AT&T ATM Switching-Network Products

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Superior broadband functionality can be realized by the economical and timely introduction of networks and services, based on asynchronous transfer mode (ATM) technology, into traditional and new markets. In the traditional networks of voice and data, this introduction may best be accomplished by extensions of the embedded investment. Different configurations of the same basic building blocks, however, can be used for new networks that combine voice, data, and video. By providing building blocks for fabric and line units, provisioning, signaling, and call processing—as well as operations, administration, maintenance, and provisioning (OAM&P)—both existing and new networks can evolve economically into an information superhighway having universally deployed multimedia networks.

Introduction

Asynchronous transfer mode (ATM) products and services are being introduced at several points in today's communication networks. These introduction points include customer-premises-equipment (CPE) work stations and local-area networks (LANs), as well as access, backbone-infrastructure, and cable-television (CATV) networks.

Newer work stations provide for direct ATM connections. LANs and leased lines provide for ATM interfaces among work stations and directly to carriers. Today, traditional data carriers provide, primarily, switched multimegabit data service (SMDS) or frame-relay services between customers' work stations, LANs, and wide-area networks (WANs). However, they have either begun to supply provisioned ATM services or have announced their intention to do so. These service providers are also introducing ATM into their backbone networks, in order to handle the several existing protocols—and ATM protocols—uniformly. As a next step, these traditional data carriers want to provide switched services, along with the whole plethora of multimedia services, in the not-too-distant future.

In addition to U. S. service providers, operators of traditional telecommunication networks around the world are introducing ATM into their access networks. ATM provides many desirable broadband capabilities—including video services—to their existing narrowband voice customers. In order to avoid increasing administrative costs, these network operators plan to introduce ATM into their backbone networks, allowing multiple protocols and services on a single network. As with U. S. companies, they want to provide switched broadband services too, including the entire range of multimedia offerings.

CATV companies are now introducing ATM technology and hubs. ATM technology will serve as the switching and transport protocol between program providers and cable heads. In addition to current services and video on demand, CATV companies intend to become the primary customer access for all types of services. They intend to sell access—narrowband and wideband—to any service provider who desires it (for example, traditional narrowband telephone services, home shopping, such network entertainment services as video games, and so forth).

Economics and timing must be considered carefully in introducing products to customers with such a diversity of existing networks. The approach suggested in this paper is the introduction of a set of ATM-network building blocks. These building blocks provide the required, increased functionality as they are

Panel 1. Abbreviations, Acronyms, and Terms

ATM — asynchronous transfer mode
AXC — ATM cross-connect
BSS — broadband switching system
CATV — cable television
CMISE — common management information service definition
CPE — customer premises equipment
CSG — AT&T Communications Services Group
integrated services platform—the suggested approach to ATM employs this platform, or set of four building blocks, which can be used to set up new ATM-based networks or introduce ATM functionality into an existing network
LAN — local-area network
NSG — AT&T Network Services Group
OAM&P — operations, administration, maintenance, and provisioning
PBX — private branch exchange
PTT — postal telegraph and telephone (European equivalent of an LEC or local exchange carrier)
SDH — synchronous digital hierarchy
SMDS —switched multimegabit data service
SNMP — simple network-management protocol
SONET — synchronous optical network
STM — synchronous transfer mode
TMN — telecommunications management network
WAN — wide-area network

merged to form new multimedia environments, preserving both initially deployed ATM investment, as well as current data, voice, and video-network investment.

This paper provides a review of today's networks, along with suggested methods for introducing the ATM-network building blocks. Following sections discuss techniques used for augmenting existing network elements to introduce ATM, preserving the current investment, and realizing the present and future potential of ATM services. ATM networks, using the AT&T Network Services Group (NSG) GlobeView™-2000 Broadband System of building blocks, are also discussed. [1-8]

ATM Building Blocks

The suggested approach to ATM uses a set of building blocks, referred to as an *integrated services platform*. As shown in Figure 1, each block has distinct functionality, and can be used to build new ATM-based networks or introduce ATM functionality into an existing network. Four building blocks are described:

- Access node;
- Service node;
- Service-management module; and
- Switched-services module.

