

# Broadband Applications and Services Prospectus

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Not too long ago, network traffic was almost entirely comprised of voice or voice-grade traffic. Today, networks must support a rapidly growing percentage of several different kinds of high-bandwidth or broadband traffic—data, image, and video—in addition to conventional voice traffic. There are several factors that create the demand for these new capabilities. Telecommunication customers want faster performance, better quality, customization, lower costs, and an ever increasing variety of advanced information services. For network-service providers, increasing competition requires an accentuated focus on providing timely, reliable, flexible, and evolvable information-network services. But, while network-service providers require new networking technologies to enable the deployment of advanced services, they must also increase network efficiencies to maintain control of their operating expenses. How might asynchronous transfer mode (ATM) technology be used to address these needs? This paper discusses some of the expected broadband applications and services enabled with ATM technology, as well as applications and services involving more than a 1-Mbit/s peak transport capability. In addition, the prospects for broadband services and applications deployment are also presented.

## Introduction

Dramatic changes in the global marketplace suggest extraordinary telecommunications changes in the not-too-distant future. While basic telephony may remain a centerpiece of telecommunications for many years to come, several new information-networking services promise to have a profound effect on the next-generation telecommunications network. These new services are driven by several converging factors. Among them are: changes in the business climate; technology-driven change; legal and regulatory changes; and new consumer demands.

**Changes in the Business Climate.** Due to intense competition in today's business environment, cost management and time-to-market factors have become critical for the ongoing success of businesses. Consequently, fundamental changes take place in the organizational structure and scope of most large businesses, and even some

moderate-size companies. Many are moving toward cross-functional work groups with geographically disparate (even mobile) staffs, responding dynamically to rapidly changing market conditions. Moreover, the acceptance of company-endorsed work-at-home arrangements (telecommuting) appears to be rising.

Many corporations are also becoming more multinational and global; they are pursuing competitively driven, strategic partnerships on a worldwide scale. Finally, the universal "push" for increased quality in every phase of the product life cycle has expanded communications requirements between the business' suppliers and its customers.

In addition to these commercial business changes, there is also a strong stimulus for change coming from governments all around the world. For example, in the United States, the end of the cold-war era has provided the incentive to invest in the conversion of the military-industrial complex into an

**Panel 1. Abbreviations, Acronyms, and Terms**

ATM — asynchronous transfer mode  
broadband — a system capable of transmitting and receiving voice, data, and video information over a common fiber-optic or metallic cable at 1.544 Mbits/s and higher transmission rates  
“bursty” — sporadically occurring signals or traffic, such as data and image  
CATV — cable television  
EEC — European economic community  
frame relay — an advanced packet-transport service operating at 1.544 Mbits/s or slower  
FCC — Federal Communications Commission  
HDTV — high-definition television  
LAN — local-area network  
LEC — local exchange carrier  
MPEG — Motion Picture Experts Group  
PC — personal computer  
PCS — personal communications services  
SMDS — Switched Multimegabit Data Service

information-networking and computing complex. Many envision this transformation as a key element in revitalizing the world economy. The interplay between government and commercial sectors in implementing this vision will increase the already intense interest in high-speed, multimedia information networking for non-military applications.

These changes validate several new information-networking needs: increased data networking; growth in public-carrier (non-private) information networking; the use of a variety of diverse network services-on-demand through a common network interface; new applications requiring high-resolution graphics and images; visual telecommunications; and multimedia. In addition, the deployment of new network-based “mission-critical” applications requires that networks provide increased service flexibility, a greater variety of services, higher service reliability, and high-speed performance.

**Technology-Driven Change.** At the same time, rapid advances in technology can be seen: the decreasing cost of processing power; decreasing memory costs; the decreasing cost of bandwidth; the increasing use of desktop client-networked and server-networked computing

and “user-friendly” graphical interfaces; and the convergence of telecommunications and computing. These changes have not only intensified computing capabilities, but they also have spawned the development of many new applications involving graphical and visual communications. These new applications will greatly intensify interface-bandwidth requirements, a trend that is expected to continue for the foreseeable future.

**Legal and Regulatory Changes.** In the United States, recent Federal Communications Commission (FCC) rule modifications and proposed rule changes will have a significant effect on both the kinds of services offered, as well as the companies that are legally permitted to offer telecommunication services. Specifically, the local exchange carriers (LECs) are permitted to offer “video dial tone,” and the FCC has recommended elimination of telephone company and cable television (CATV) company cross-ownership restrictions. The impact that these changes may have is already evident from the aggressive plans of the LECs and CATV companies to expand into each other’s former businesses.

