploying switched digital video fiber-to-the-curb systems to accommodate long-term bandwidth requirements. Asynchronous transfer mode (ATM) is expected to become the primary protocol as implementation costs are reduced.

Wireless networking for mobility, as well as approaches to extend the existing POTS network, such as simultaneous voice and data, are also being deployed. Moving information around within the premises is also crucial, and many companies are deploying higher speed LANs and switched LANs.

Together, these capabilities will provide more intelligence, bandwidth, and wireless capabilities to give users a wide variety of networking options.

Software Evolution. Perhaps the area in which the least progress has been made is software developer productivity. Software is a key component throughout systems, appearing as the firmware in chips, the intelligence in networks and servers, and the user interfaces and feature-enablers in terminals. As hardware costs have plummeted, software has become the largest bottleneck in cost and time to market. The paper by Beyler

Figure 5. Numerous standards organizations, shown in the drawing, are involved in multimedia. Many organizations and companies try to create standards. These efforts sometimes result in conflicting approaches, which can create customer confusion and inhibit progress. AT&T participates in many standardization forums, acting to encourage industry-wide agreement to support market growth.



et al. describes a Software Assembly Workbench that accelerates software assembly through reuse of software modules.⁵

Bandwidth Requirements

As communications providers deploy broadband networks having much higher bandwidth than ever before, applications are emerging to take advantage of the growing bandwidth.

The increasing availability of networks having the required amount of bandwidth enables a wider range of applications. At the same time, compression technology helps to reduce the amount of bandwidth required.

Different kinds of information and media have distinct bandwidth requirements. Text has the lowest bandwidth requirement and high-resolution video the highest. Figure 4 shows the bandwidth requirements for a range of media types from text to high-resolution multimedia document scanning.

Interoperability

One consequence of creating solutions composed of elements from multiple vendors is the need for interoperability. Customers want open communications and full connectivity. Thus, it becomes very important that elements work with one another. The need for interworking drives the industry toward open interfaces and standards. Many existing and newly created standards affect the design of solutions because of the breadth of technologies and industries influencing the elements of multimedia.

Standards Organizations. Figure 5 shows some of the organizations involved in relevant standards. Many organizations and companies attempt to create standards. These efforts sometimes result in conflicting approaches, which can create customer confusion and

inhibit progress in the market. AT&T participates in many of these standardization forums, acting to encourage industry-wide agreement on open standards to support market growth.

For example, AT&T participated in the creation of the H.320 standard, which has become widely accepted for video teleconferencing. The broad acceptance of this standard has helped to reduce uncertainty in customers' buying decisions.

Convergence

Another measure of the pace of change since the *AT&T Technical Journal* issue on video communications is what has been termed *convergence*. Although the word is overused, it nonetheless describes the market reality. Three key aspects of this convergence are:

- *Functional convergence*, which refers to single devices integrating multiple functions from what were traditionally different industries and user devices. This aspect is exemplified by today's PCs, which simultaneously support traditional PC programs and modem communications; telephony functions, such as answering machines and desktop videoconferencing; and entertainment functions, such as games.
- *Competitor convergence*, which refers to the increasing overlap of companies from traditionally different industries. Thus, many computer, communications, and entertainment/content companies increasingly compete and/or partner with each other. The relationships between U. S. West and Time-Warner*; Disney* and Ameritech, Bell South, and Southwestern Bell; and Microsoft* and TCI are examples of this trend.
- *Technology convergence*, which enables both functional and competitor convergence, and through which companies in different markets use common



Figure 6. Many ways exist by which to segment and analyze multimedia markets. One of these is the value chain, exemplified by this simplified version. Each block is a business area from which firms can derive value, ranging from content-based services to providing end-user devices or information appliances. Although the value chain elements exist as separate businesses, they must work together to provide customer solutions.

technology elements.

Technology convergence is a major enabler for communications, computing, and entertainment companies as they search for new sources of revenue. The hybrid fiber-coax architecture, which has its origins in the CATV industry, is finding its way into the plans of many LECs as the mechanism for deploying video entertainment services.

ATM switching is being introduced in the data communications industry to break the bottlenecks in shared media architectures and to support the demands of client-server architectures. ATM switching is also being introduced by telephone companies for high-speed backbone networks, as well as by CATV companies to build full-service networks for services ranging from voice communications to interactive TV.

Markets

Several interrelated areas of uncertainty exist in moving multimedia from vision to reality. These areas include the technologies, customer behavior and adoption, and the relationship of costs to willingness to pay. Of these, technology in some ways is the simplest; customer behavior is the most complex.

The Multimedia Value Chain. Multimedia markets can be analyzed and segmented in many ways. One of these is the *value chain*, as shown in Figure 6.