Each building block is an integral part of the AT&T NSG GlobeView-2000 Broadband System.

The *access node* serves as a multiplexer, converting the various protocols that exist in today's networks into the cell-based protocol of ATM. The access node is compatible with current synchronous optical network/synchronous digital hierarchy (SONET/SDH) rings. It provides low-cost, point-to-point ATM connectivity and protocol conversion of many types, to and from ATM. Within an ATM-only network, the access node multiplexes between the various SONET/SDH rates, which carry ATM at the transport layer. It provides open, industry-standard interfaces on both access and network sides.

The *service node* is a highly reliable network switch for ATM, having duplex equipment options. It interconnects directly with ATM-capable CPE, access nodes, and other ATM switches to provide networks of various configurations, carrying any combination of voice, data, and video. In addition to ATM cell switching, the service node provides priority levels for different types of traffic, policing, multicasting, measurements, and interconnection of various ATM-carried rates and physical layers. It has a shared memory fabric, which provides superior performance characteristics for either a constant-bit-rate, variable-bit-rate, or mixed-bit-rate network.

The *service-management module*, in its simplest form, introduces provisioned services in a single ATM-node network. In its most robust form, it provides both element and network management for complete administration of a multi-node ATM network, including network-measurements collection, maintenance, and operations. It can span a large set of service nodes and access nodes, orchestrating the administration of the sum of all nodes comprising a network. It provides simple network-management protocol (SNMP), telecommunications management network (TMN), and common management information service definition (CMISE) interfaces for a customer's complimentary service and network-management systems. A functional subset of the service-management module, the *management module*, is used for low-cost, local-element management of the service node when the service node is a network element remote from a central service-management module. The central service-management module provides element management for any co-located service node, as well as management for the entire network through the remote modules.

The *switched-services module* provides control for switched services in a network. It is a multiprocessor

module, available in various sizes, and having highly reliable $n + k$ processor sparing arrangements. The switched-services module provides call and signal processing for various types of calls, ranging from a single, switched-virtual-circuit to multimedia calls comprised of voice, data, and video segments. It incorporates the functionality of the management module to provide element management for itself and its co-located service node. It connects to a service-management module to facilitate network management. Initially, there is a one-to-one relationship between the switched-services module and a service node in a switched-services network. As the networks become more robust, however, it is expected that the switched-services modules will be "remoted" from the service nodes, controlling several geographically dispersed service nodes. The switched-services module supports a wide variety of standard signaling, which allows interworking with other types of switching and intelligent networks. The signaling access to the switched-services module can be carried within the ATM network or over a separate signaling network, as is the case with today's common-channel signaling. Figure 2 shows how the access node, service node, and service-management module interact with other ATM network functions.

