The Leading Edge in High-Speed Data Communications Services: The InterSpan® Asynchronous Transfer Mode Service

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The emergence of new high-speed client/server and multimedia applications demands a new generation of computer communications services. The InterSpan® Asynchronous Transfer Mode (ATM) Service, first introduced in May 1994, is a highly reliable, low-cost, shared transport service for these and other applications. Using the ATM interface protocol, the service provides multiple grades of service over a wide range of transmission speeds (currently up to 45 Mb/s), ensuring a smooth evolution to the future. The service has three main features that differentiate it from the competition: the ReliaBURST℠ traffic management method, which improves data transfer performance; an industry-leading Customer Network Management System, which lets customers "see" their portion of the shared network; and a frame relay-to-ATM protocol conversion service, which makes the evolution to ATM easier by protecting the investment of customers currently using the InterSpan Frame Relay Service. The service development plan has a rich set of additional features, including higher speeds, switched virtual circuits for high-capacity bandwidth on demand, and globalization.

Introduction

The advent of asynchronous transfer mode (ATM) switching is about to revolutionize the data and voice communications networks of the Fortune 500 companies. ATM transports voice, video, and data in small fixed-size cells over both local and wide area networks, promising to integrate switching and transport for these applications onto a single platform. This paper discusses why ATM is receiving considerable interest from all segments of the communications industry and, in particular, how AT&T has applied this technology to its InterSpan® ATM Service.

Today's data, voice, and video applications are supported separately on different types of network technology. Emerging multimedia applications, however, are not optimally supported on any of these separate networks. Separate staffs are required to operate these networks, limiting the economies of scale and increasing costs.

Initially, ATM technology promises to support emerging multimedia applications by offering multiple classes of service. In the next few years, ATM technology will be used to integrate disparate networks onto a single communication infrastructure, both on customers' premises and in the wide area network. In fact, many Fortune 500 companies are developing multimedia applications and conducting trials of ATM to take full advantage of this technology.[1] Figure 1 illustrates an eventual integrated communication infrastructure based on the ATM technology, supporting both existing and new multimedia applications.

This vision of an integrated architecture is generating considerable interest in the communications industry because of several key benefits:
- A combination circuit and packet technology based on switching fixed-sized informa-

Panel 1. Abbreviations, Acronyms, and Terms

AAL—ATM adaptation layer, which maps the large variety of upper-layer protocols onto the ATM cells

ABR—available bit rate

API—application programmer interface

ATM—asynchronous transfer mode

B-ICI—broadband interexchange carrier interface

BPX—broadband packet exchange

CBR—constant bit rate

CBS—committed burst size

CLI—command line interface

CLP—cell loss priority

CNM—Customer Network Management

DSU—digital service unit

EFCI—explicit forward congestion indicator

FTP—file transfer protocol

IP—Internet protocol

IPX—integrated packet exchange

ISDN—integrated services digital network

ITU-T—International Telecommunications Union, the body that sets international telephony standards. The ITU Telecommunications Standardization Sector (ITU-T) is the portion of the ITU that has jurisdiction over speech coding standards. It was formerly known as the CCITT.

LAN—local area network

MIB—management information base, which defines the network management objectives and variables supported by the SNMP agent.

NOC—Network Operations Center

NNI—network-to-network interface

PBX—private branch exchange

PCR—peak cell rate

PLCP—physical layer convergence sublayer, which defines how the fixed-size ATM cells map onto the various physical transmission standards available to the ATM layer.

P-NNI—private network-to-network interface

PVC—permanent virtual connection

SCR—sustained cell rate

SMDS—Switched Multimegabit Data Service

SMM—Service Management Module

SNMP—Simple Network Management Protocol

SONET—synchronous optical network

SQL—structured query language

SVC—switched virtual circuit

TCP—transmission control protocol

UNI—user-to-network interface

VBR—variable bit rate

WAN—wide area network

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tion units (as in circuit technology) that carry headers identifying their contents (as in packet technology);

- Statistical multiplexing of delay-insensitive traffic, such as typical data applications, and circuit-like switching of delay-sensitive traffic, such as voice and video, on a common platform;
- Complete flexibility in information transfer rates, unlike today's circuit-based networks, in which service rates such as DS-1, DS-3, D, B, H1, and H2 are rigidly defined;
- An architecture with scalable support for high-speed transport into the Gb/s range, capable of extensive wide area network (WAN) and local area network (LAN) capabilities; and
- An integration of the best networking capabilities, from voice and data networks through a blending of ideas in the numerous standards organizations defin-

ing ATM networking and internetworking.

