

Broadband ISDN: An Overview

Harry L. Bosco
Michael J. Stefanik

This issue of the *AT&T Technical Journal* is dedicated to the architecture known as the broadband integrated services digital network, or BISDN—the standards recommendations that define it, the technologies that enable it, and trends in business and society that are intensifying market demand for the emerging applications it will support. BISDN has the potential to be the next-generation infrastructure not only for the telecommunications carriers' public networks, but also—in the context of increasing demands for sophisticated high-bandwidth, or broadband, services—for customers' private networks, including local-area, metropolitan-area, and wide-area networks. This remarkable new synergy between premises networks and public networks offers customers dramatic new possibilities of seamless end-to-end information networking. Together with new techniques for transporting voice, data, and video, BISDN makes it possible to deploy multimedia services with powerful signaling and control capabilities. The papers in this issue capture a broad, representative view of this dynamic subject and provide a snapshot of AT&T's rapidly expanding activities in implementing BISDN.

Introduction

In an increasingly mobile, competitive, and quality-conscious environment, large corporations, engineering and manufacturing enterprises, government agencies, hospitals, and educational institutions are increasingly united in demanding high-bandwidth applications. Visual and multimedia communication services will support such applications as desktop video conferencing, high-resolution full-motion video, and remote training. High-speed data services will help businesses, agencies, and institutions provide better services while increasing productivity. In the residential-services market, the entertainment industry is expected to play a major role in creating demand for high bandwidth, beginning with such applications as video on demand and network-based video games.

Market research indicates a strong trend for a significant, continuing increase in bandwidth demand for advanced communication services. A standardized technological framework for meeting this demand began to

take shape nine years ago in the International Telegraph and Telephone Consultative Committee (CCITT)—now known as the International Telecommunications Union Technical Standards Sector (ITU-TSS). That framework is essentially complete today.

High-bandwidth multimedia services and applications seem to be best offered by broadband ISDN, based on asynchronous transfer mode (ATM) protocols. These protocols define a structure for the “cells”—data packets of a fixed length, with standard header and payload attributes—that both carry and route information through the network. BISDN is the standard term used to identify high-speed digital networks using ATM as the transfer mode and ITU-TSS recommendations, such as Q.93B, for signaling and call control.

The single most important aspect of BISDN is its integrated support of a wide range of services and multimedia applications, including any combination of audio, video, and data, not only in the same network but also as part of the same call configuration. A

key element of service integration for BISDN is the provision of a wide range of services to a broad variety of users utilizing a limited set of connection types and multipurpose user-to-network interfaces. But BISDN is not limited to connecting customers to high-bandwidth digital transport facilities; it also gives users additional capabilities to control and manage the type of connections, the quality of service, and the number of endpoints involved in a call.

BISDN supports switched and permanent, point-to-point and point-to-multipoint connections. These connections in turn support circuit-mode and packet-mode, variable-bit-rate and constant-bit-rate services. The services provided on BISDN can be single-medium or multimedia, connection-oriented or connectionless, and bidirectional or unidirectional in configuration.

The cell-transport concept and specific cell-transfer principles of ATM are responsible for the great flexibility it provides, in terms of both network access and types of service. Two key ATM concepts, referred to as "virtual path" and "virtual channel," enable easy provision of semipermanent connections. ATM also allows dynamic bandwidth allocation, on demand, with a fine degree of granularity.

Independence of the means of transport at the physical layer is another advantage of BISDN. In its purest conceptual form, BISDN/ATM technology is tightly coupled both to the use of single-mode fiber and to physical-layer transport as defined for the synchronous optical network (SONET) and synchronous digital hierarchy (SDH). ATM, SONET, and SDH are mutually compatible and make perfect sense together in the public networks. But the BISDN recommendations also enable the use of ATM technology on premises networks such as multimode fiber or twisted-pair local-area networks (LANs). They also allow for a graceful evolution from today's mix of public and private network-specific technologies to what may become a common technology infrastructure for all.

From Narrowband to Broadband ISDN

From the very start of CCITT discussions of BISDN in January 1985, the key concept of integrated services was a primary consideration. An initial set of recommendations for ISDN, the integrated services digital network architecture based on ubiquitous copper distribution facilities and existing digital switching technology, had just been completed. It was time to extend the essential

ISDN concepts into recommendations for a broadband network architecture, based on optical fiber and next-generation switching technologies, that would support high-bandwidth applications.

Several key advances spurred on this work. They included the availability of single-mode optical fibers with raw physical bandwidth in excess of 30 terahertz (10^{12} Hz); the development of increasingly reliable, high-speed lasers, light-emitting diodes, and photodetectors; and experiments conducted in labs around the world demonstrating that it was technically feasible to deliver hundreds of megabits per second to homes and businesses. There were advances outside the laboratories as well. Telephone company executives and other business leaders began to talk seriously about fiber in the loop and fiber to the home, giving added impetus to the BISDN standards proceedings.