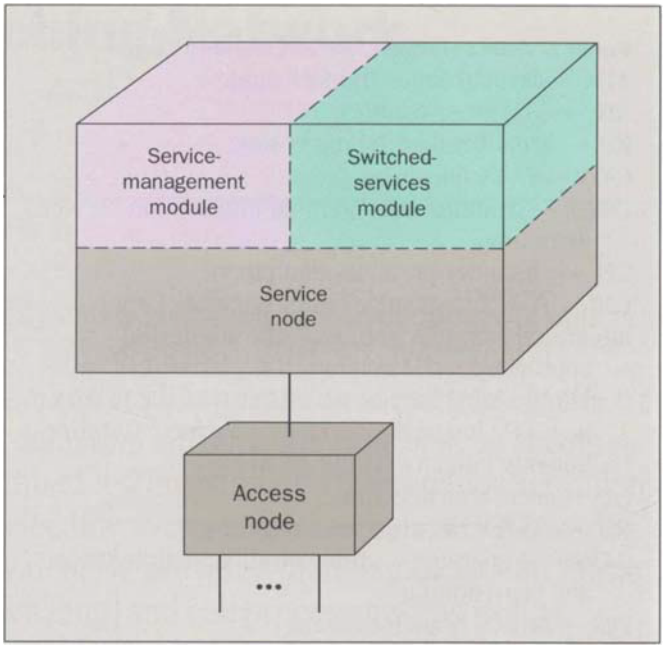

Figure 1. The suggested approach to ATM uses a set of building blocks, referred to as an *integrated services platform*. This illustration shows the four building blocks for introducing new ATM networks. These building blocks can also be used in existing networks to introduce ATM services and to migrate today's separate data, voice, and video networks into a combined, multimedia network.

New ATM Networks

Increasing levels of connectivity and service can be designed into new ATM networks by using the building blocks, interconnected by SONET or SDH transmission media. Access nodes may suffice when used to interconnect the private network of a moderate-size enterprise having dedicated facilities between the nodes carrying all types of traffic within the ATM protocol. The access nodes serve to convert the various protocols of LANs and private-branch-exchange (PBX) voice systems, which are found throughout today's enterprises, to the ATM protocol. The service-management module is added to administer access nodes as network complexity increases. As the network grows, larger enterprises and public carriers, serving a multitude of customers, add the service node and its switching capabilities. At this point, large WAN and local public carriers can use provisioned ATM networks to serve their end-users and customers.

A network of several service nodes is the next evolutionary step. These nodes have many subtending access nodes and supply network-wide management by means of the service-management module, providing national and international provisioned-network services.

The final step in this evolution is the addition of switched services to a network, with placement of the switched-services module at one or several service nodes. Each network upgrade in functionality and service is done without the wholesale change-out of the existing ATM network, thus preserving initial investments in ATM networks. New ATM networks—beginning at any level of functionality and service—can be built and then added to, as needed, without expensive change-outs or redesign.

These same ATM building blocks can be used to augment existing networks. Augmentation is accomplished either by adding lower cost, more flexible technology to increase present functionality, or by coupling with the new ATM networks. Such coupling provides multimedia services, and preserves most of the current, embedded base-of-investment in data and voice networks.

Introducing ATM Into Existing Networks

Modern networks can be voice, data, or video centered, private or public, and exist in all sizes and levels of sophistication. A network can be as simple as a LAN or a local CATV network. It can also be as complex as a national public network having global reach, or the international, private network of a large corporation. In contrast, network elements may be simple bridges and multiplexers, routers and digital cross-connects, large