Significant legal and regulatory changes aren’t restricted to wire-line carriers. The recent FCC decision to allocate unoccupied radio spectrum in the 900-MHz band for narrowband personal communications services (PCS), and the anticipated allocation of frequencies in the 1,800 MHz band, are expected to spur the development of next-generation, wireless, high-speed voice and data PCS. These capabilities may well blur the distinction between services offered via traditional networks versus wireless-access networks.

In Europe, the development of the European economic community (EEC) is having an equally dramatic effect on telecommunications policy throughout western Europe—even in the non-EEC countries—and will also affect most of eastern Europe over time. Similar, though less pronounced, telecommunication policy changes are also occurring in several Pacific-rim countries—most notably Japan. These changes are encouraging more and more competition.

**New Consumer Demands.** There are a number of economic, social, and lifestyle changes that are dramatically altering consumer demands for information services. On the economic front, transportation costs continue to rise, and the cost of living close to one’s workplace is often prohibitively expensive. Consequently, research confirms that a growing number of employees

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are opting for work-at-home arrangements and “flex-time” work schedules. Similarly, concerns about the environment and crime have many people seeking ways to minimize personal travel through telecommuting. Finally, for a variety of reasons, studies show a marked shift toward spending more leisure time at home, as well as the growing acceptance and use of PC-like equipment in the home. Coupled with these changes is the desire for entertainment and information that fits the consumer’s schedule, rather than the producer’s.

**Summing It Up.** In the business world, the changing organizational structure and scope—coupled with the increased use of high-capacity, high-speed networked computing—suggests an increasing demand for high-bandwidth, broadband communications. On the technical front, improvements in transmission and switching technology promise decreasing costs for high-bandwidth communications and more cost-effective visual telecommunication applications. These phenomena may be synergistic, leading to an overall increase in the demand for high-bandwidth communications by a broader segment of the market than would otherwise be the case.

On the residential front, non-business consumers will want fundamentally more advanced telecommunication services than traditional, basic telephony services. But, will the price be right and will consumers buy? How quickly will the synergism help bring down the cost of broadband services, so that even typical residential customers can afford them? Several market trials are underway to help answer these questions. One thing is clear: the telecommunications network will be dramatically changed in the coming years.

#### **Broadband Application and Service Evolution**

The deployment of broadband ATM communications will evolve through multiple phases. Initial “niche” services, such as frame relay, Switched Multimegabit Data Service (SMDS), and 1.544 Mbits/s (DS-1) switched services will evolve to include early, provisioned ATM network services. Finally, as new applications develop and network capabilities mature, fully integrated, broadband-ATM switched services will emerge. The starting point for this evolution is the combination of today’s communication networks, available telecommunication standards, and the most pressing near-term demands for broadband applications (the mechanisms used to achieve what people want to do at work or at play) and services (the

telecommunications capabilities by which applications are implemented). Differences between the business and residential markets suggest that ATM applications and services will follow different introduction schedules.

**Business-Market Evolution.** In the business market (assumed to include work-at-home situations), ATM services will initially augment the currently available set of voice-networking and data-networking services. Today’s business networks carry a wide range of applications, which can be sorted into various classes. These classes include voice service, low-speed terminal data communication, higher-speed local-area network (LAN) interconnect and LAN backbone transmissions, imaging data services, bulk data transfers, and video teleconferencing sessions. These applications are carried over a correspondingly wide range of communication networks. Typically, each application structures its own subnetwork around a communication-network service that is best matched to its needs.

Current market-driven applications—LAN interconnect, collaboration using high-resolution imaging data, and video teleconferencing—have hastened the introduction of several new high-speed services, based on relatively mature circuit-oriented and packet-oriented technologies. As new ATM-based customer premises equipment and networking capabilities become available, demand for semi-permanent (provisioned) ATM public-network services will emerge.

These network service offerings will enable end-users to design private and virtual private networks at broadband rates. New service offerings will coexist with today’s non-switched and switched network services. The initial use of ATM services in this environment will be to extend further the available set of networking options so that high-speed, packet-like applications—including LAN interconnect, LAN backbones, and high-resolution image transfers—can take advantage of ATM’s efficiency, high transmission speeds, and its ability to handle “bursty” data traffic. In some cases, existing application networks will move to ATM, possibly using protocol adaptations between existing application protocols and ATM. In other cases, new applications that were not practical earlier (because of cost or performance limitations) will become possible due to the availability of ATM services.