The figure shows a simplified value chain. Each block is a business area from which firms can derive value, ranging from content-based services to providing end-user devices (sometimes called information appliances). Although the value chain elements exist as separate businesses, they must work together to provide customer solutions.

The very complex multimedia business typically incorporates the following elements:

- Hardware and software;
- Content, which includes video, audio, and programming; and
- Customer distribution, which includes delivery through networks or physical delivery, such as on CD-ROM.

No single company has the required expertise and market presence in all these elements. Thus, companies often seek partnerships and alliances with others having complementary skills and assets to strengthen their market position.

Many AT&T business units are active in the multimedia value chain. AT&T has announced relationships with other companies to meet the wide variety of customer needs for multimedia solutions. Examples include the AT&T alliance with Lotus Development Corp. and Intel* to provide seamless integration of desktop conferencing, messaging, and stored data. In addition, the AT&T Network Systems and Silicon Graphics joint venture (Interactive Digital Solutions) was initiated to deliver to network service providers interactive video-server solutions as part of a consumer broadband network offering.

The value chain is being affected by technology developments and changes in the market. The Internet is one of the more noticeable destabilizing forces on the value chain. The World Wide Web is enabling rapid outward diffusion of multimedia production from just a few professionals to many more individuals using simple, readily available software. The proliferation of individually created home pages illustrates that today's tools are diffusing the ability to create content.

Servers connected to the Internet provide another element of diffusion. The continuing increases in processing power, decreases in cost, and movement toward a client-server architecture have led to an increasing number of smaller servers. These include RISC workstations and even home PCs.

Currently, the Internet is a cultural phenomenon, having many implications for the way people think about and pay for communications and access to information. As the Internet undergoes rapid change and experimentation, Internet business models—not yet crystallized—continue to evolve. Businesses—especially those associated with the world of convergence—must be tuned in to these changes and their potential effects.

Customer Needs and Expectations

AT&T serves three major groups of customers:

businesses, consumers, and network service providers. The company recognizes the increased blurring between people's business and personal lives, but it uses this segmentation as a means of determining who pays for products and services being used.

The understanding of customer needs and expectations is crucial to the successful use of the enabling technologies. Thus, a brief discussion of some of these needs by customer group and how AT&T is meeting these needs is in order.

Business Customers. Most companies recognize that time to market is very important for survival and growth. They need timely and relevant information about markets, customer needs, and competition. Collaboration and teamwork among employees—as well as personal relationships with customers, suppliers, and associates—facilitate rapid decision-making.

Multimedia solutions support these business needs by bringing people and information together easily, using any media, to improve the way they work. The following two examples illustrate such support:

For a large forest products company, desktop video collaboration has been particularly effective for engineering and technical meetings. Multimedia technology allows meeting participants—including geographically remote consultants and contractors—to collaborate on technical drawings and files and actually see the other participants on a computer screen.

A global health care and consumer products company collaborated from three sites to build a manufacturing plant. Real-time decisions were made about construction, technology, and personnel. Saving time in the decision-making process was important to meeting the pressures of a globally competitive business.

The paper by Ahuja et al. discusses the architectural elements that enable such collaborations to occur electronically.⁶

Consumers. Many societal and economic trends are shaping consumer needs. A discussion of some of these principal trends follows.

Occasional or full-time *work-at-home arrangements* are becoming increasingly common. As organizations “flatten” and downsize, fewer people are available to do more work. In many cities, the highway infrastructure is already overloaded, and traffic tie-ups are increasing. Moreover, the U. S. government is pressuring companies

to help improve air quality by reducing commuter trips.

New computer and communications technologies permit people to work from their homes while remaining linked with their colleagues. Such linking minimizes feeling isolated and out of touch.

Entertainment and diversions are being sought as a way to relieve the pressures of daily life. The TV and video game generation expects to be entertained. Users want learning to have some of the fast-paced, visual MTV attributes.

In a mobile society in which families are sometimes separated by great distances, people seek communication with other family members or those having common interests. Individuals value emotional closeness, even when geographically separated.

With more demands and less time, people are unwilling to read manuals to learn how new appliances operate. They expect new devices and services to be easy to learn and use. They also expect convenience, choice, and control.

The need for multimedia. Multimedia products, services, and applications are envisioned as important mechanisms for satisfying many aspects of customer needs and expectations. To address these needs, the following must be available:

- A wide range of easy-to-use products;
- Services and servers that facilitate the tasks to be completed, whether working at the office or at home; and
- An underlying infrastructure.

Multimedia products. End-user products, also known as *information appliances*, will be designed according to differing consumer needs that include location, applications, and user preferences. For example:

- Appliances having different form factors for each location might be found in the home office, kitchen, living room, and even on the move.
- A bill-payment application has very different requirements than entertainment or video telephony.
- Users differ in their level of comfort with technology and their desire to “message” by voice, text, or video.