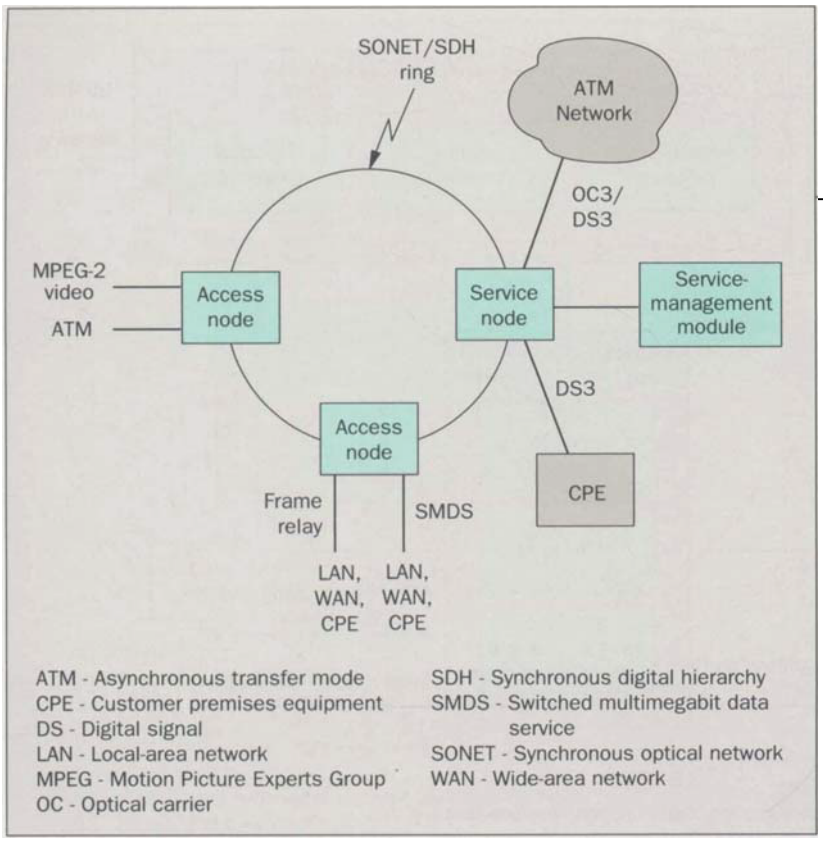

Figure 2. This diagram exemplifies a network of complete, permanent-virtual-circuit functionality using the three initial building blocks of the access node, service node, and service-management module.

and sophisticated digital-stored-program PBXs, or even switching exchanges.

A network can be viewed as a layered hierarchy of transport, routers, or digital cross-connects, and data or circuit switches with attendant signaling. The simpler networks provide dedicated point-to-point connections, as found between two computation centers within the same enterprise. Administrators of larger networks find it advantageous, from a cost viewpoint, to add bridges and multiplexers for the purpose of providing multiple access of varying types to scarce transmission resources. Routers and cross-connects are used to provide flexible access to various end-points by means of some provisioned addressing schema and topology. Finally, real-time switching—directed by signaling from the CPE or network servers—is used to provide universal connectivity, across the network domain, and full utilization of scarce resources during busy hours. An administrative layer is always present in some form, and cannot be ignored in any network.

Several techniques lend themselves to introducing ATM in current networks. Some are driven by the cost advantages and savings of ATM networks deployed with combined data, voice, and video capabilities. Others are induced by the additional revenue expected from the multimedia services an ATM-based data, voice, and video network can provide. These techniques include adding interfaces between current protocols and the evolving ATM world. They include the embedding of cost-effective ATM technology in today's network elements, in anticipation of merging current networks with ATM networks to form the multimedia-capable networks of tomorrow. Video protocols, such as MPEG-2, can be embedded in the ATM protocol. Digitally encoded voice can be "packed" into the ATM cells over provisioned ATM virtual paths, in order to ensure that voice-delay criteria are met and that the cells of the ATM network are used efficiently. ATM cell protocol becomes the cost-effective, universal protocol for carrying various types of services between end-points. This preserves the investment in equipment at the end-points, and allows for combined and simplified operations, administration, maintenance, and provisioning (OAM&P) of several disjointed networks into one homogeneous, universal approach based on ATM.

Once the many protocol conversion techniques—used to change current protocols into the universal, cell-based ATM protocol—are understood at various levels of the protocol stack, elements of modern networks can be replaced with ATM-based elements. Or, as an alternative, subportions of today's networks can be replaced or augmented by ATM technology.

Several current network elements can deploy—or have begun deploying—ATM technology, thus migrating toward full ATM-based networks. The access node was mentioned earlier as a converter of current protocols to ATM and back. Its predecessors—multiplexers and bridges—can have synchronous-transfer-mode (STM) to asynchronous-transfer-mode (ATM) conversion added to their interfaces. Then—as ATM backbone networks are added—current multiplexers can be used, with minor changes, to interface to the evolving ATM networks. In data networks, the same can be accomplished with current routers and data switches, so they become edge vehicles for the emerging ATM networks.