Clearly, the challenge to the communications industry as a whole is to define a robust, usable ATM technology, building the appropriate products and services to meet growing customer needs and expectations. AT&T is actively deploying its public ATM service. The section that follows gives a brief overview of ATM standards' activities. The rest of this paper addresses AT&T's plans for deploying and evolving its public ATM service to meet the needs and expectations of its growing customer base.

ATM Technology and Standards

During the early development of ATM, the critical decision was to base the transport on a fixed-sized packet format, called the ATM cell. The fixed size (a 5-
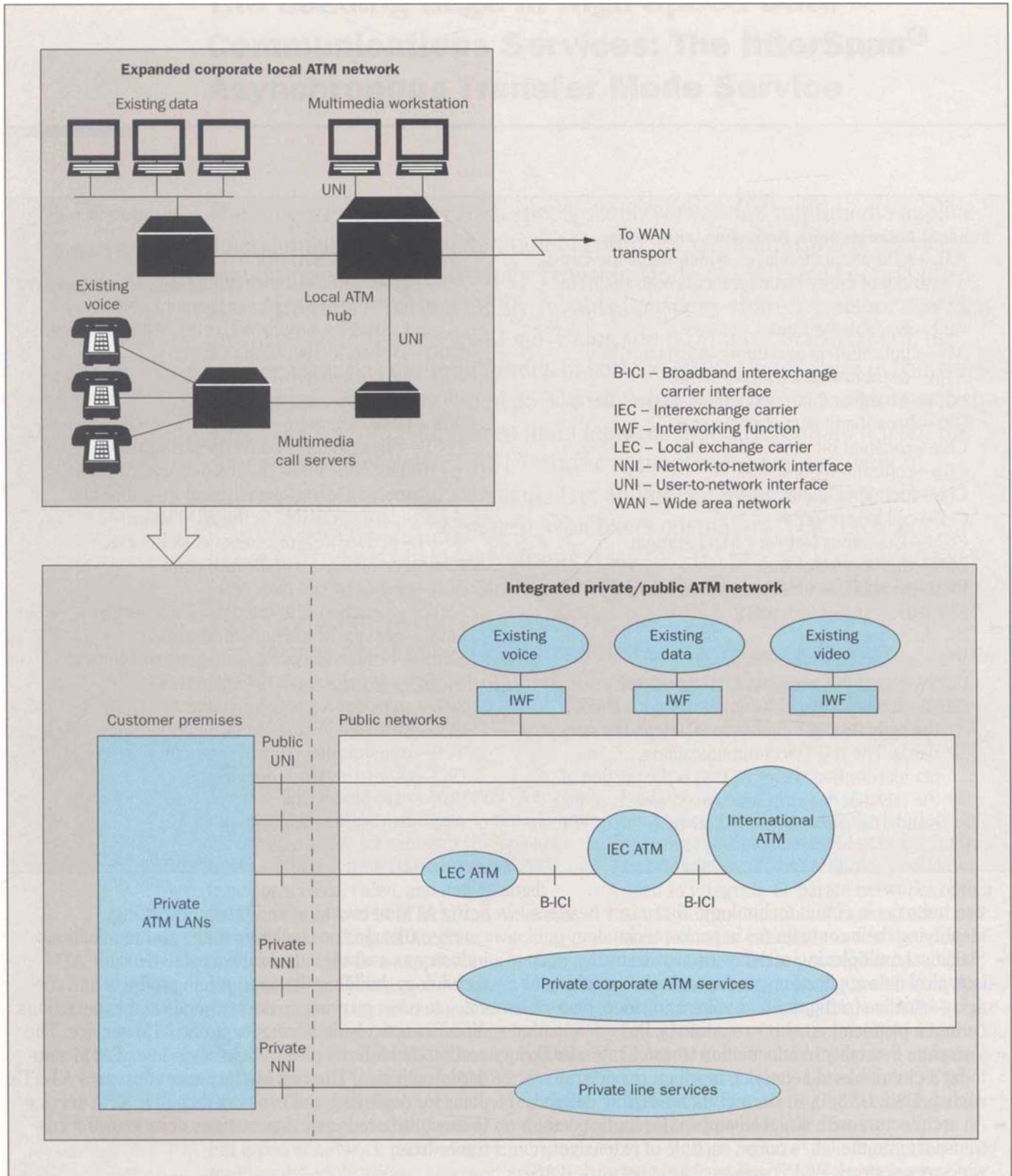
Expanded corporate local ATM network