Underlying these differences, however, will be some commonalities. Increasingly, these appliances will be intelligent, addressable, screen based, and networked.

The use of display screens in products designed for the consumer and business markets is explored in the paper by Crouch, Rodriguez, and Schwartz.⁷

Network Service Providers. Such businesses as LECs, CATV companies, interexchange carriers, and competitive access providers are known as *network service providers*. They build networks and provide services, which in turn serve the businesses and consumers whose needs were just discussed.

As these companies deal with slowing expansion in traditional services, as well as regulatory and competitive changes, new technologies can offer them growth alternatives. Telephone and CATV companies have three general options:

- Extend their current markets;
- Enter markets in which they currently do not compete; or
- Develop new markets.

For example, CATV companies can consider acquiring customers for service in new geographies; they can expand into the telephony business; or they can offer a whole new range of interactive TV services.

Many LECs are moving from their origins in telecommunications by exploring opportunities in delivering consumer entertainment. Conversely, CATV companies are transitioning from one-way entertainment delivery into two-way telecommunications. Both types of companies also are experimenting with future, not yet well understood applications, such as interactive TV. Service providers want to build capabilities to deliver new (at least for them) services and applications today's customers will buy. At the same time, they want to maintain the flexibility for future expansion to newer, not yet completely defined offerings. The paper by Szurkowski and Warner discusses insights gained from early user trials of some new services.⁸

Although telephone and cable companies have very different starting points in terms of their installed infrastructure, the technology solutions they are installing often are very similar. For example, hybrid fiber-coax systems can simultaneously support conventional broadcast television and telephony and provide growth for video telephony, interactive television, and PC data services. Thus, this solution is being deployed both by cable operators and telephone companies.

The same ATM switches are being used by Time-Warner in Orlando, Florida, and the Southern New England Telephone company in Connecticut. Such use exemplifies the concept of technology convergence. The paper by Libman et al. provides further details on the basic

network architectures and common technology elements being used both by LECs and cable companies.⁹

The AT&T Multimedia Portfolio

During the first few months of 1993, a number of multimedia product-development efforts were under way throughout AT&T. The expansion of these efforts and their integration with the mainstream businesses of AT&T is remarkable.

Figure 7 shows how AT&T has been actively building its multimedia portfolio over time. Although only selected offerings are shown, they represent virtually all AT&T business units.

AT&T Multimedia Solutions

The following three subsections detail some examples of AT&T multimedia solutions for businesses, consumers, and service providers.

Solutions for Businesses. A primary goal of businesses is to enable employees—no matter where they may be located—to work cost effectively on shared projects. AT&T has created multimedia solutions that address the needs for improved communication, as well as employee collaboration and coordination, even for work groups situated in remote locations.

For groups working together in real time, AT&T provides the ability to place multimedia telephone calls. Such calls include voice, video, and application-sharing features (for example, AT&T WorldWorx™ Solutions). The multimedia PCs used to support desktop videoconferencing—plus collaboration software—can be the AT&T Vistium™ terminal or any of a variety of terminals from WorldWorx partners including Apple,* IBM,* Intel,* and Sun.*

To enhance information flow when users are working at different times and in different places, the AT&T Network NotesSM service is being used. For example, for a market research firm, a series of reports could be produced every morning. These reports would be replicated for use by key reviewers and contributors at multiple sites. After team members review and revise the material, it is replicated back to the source. Senior managers have the capability to complete a final review no matter where they are. Subsequently, they release the reports to clients. Such extended workgroup collaboration applications greatly improve the ways in which com-