At the same time, the market pull was already exerting some force. Demand was building for wide-area networking and high-speed data services. And while it may not have been generally believed that visual and multimedia applications would advance as rapidly as they have, it was clear that they were coming. Since few could have foreseen how successful the efforts to compress visual information would be, future demand was projected in multimegabits per second, per customer. For example, high-resolution digital video, with applications in areas such as telemedicine, entertainment, and advertising, was expected to require bandwidth of at least 155 megabits per second.

Initial proposals for switching broadband traffic included ingenious but cumbersome arrangements that would require multiple switching fabrics, if not multiple switching systems, to handle different types of calls. Entertainment video might be routed through a broadband circuit-switching fabric, voice through a lower-speed circuit-switching fabric, and data through a packet-switching fabric. But advances in broadband packet switching research had fostered growing confidence in the feasibility of handling all types of traffic—audio and video, with their long holding times and sensitivity to delay, as well as bursty data traffic—with one switching technology. Subsequent developments justified this optimistic view.

The result is ATM, integrated switching for integrated services. ATM technology promises to bring about a world in which, from the user's point of view, wide-area

communication is as easy as local communication; a world in which computers, large and small, have global connectivity to multiple information platforms with LAN-speed connection-setup time. It promises to bridge the gap between computer communication and telecommunications for data, voice, and video services.

BISDN based on ATM will become the technology for future networking because it is driven through the standards bodies, expediently and with determination, by a collaboration of users, customer-premises equipment (CPE) vendors, and network service providers and their vendors, worldwide. This unprecedented collaboration among all players in the communications and computer industries ensures that the task of enabling global high-speed networking will be realized in the time frame required by end-user customers.

Customer Needs: Driving Forces for BISDN

What common goal could have inspired such cooperation among companies that view each other as competitors, or between industry participants—computer makers and public network providers, for example—that were not traditionally viewed as being in the same industry? Perhaps it was the recognition that their customers' needs, together with their own market and technology domains, were converging.

The convergence of telecommunications, computing, and video has reached the worker's desktop and, on the home front, is approaching the television set-top. When customers across a wide range of traditional markets increasingly demand multimedia capabilities, compatible products, and integrated solutions, all concerned can see that cooperation on standards is just good business. Also, in light of the industry's experience with narrowband ISDN, all parties have been eager to communicate to avoid the economic consequences of standardization following product and service introduction. Industry efforts have received a more or less direct push by customers through the ATM Forum, a cross-industry group with representatives from both computer and communications industries. Customer needs provided common ground and motivation for ATM Forum members representing more than 300 corporations, including service providers, equipment manufacturers, and users. It was in fact the ATM Forum that drove BISDN technology from being strictly a telecommunications infrastructure enabler to being a customer-premises networking vehicle as well.

Marketplace competition and the pressure to turn new concepts into products more rapidly have never been greater. Time is a precious resource, and businesses and consumers alike are searching for ways to do more in less time. Corporations are changing the way they conduct business. Collaborative work among many locations is becoming a critical success factor in responding to market demands. BISDN technology offers a wealth of opportunities to conduct business over great distances without leaving the office. Applications such as multimedia conferencing, for example, can help corporations cut travel expenses at the same time they emphasize teamwork and communication to boost productivity.

In the future, increased revenues derived from the ability to get products to market more rapidly, together with savings in travel and shipping costs, are expected to motivate and finance continuing growth in communication demands. Increased investment in sophisticated communications technology will be required to achieve significant new revenue growth and cost savings. And, as corporations realize the benefits of technology, they will demand higher-bandwidth transmission and faster processing power.

Other forces driving investment in BISDN are generated by movements such as educational reform in forward-looking institutions. Schools at all levels are looking to distance learning as a means to enhance educational opportunities and control costs. Moreover, as students in the next generation enter the workforce, they will demand the tools of their education—personal computers linked via high-speed networks to the resources they require to contribute effectively to the corporation.

Demand is building even among nontechnical consumers. They already have options to bank and shop without leaving the home and are being offered increasingly flexible video programming from cable companies. In addition, customer-premises vendors are racing to develop user equipment to ensure the success of BISDN and the migration of our society into the "network age," in which many aspects of interaction among individuals will rely heavily on multimedia telecommunications.

AT&T ATM Strategy

AT&T's stated mission is to be the global leader in enabling customers to reap the benefits of information technology. An integral part of the corporation's overall plan for achieving this mission is its strategy for ATM technology, products, and services.



Joining its technological vision with insight into customers' needs, AT&T has mapped out a broad evolutionary path for migration to BISDN, beginning here and now. The final article in this special issue — starting on page 76 — describes a number of ATM-based products and services from AT&T Network Systems Group and Communications Services Group. The Service Node module shown here is part of the GlobeView-2000™ Broadband System.