As applications move to ATM, ATM-based networks could be used to consolidate multiple, separate data networks. These applications will take advantage of

**Panel 2. Business Applications Having Good Prospects for Broadband ATM Services**

**High-speed Image Networking**

- Design automation (CAD/CAM/CAE)
- Medical imaging/consultation
- Photographic editing
- Scientific visualization
- High-resolution graphics/image rendering

**Interactive Multimedia**

- Interactive tele-training
- Work-at-home/telecommuting
- Executive (desktop) teleconferencing
- Print/publishing collaboration
- Subject-matter-expert consultation
- Virtual reality
- Multimedia telephony

**Wide-Area-Network Distributed Computing**

- LAN backbone/interconnect
- Host-to-host channel networking
- Disaster recovery/information vaulting
- Load sharing

the fact that many carriers and equipment manufacturers will transport communications protocols, such as frame-relay and SMDS services, over ATM backbone networks. By taking advantage of protocol adaptations, current applications (using frame-relay and SMDS services) as well as new applications (running over ATM services) can be combined onto a single data-networking environment based on ATM. Eventually, as multimedia applications become more prevalent in data networks, many will evolve to employ the ATM protocol directly. Over time, this will reduce the need for protocol adaptations.

As broadband ATM becomes more cost effective and ubiquitous, end-users will take advantage of ATM's ability to carry many different types of traffic, and will extend the trend toward network consolidation to areas beyond data networking. For example, the ATM backbone, which will initially be deployed to support data networking traffic, can readily be used to transport high-speed circuit payloads, such as video traffic and voice trunks, at 1.544 Mbits/s (DS-1 rate) or higher. This consolidation trend will lead to the use of ATM-based, integrated, wide-area-network access. Integrated access involves converting all of a customer's communication

services to ATM at the customer's premises, and then carrying them into the wide-area network by means of a single, high-speed ATM access line. Each service may still be treated as a part of its own subnetwork, but the common ATM access line allows transport efficiency and bandwidth sharing among the services and subnetworks.

As this continues, the desire for on-demand (real-time switched) networking capabilities will emerge. The addition of intelligent switching capabilities to the network will enable the introduction of many new and useful features. First, the required bandwidth can be allocated and de-allocated on demand and in real time. Second, connections beyond a company's private or virtual private network can be established when and where they are needed around the globe. More significantly, features now available for voice services through the intelligent network can be applied to broadband ATM services—for example, "700," "800," and "900" switched services, call screening, and call forwarding, to name a few. All the while, the more "bursty" traffic—data and image—will be statistically multiplexed to maximize bandwidth, thereby increasing transport-network facility utilization.

Over time, as multimedia applications become more prevalent and as other applications increasingly demand flexible service capabilities, the multiple services provided over integrated access lines will evolve toward fully integrated network solutions. In an integrated network environment, a wide range of services—with various levels of performance and intelligence—will still be available. However, these services may be offered in selectable grades within a single, integrated networking environment. The resulting integrated communications environment will provide the full service and bandwidth flexibility needed to meet, most efficiently, the diverse and rapidly evolving applications that will likely characterize the progressive business environment.

Panel 2 identifies business applications that have good prospects for three classes of broadband ATM services: high-speed image networking, interactive multimedia, and wide-area-network distributed computing.

**Residential Market Evolution.** Advanced residential information services have achieved only limited market penetration to date. On the other hand, with the trend toward more leisure time spent at home, residential video-entertainment services have been very successful. For reasons that follow, ATM technology will play a key role in the evolution of advanced video-entertainment

services. This may provide the stimulus for widespread demand for residential, broadband data and multimedia services, in addition to video-entertainment services.

While today's video-entertainment delivery systems are based on analog technology, there is considerable consumer demand for higher quality and more reliable CATV services. Consequently, the industry is quickly moving toward systems now in development that will use digital channels and rapidly advancing, digital video-compression technology. These systems will provide brand-new capabilities, such as video-on-demand, high-definition television (HDTV), and 500-channel CATV.

In several of these capabilities, multiple, compressed, digital video channels are carried over a single digital bit stream. Digital video-compression technology permits encoding video signals at variable bit rates. In many applications, a single bit stream may carry multiple digital channels running at different bit rates. (Various aspects of the program material can affect the desired video bit rate, such as the amount of motion, and whether the original source material was from film or videotape.)

Within a telecommunications network, ATM technology is ideally suited to serve as the multiplexing technique for carrying multiple, compressed, digital video signals over a single digital bit stream to the home. ATM technology is highly effective in carrying multiple channels of arbitrary bandwidth over a single digital bit stream. In addition, ATM is well suited to the additional flexibility demanded by some digital video-entertainment applications. In many cases, a single video program can be associated with multiple audio signals (multiple languages) or data overlays (closed captioning or ordering information). All of these signals and overlays can be carried efficiently as ATM virtual circuits in a single, multiplexed bit stream.