Existing data

Multimedia workstation

UNI

To WAN transport

Existing voice

Local ATM hub

UNI

Multimedia call servers

B-ICI – Broadband interexchange
        carrier interface
IEC – Interexchange carrier
IWF – Interworking function
LEC – Local exchange carrier
NNI – Network-to-network interface
UNI – User-to-network interface
WAN – Wide area network

Integrated private/public ATM network

Existing voice

Existing data

Existing video

IWF

IWF

IWF

Customer premises

Public networks

Public UNI

Private ATM LANs

International ATM

IEC ATM

LEC ATM

B-ICI

B-ICI

Private NNI

Private corporate ATM services

Private NNI

Private line services

Figure 1. An ATM network infrastructure showing integration of private, local, interexchange, and international ATM services.

octet header with a 48-octet payload) allows conceptually simple algorithms to support isochronous, constant bit rate (CBR) services. The packet format, consisting of a cell header and a cell payload, allows for statistically multiplexing the information that supports variable bit rate (VBR) services. This single decision has been the central reason that the communications industry is now driving ATM technology and standards development at a rapid pace. Initially, ATM was a way of extending narrowband integrated services digital network (ISDN) services to higher rates—hence the term broadband ISDN. However, interest is no longer confined to the realm of traditional voice-service providers. Equipment manufacturers across the entire industry are developing ATM interfaces for their products, including workstations, PC and host computers, high-speed LANs, private branch exchanges (PBXs), digital service units (DSUs), routers, multiplexers, and ATM switches for private and public networks. Many now view ATM as the technology that will network high-speed applications—including multimedia—into the 21st century.

Because of the broad support for this single networking technology, all segments of the communications industry—voice, video, and packet networking—are working together to develop standards for ATM. The ATM Forum, a group of companies cooperating in the development of ATM implementation agreements, is rapidly defining many new capabilities based on ATM. Within the last several years, this organization has defined:

- New, low-cost, physical layer ATM interfaces for LAN environments,
- An interface management protocol, called Interim Link Management Interface, based on Simple Network Management Protocol (SNMP) message sets,
- The beginnings of an Internet-style routing protocol for complex ATM network topologies, called the private network-to-network interfaces (P-NNI) routing protocol, and
- A LAN emulation protocol to support the interworking between ATM devices and IEEE 802-style LANs.

This organization is also defining implementation agreements for:

- Switched virtual circuit (SVC) connections for both user-to-network interfaces (UNIs), P-NNIs, and broadband interexchange carrier interfaces (B-ICIs),
- Interworking between other communication proto-

cols, such as Switched Multimegabit Data Service (SMDS), a connectionless service developed by Bell Communication Research (Bellcore), and frame relay, a lower-speed, variable-length packet protocol,
- An ATM application programmer interface (API), and
- An end-to-end network management architecture extending from private networks to public, multicarrier networks.

In addition to defining the ATM-layer standards, which cover the precise structure of the ATM cell and the basic cell-based transport and multiplexing capability, the ATM standards bodies have also defined adaptation standards for the layers above and below the ATM layer. For instance, looking downward, the *physical layer convergence sublayer (PLCP)* defines how the fixed-size ATM cells map onto the various physical transmission standards available to the ATM layer. These range from DS1 (1.544 Mb/s) to STS-12c (622 Mb/s) signals. Above the ATM layer, the *ATM adaptation layers (AALs)* map the large variety of upper-layer protocols onto the ATM cells. Typically, the AAL protocols convert variable-sized data packets into cells (called segmentation and reassembly), detect and correct errors, and ensure proper cell sequencing. Reference 2 gives an overview of the ATM standards.

The InterSpan ATM Service. The emerging ATM technology has great promise, but making that promise meet real customer needs is a major challenge to AT&T and the entire industry. The InterSpan ATM Service addresses the challenge by focusing on three major areas: implementation of a shared public network, enabling interworking and smooth evolution, and provision of industry-leading reliability, performance, and traffic management.