AT&T believes that ATM is the cornerstone for enabling future visual and multimedia applications by building on the existing communications infrastructure in an evolutionary way. The emphasis on evolution, rather than revolution, reflects AT&T's commitment to a realistic migration strategy for current voice and data networks to protect the customers' investment and allow alternative paths for future growth.

There is no single path to the future communications infrastructure. Neither a "data only" path nor a path based exclusively on voice-oriented networks and services can lead to the envisioned era of multimedia networking without some sacrifice in terms of interoperability, scalability, real-time communications, or the flexibility of customers' options. AT&T is committed to supporting the complementary, simultaneous evolution of both voice and data networks, enabling customers to introduce ATM technology and applications in the ways best suited to their needs.

The solution is for networks in both domains, voice and data, to evolve to a common point of convergence as visual and multimedia networking becomes established. AT&T's strategy is to offer flexible migration paths characterized by a sequence of networking products that move voice and data networks toward each other incrementally, until the point at which they converge in a single integrated voice/data/video architecture, the cornerstone of which is ATM. Another imperative is that interpremises networks evolve in a coordinated way, to support true end-to-end solutions that are global in scope. AT&T believes it is uniquely prepared to bring this vision to the marketplace.

The reasons for AT&T's strategic commitment to ATM can be summed up in five statements. *ATM is correct.* Specifically designed for the integrated movement of voice, data, and video, ATM represents the industry's accumulated learning in the areas of voice and data, and on the future needs of video. *ATM is accepted.* It is common ground for voice and data technologies and technologists, customer-premises equipment vendors, public

network providers and their suppliers. *ATM is simple.* Providing a single protocol, end-to-end, seamless and extensible from the premises to global networks, ATM is an antidote to the complexity associated with future systems and applications. *ATM is fast.* Designed for flexible bandwidth management, ATM is scalable from kilobits and megabits per second at the desktop up to gigabits per second in public network switching systems or private backbone networks. *ATM is protective of both past investment and future options.* Appropriate to incremental growth and compatible with existing wiring, protocols, equipment, physical plant, and applications, ATM can easily evolve along with application needs.

In This Issue

The extent of AT&T's involvement in BISDN and the pace with which its business units are developing BISDN products and services make it nearly impossible to capture more than a snapshot of this dynamic subject. Nevertheless, these papers go a long way toward illustrating the uses, status, and future directions of BISDN. They present a view of BISDN that stretches from fundamental concepts to products and services, from standards recommendations to field trials.

Levy, Prasanna, and Swenson describe the principles of this technology and its status in the standards bodies and industry forums. Kafka examines the evolution of broadband technology in the telecommunications network, some of the forces behind it, and the importance of considering long-term evolutionary directions when establishing the initial stages of broadband equipment and services. DeMaio and Kafka review some of the expected applications and services enabled by BISDN/ATM technology, as well as prospects for new revenue-generating business and residential services.

Anderson, Kafka, and Soneru address network aspects of BISDN, explaining that the signaling and call control for BISDN are expected to support a wide spectrum of services and infrastructure applications, allow rapid introduction of new services, and provide unified

operations and customer control. Martin, Pashan, and Soneru focus on three key technologies for broadband switching: the ATM fabric, ATM line cards, and ATM control structures.

The paper by Bergland, Ferenc, Morano, Pitio, Shugard, and Smith describes a platform of electrical and optical components to support integrated services on customers' corporate and campus networks. Lewis, Morton, and Reustle highlight the Intelligent Bandwidth Manager as a vehicle for aggregating traffic from customer-premises equipment, and as a gateway to a variety of network services.

Nanke and Prieve discuss what has been learned from broadband trials, focusing in particular on the US WEST COMPASS trials, five sets of projects in which AT&T played a critical role. The paper by Bosco, Stefanik, and Stuntebeck surveys some of AT&T's major networking product and service plans in detail.

Together, the papers in this issue provide a snapshot of AT&T's rapidly expanding activities in this dynamic and important field.

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Harry L. Bosco is the ATM Platform Organization Vice President in AT&T Network Systems, Red Bank, N.J. Mr. Bosco began his AT&T career in 1965 in the Data Communications area of Bell Labs. His responsibilities have included design and overall project management for the 5ESS® switching system, operations systems development, and product management for medical systems. He was appointed Data Networking Vice President in 1989 and assumed his current assignment in 1992. Mr. Bosco received an A.S.E.E. degree from Pennsylvania State University, a B.S.E.E. from Monmouth College, and an M.S.E.E. from the Polytechnic Institute of New York.

Michael J. Stefanik is head of the Next Generation Network Architecture Department at AT&T Bell Laboratories in Holmdel, N.J., responsible for specifying intelligent network and broadband network architectures. Since joining Bell Labs in 1973, he has held a variety of positions in switching systems engineering, network planning, and technical field support, and has led standards groups responsible for aspects of the analog-to-digital transition and ISDN. He has a B.S.E.E. degree from Valparaiso University and M.S. and Ph.D. degrees in electrical engineering from Ohio University.