The value of ATM in carrying compressed digital video is reinforced by recent video-compression standards work from the Motion Picture Experts Group (MPEG). The MPEG-2 standard has been designed to enable MPEG-2 compressed video information to be transported via ATM calls over an ATM network.

Initial residential use of digital compressed video will be for CATV systems with an extended number of channels. Early services will probably include an expanded channel selection, a wider range of pay-per-view events, and an enhanced pay-per-view system, which might provide the most recent movie releases at

### Panel 3. Residential Applications Envisioned Through Broadband ATM-Based Services

#### Distribution Video

- Broadcast TV/HDTV
- Broadcast distance learning
- Enhanced pay-per-view (near video-on-demand)
- Video-on-demand
- Video catalog/advertising
- Tele-shopping

#### Interactive Multimedia

- Multimedia electronic mail
- Multimedia "700," "800," and "900" services
- Sports event simulcasting/tele-wagering
- Interactive distance learning
- Multimedia videotext/"Yellow Pages"
- Interactive TV/games
- Multimedia telephony and virtual reality

15-minute intervals. These services will be followed by video-on-demand service, which will use the extended number of channels to provide interactive and fully controllable viewing of movies supplied by video servers.

The network and customer-premises equipment used to provide these video entertainment services includes key underlying capabilities, which facilitate the deployment of more advanced residential services. The underlying capabilities of a CATV channel-expansion system with video on demand include:

- Broadband channels to the residence,
- The ability to select and process broadband digital channels, and
- The ability to transmit information in the "upstream" direction from the residence into the network.

With the flexibility of ATM, these basic capabilities will help to provide a full range of audio, video, data, and multimedia applications to the home. Applications will include entertainment, education, and telecommuting services. Thus, the initial deployment of ATM video-entertainment services will lead to the widespread deployment of high-bandwidth equipment for the home. This equipment will have the flexibility to offer the sophisticated capabilities expected by today's media-conscious residential consumers.

Fiber-based and coaxial-cable-based distribution systems, which are being installed today, can deliver 50

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to 80 analog channels to communities ranging in size from a few hundred homes to a few thousand homes. With the technology described earlier, these types of installations could provide a dynamically "sharable" bandwidth of 1.5 Gbits/s to 2.4 Gbits/s (or more) to each community. These broadband distribution systems, when combined with the bandwidth flexibility provided by ATM networks, create an astounding array of opportunities for service and application evolution.

Panel 3 lists some of the residential applications that are envisioned through the use of broadband distribution video and interactive multimedia services.

### Conclusions

The development of broadband ATM services will be driven by end-user application demands. In the business environment, explosive growth in data networking will drive the deployment of ATM campus-backbone networks. Deployment will be accelerated by client and server distributed-network computing, and applications utilizing progressively more graphic and video-oriented content. Moreover, the requirement to extend local campus-network capabilities to the entire wide-area corporate enterprise will spur demand for initial, carrier-based, ATM-provisioned services. Emergence of cost-effective client workstations will encourage the development of many new multimedia applications. And finally, the need to extend the information "superhighway" to corporations' external clients (both its customers and its suppliers) and to its telecommuting employees will usher in the evolution to intelligently switched, broadband ATM services—on premises and across public networks.

In the residential market, consumer preferences, new regulatory rules, and technology advances will encourage the development of an exciting array of advanced video-entertainment services to the home. Some of the most advanced video-distribution services have already been field tested and are in the early market-deployment stage. Consumer demand for interactive video applications will encourage the introduction of early multimedia service offerings. Some of these include interactive TV, interactive tele-education, and perhaps even event simulcasting with tele-wagering.

Initial success in broadband market development in the business and residential sectors—coupled with the technology trends discussed earlier—may reinforce each other in much the same way that the cellular telephone

market has developed. This market "churn" will further encourage competition between traditional LECs, access providers, and CATV companies—thereby stimulating the rapid introduction of broadband services and capabilities based on ATM technology. Then, as market penetration rises and prices fall, the dream of advanced multimedia telephony services for the mass market can become reality.

At the core of this change is ATM, a technology that can dynamically support a broad range of applications. ATM will provide the communications infrastructure to support the convergence of telecommunications, computing, and video (television). It is difficult to predict whether ATM technology will deliver on all its promises, but there is compelling evidence that suggests it will do so in the near future.

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