Applying the ATM technology to creating a public network infrastructure benefits the customer by increasing economies of scale in the public network, and reducing or capping operations costs and staff expertise. Two capabilities allow customers to capitalize on the shared network infrastructure: the customer-focused support program and the Customer Network Management System. First, the *customer-focused support program* ensures the highest-quality customer care. The processes, automated systems, and quality programs in place to support provisioning, maintenance, performance management, and billing for the ATM service are
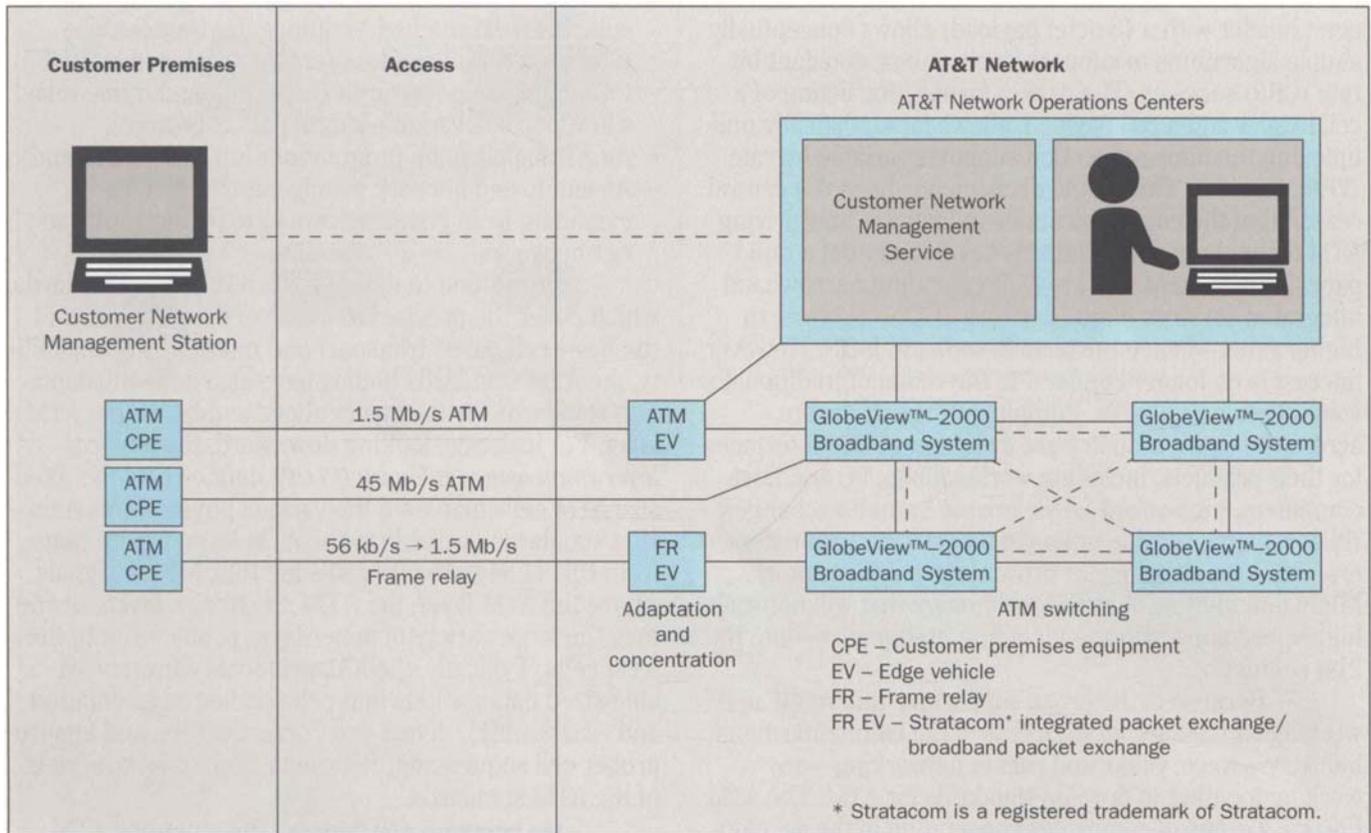
Customer Premises	Access	AT&T Network

Customer Network Management Station

ATM CPE — 1.5 Mb/s ATM — ATM EV

ATM CPE — 45 Mb/s ATM

ATM CPE — 56 kb/s → 1.5 Mb/s Frame relay — FR EV

AT&T Network Operations Centers

Customer Network Management Service

GlobeView™-2000 Broadband System — GlobeView™-2000 Broadband System

GlobeView™-2000 Broadband System — GlobeView™-2000 Broadband System

Adaptation and concentration

ATM switching

CPE – Customer premises equipment
EV – Edge vehicle
FR – Frame relay
FR EV – Stratacom* integrated packet exchange/ broadband packet exchange

* Stratacom is a registered trademark of Stratacom.

Figure 2. InterSpan ATM Service network architecture.

extensive and complex. Second, the *Customer Network Management System* gives customers the visibility of a private network on a public network infrastructure.