Digital cross-connects are currently ubiquitous in the backbones of public networks and large, private networks. In many cases, additional center stages of switch-

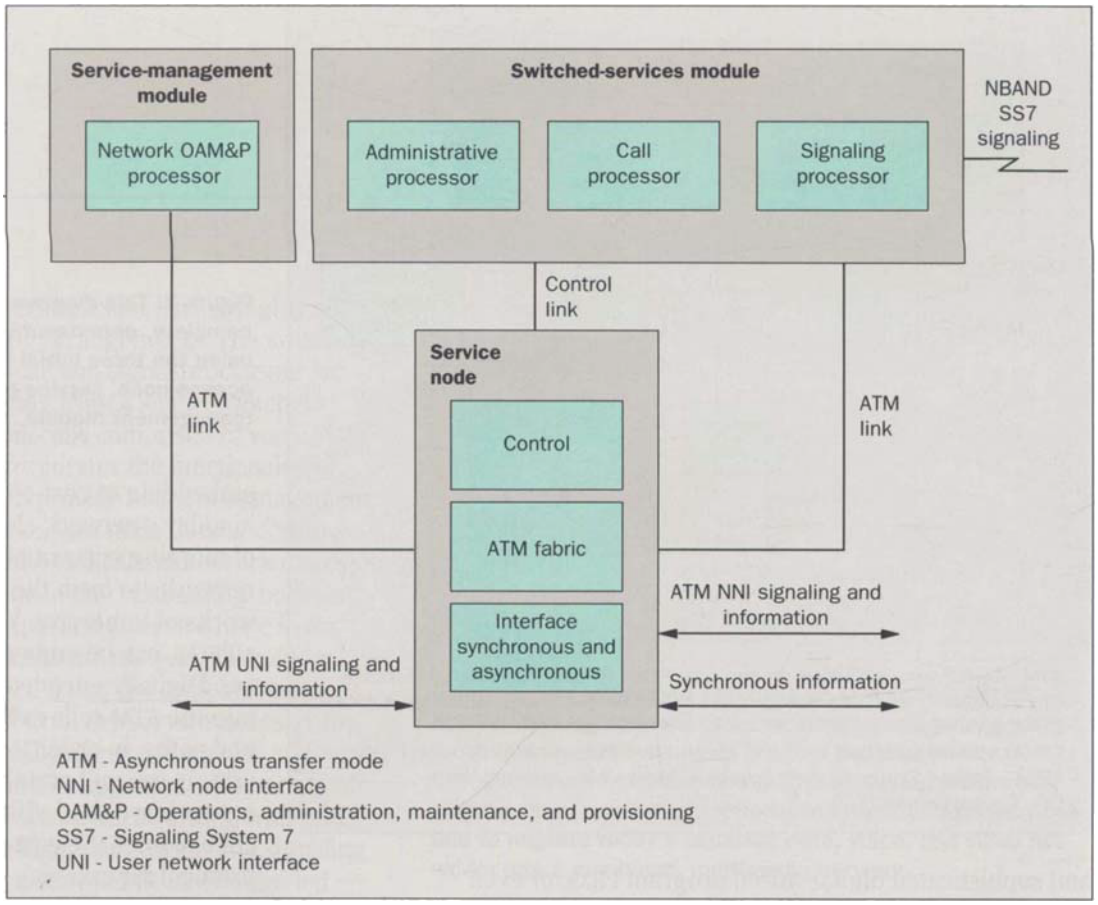

Figure 3. The switched-services module can be added to the ATM cross-connect (AXC) or GCNS. These combinations are called the GlobeView-2000 Broadband Switching System (BSS), which allows switched services to be added to the current AXC and GCNS, while protecting customers' initial investments in their ATM networks. The drawing shows a GCNS that was upgraded from a permanent-virtual-circuit switch to the BSS configuration.

ing are needed to accommodate the growth of these large networks. ATM switches, such as the service node with STM-to-ATM protocol conversion in their line cards and digital-voice-encoding packed cell-relay capabilities, can provide for this need. These switches can also position the current, large STM-based networks for inclusion in emerging ATM networks and STM-to-ATM based services.