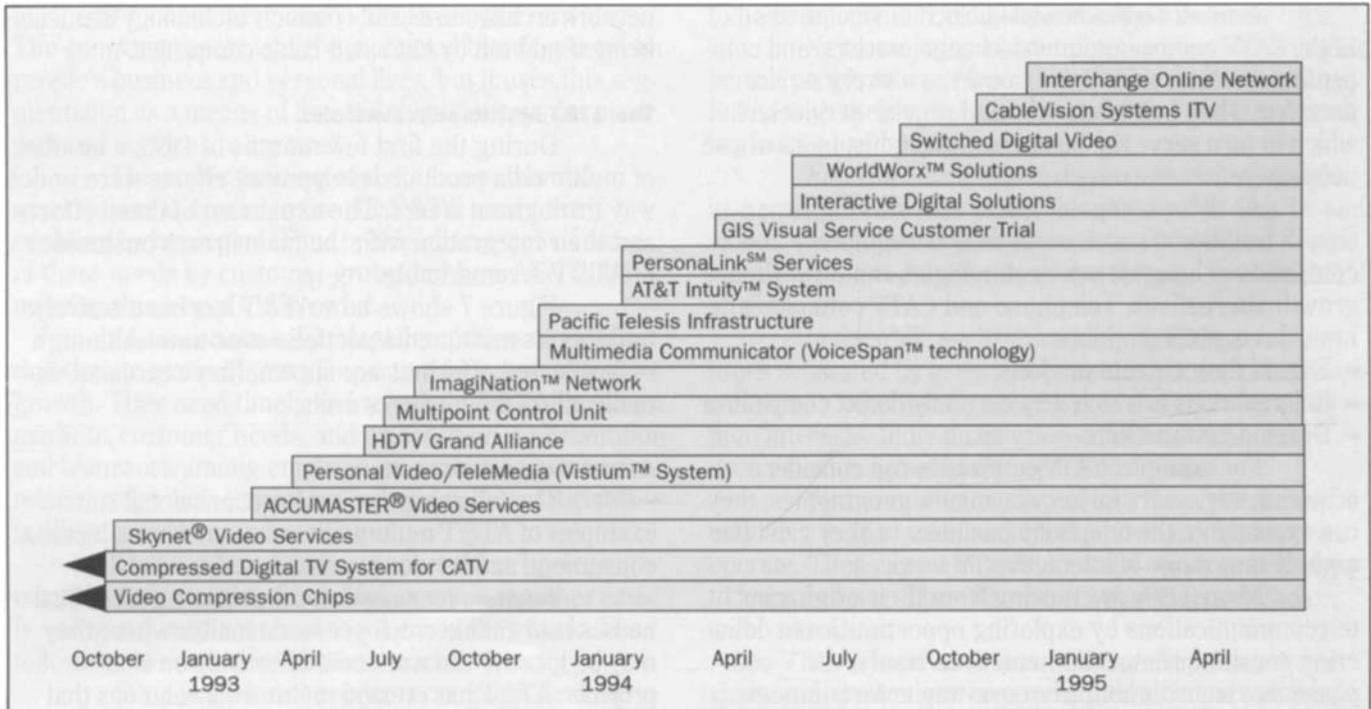


Figure 7. AT&T's progress in multimedia technology has been rapid. During the first few months of 1993, a number of multimedia product-development efforts were under way throughout AT&T. The expansion of these efforts and their integration with the mainstream businesses of AT&T is remarkable. This chart shows how AT&T has actively built its multimedia portfolio over time. Only selected offerings are shown but they represent virtually all AT&T business units.

panies create and share information.

Solutions for Consumers. Videotelephony is one of the ways in which AT&T is seeking to address consumers' needs for closer contact despite geographic separation. One new offering expected later this year will be a videophone product being jointly developed by AT&T and Hitachi.

The technology for providing videotelephony over POTS connections continues to improve. AT&T Microelectronics has recently launched a new AVP-III chip and associated software. It includes support for H.324, the new standard for international POTS videotelephony.

For consumers seeking interactive entertainment, AT&T provides the ImagiNation Network. It is an

electronic community in which people meet and form relationships through games and other activities they enjoy together..

Solutions for Service Providers. To advance along an evolutionary path into the world of integrated interactive video, service providers will need the ability to provide all the network elements (for example, access distribution, transport, application servers, and so forth). They also will need to provide professional and financial services, as well as additional business partnerships.

Some examples from the AT&T Network Systems portfolio of multimedia offerings include:

- Interactive video server solutions through participation with Silicon Graphics* and Time-Warner in Interactive Digital Solutions;
- End-to-end digital video solutions for interactive television;
- The GlobeView-2000 Broadband System, which includes support for standards-based switched-virtual-circuit capabilities in a public-network ATM broadband system;
- The AT&T Video Manager, which sets up pathways between viewers and video server and dynamically man-

ages the bandwidth needed for those connections; and

- Both hybrid fiber-coax and switched-digital-video access solutions, provided through HFC 2000™ and the SLC®-2000 Access System with FLX® Switched Digital Video, respectively.

Summary

Networked interactive multimedia is providing new ways for people to perform familiar activities. Developments in home entertainment, telecommuting, telemedicine, desktop collaboration, and electronic home shopping bear witness to this trend. AT&T is investing in multimedia-related research and development to ensure that it will continue to provide innovative solutions to customer needs.

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Sandra L. Teger is the strategy director in the Visual Multimedia Initiative department at AT&T



Communications Services Group, Basking Ridge, New Jersey. She is responsible for supporting increased collaboration across AT&T in multimedia and visual communications. Her group acts as a focal point for strategy integration and for planning new multimedia applications. Ms. Teger has a B.A. degree in mathematics from Vassar College in Poughkeepsie, New York. She also completed her M.S. degree coursework in mathematics at New York University's Courant Institute of Mathematical Sciences in New York City. She joined AT&T in 1977.