In narrowband stored-program digital switches, the central stage of switching is a relatively inexpensive portion of the switch. This portion can be cost effectively replaced by an ATM switch—similar to the service node—by using the same digital-voice-encoding packed cell-relay techniques as used for cross-connects. The large expense of the embedded base of narrowband voice switches, which is primarily in the narrowband line units and application software, is preserved. As a result, narrowband and broadband interworking can be performed through the new ATM center stage. Such interworking can be illustrated with the AT&T 5ESS® switch, where most of the cost and functionality are distributed in the switch modules, which contain the line units and most of the application software. The switch modules are linked—often remotely—to the center stage of switching, the communications module, and to an administrative module. The software associated with the administration module can be preserved by porting it to a duplicate pair of single-board processors of the switched-services module. The majority of the embedded base can also be preserved, because most of the cost of an embedded 5ESS switch is in the switch modules and administrative-module software.

ATM transport and switching should be considered as cost-effective alternatives in all portions of existing networks—for example, as the protocol used between cell sites and the central-office switches of cellular telephone systems. Currently, these are point-to-point connections. As cellular telephone systems expand, however, flexibly provisioned interconnecting networks will need to be placed between the cell sites and central switches. The use of a cost-effective ATM cell protocol in this present, unique point-to-point application allows for its inclusion in the backbone ATM networks as they are deployed.

ATM Networks of Today

The ATM building blocks are being used to introduce ATM networks and technology, as AT&T NSG GlobeView-2000 Broadband System products, throughout the world. In Europe, the service node and service-management module are combined as the AT&T GlobeView-2000 Broadband System AXC (ATM cross-connect). It is being used in the Netherlands, Spain, Sweden, and the United Kingdom for the Pan-European

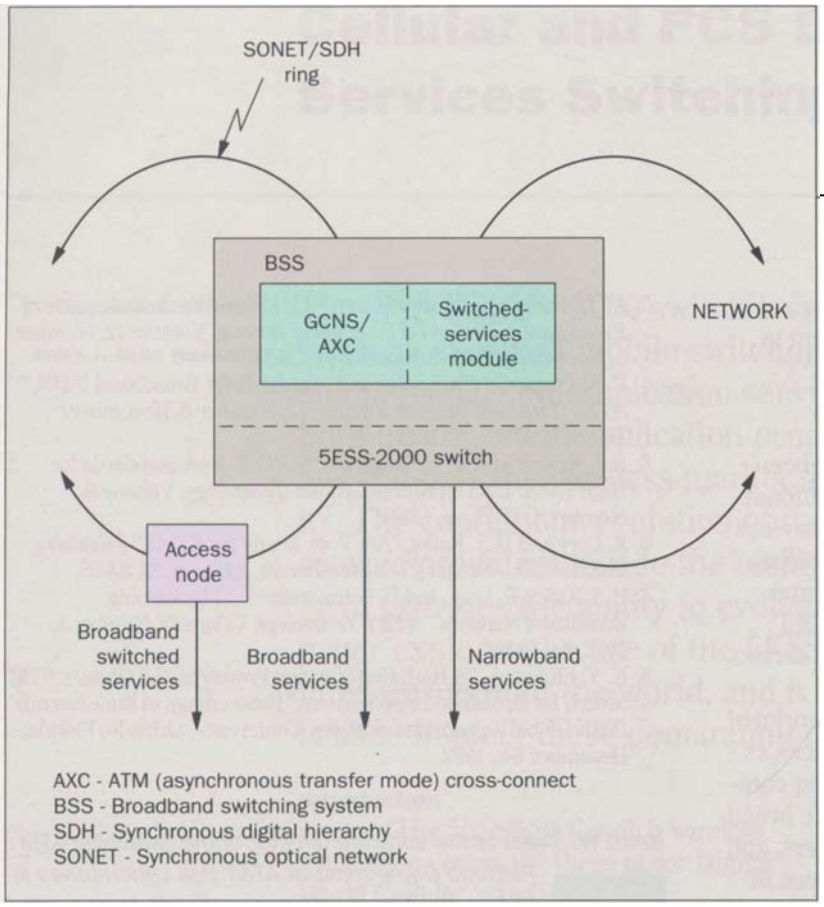

Figure 4. Through the economical growth and extension of new and embedded networks, an ATM-based, multimedia switched network can serve both broadband and narrowband customers, while a significant retention in investment going forward is achieved.

Network, which is becoming a universal, high-speed backbone network (information superhighway) throughout Europe. The GlobeView-2000 Broadband System AXC is also serving as a model for national pilot projects. Initial applications of the system are for high-speed data transmission and multimedia services.

In all other countries, the same service node and service-management module are being sold as the GlobeView-2000 Broadband System GCNS ATM provisioned switch, which is applicable to several different types of networks. Large, 20-Gbits/s GCNS switches are being used by CATV providers, including Time-Warner and VIACOM, to serve as ATM switching hubs between several servers and the distribution system that carries ATM out to the curb. Within the switch, various types of traffic are handled, including MPEG-2 video, as well as signals to and from the servers, customers' desk-top boxes, and other CPE. The various servers are capable of providing all types and combinations of voice, data, and video services. Regional telephone operating companies and inter-exchange carriers are using the GCNS in private networks for their large customers and in the backbone, provisioned networks of their rapidly expanding data networks. These networks include direct ATM access to large customers who are acquiring ATM interfaces for their CPE equipment. International carriers, such as Japan's KDD and the AT&T International Operations Division, are using the GCNS to access the costly undersea cable systems for data and voice transmission more efficiently.

Evolution of ATM Networks

As shown in Figure 3, switched-services modules can be added to the AXC or GCNS. These combinations are called the GlobeView-2000 Broadband Switching System (BSS). It allows switched services to be added to the current AXC and GCNS, while protecting customers' initial investments in ATM networks. The provisioning function, already in place with the AXC or GCNS, is used to set up internode, common-channel signaling. The function also provides provisioned signaling paths from the CPE, through intervening access nodes and the service node, to the attendant switched-services module. Thus, separate signaling networks and new line cards are not required to upgrade to a switched-services network capable of carrying voice, data, and video. OAM&P for switched services is a natural extension of the functionality already existing in the AXC and GCNS. Management-module functionality is absorbed into the switched-services module, and the services-management module serves a combination of AXCs or GCNSs and BSSs in a network, which handles both provisioned and switched services. Additional administrative functionality is added as needed. This functionality includes billing services as an augmentation of the extensive real-time measurements collected in the AXC and GCNS configurations.

The BSS, with an expandable array of call, administrative, and signaling processors in the switched-services module, has the ability to introduce increasing levels of functionality into the emerging multimedia networks. As shown in Figure 4, the embedded base of narrowband AT&T 5ESS switches can be joined with the BSS, continuing to provide narrowband services to today's customers, while serving as a gateway to broadband services.

Thus, narrowband customers are introduced to broadband services, while preserving today's investment in narrowband technology.

Network Services Trends to ATM

ATM-based network technology has long been proposed, and today some key services are operational. A good example is the AT&T Communications Services Group (CSG) InterSpan services network, which offers end-to-end ATM services and ATM to frame-relay interworking. These services are facilitated by the AT&T GlobeView-2000 Broadband System GCNS, which serves as the ATM switch.

Some of the initial, provisioned ATM networks of today will be adding switched-virtual-circuit services as early as 1995. Several regional telephone operating companies have announced ambitious plans to provide broadband access to their current narrowband customers, and they have selected ATM networks to deliver services to and from the last few hundred feet to the home.

Summary

Today, just about every U. S. private-enterprise service provider, regional operating company, CATV operator, international interchange carrier, and European postal telegraph and telephone (PTT) company is modifying existing networks, or is building new ATM-based networks, or both—in order to incorporate ATM-based functionality. ATM has become the underlying technology and network protocol of choice in progressing to ubiquitous, universal, multimedia service offerings. The building-block concept, embraced by AT&T Network Systems' GlobeView-2000 Broadband System products, is a prime force in advancing broadband multimedia technology. A complete set of switched services is rapidly becoming available to business and residential users worldwide, through a host of traditional and new service providers.

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