With the introduction of any new technology, the service provider must consider how customers will evolve from their current environment to a new one. The InterSpan ATM Service emphasizes *interworking* between ATM endpoints and other InterSpan services, such as Frame Relay Service. Customers can change their environment at their own pace, and only for those locations in which ATM provides the best fit.

To ensure that customers receive industry-leading reliability, performance, and traffic management, the InterSpan ATM Service offers the ReliaBURST℠ system, a feature that manages bursty traffic. Other sophisticated capacity management tools within the service also ensure that it meets performance objectives.

The next four sections describe the InterSpan ATM Service in more detail.

Service Architecture. Figure 2 shows the service architecture of the ATM network. Starting on the customer's premises, a dedicated private line connects ATM-compatible equipment to the nearest of more than 300 of AT&T's ATM points of presence. Two functional layers of ATM products provide the service within the AT&T network. The core layer is a high-capacity, reliable, low-cost ATM switching infrastructure based on AT&T Network Systems' GlobeView™-2000 ATM switch.[3] These switches, deployed throughout the U. S., are connected with DS-3 (45 Mb/s) trunks, with higher speeds in the planning stages. Specialized software in the switches automatically reroutes all connections around a failed switch or trunk.

Surrounding the ATM switching layer are *edge vehicles*, which multiplex low-speed (for example, DS-1) ATM interfaces onto higher-speed ATM interfaces and perform all adaptation functions, such as frame relay-to-

ATM interworking. Because the functions are so diverse and specialized, this layer uses a variety of products. The InterSpan Frame Relay Service currently uses the Stratacom* Integrated Packet Exchange (IPX) and Broadband Packet Exchange (BPX) as the service vehicles, so they reside at this layer for frame relay-to-ATM connections. As other adaptation functions are needed, other products will be added to this layer.

Not shown in Figure 1, but underlying this architecture, is the high-speed, fiber optics-based transport network used for all AT&T services. At present, a key feature of this network is Fastar telecommunications services, which provide fast, automatic restoration of service when cable cuts or other transport-layer failures occur. In the future, this transport network will migrate to a synchronous optical network (SONET) ring and ATM technology, which will restore service even faster. This technology transports not only the trunks between switches and edge vehicles, but also the *backhaul*, which brings the customers' access lines from the edge of the AT&T network to the nearest switch.

Transport Services. The network provides two fundamental resources: ports and permanent virtual connections (PVCs), each of which is described below.

The customer access line connects to a dedicated port on a switch. The port speed defines the peak cell rate (PCR) at which the customer equipment can transmit to and receive data from the ATM network over the access line. At present, the service supports 45-Mb/s (DS-3) ports and access lines; recently, a trial of 155-Mb/s (OC-3) interfaces was successfully concluded. Soon, 1.5-Mb/s (DS-1) ports will be added. The protocol interface[4] at each port conforms to the ATM UNI, as specified by the ATM Forum.[5]

PVCs carry traffic between the switch ports. At present, the service supports two classes of service:
- Class A PVCs provide "private line" service—strictly synchronized and guaranteed throughput with nearly constant delay. This service is for real-time applications, such as voice or video conferencing, which require low-delay variation.
- Class C VBR connections provide high throughput in "bursts," with some variation in delay. This service primarily supports LAN-to-LAN connectivity applications, such as file transfers and transmission control protocol/Internet protocol (TCP/IP) sessions.

VBR connections provide a sustained cell rate (SCR) at speeds from 1 to 35 Mb/s. (Lower-speed connections are also supported for connections to the Frame Relay Service.) To accommodate the "bursty" nature of the traffic, VBR connections also guarantee a committed burst size (CBS). Here, starting from an idle state, the customer equipment can send, at the port speed, a burst of data at least equal to CBS. To improve the performance of VBR connections for "bursty" data applications beyond this capability, the service has developed an enhanced traffic management and congestion control feature called the ReliaBURST system.

When the network has extra capacity available, the ReliaBURST system allows users to send data into the network at a rate higher than the SCR (for longer than the CBS). Because the network must provide capacity to meet peak busy-hour demands and reroute connections around failed trunks, which rarely occurs, some capacity is always free, and more is free during off hours. If any congestion exists along the path of each connection, the traffic policing mechanism at the ingress port receives feedback from the network. With this information, the port dynamically adjusts the amount of excess traffic admitted into the network to maintain high performance for all connections. To ensure that each customer has fair access to the available network capacity, and that one customer will not adversely affect another, each switch along the path allocates available capacity in proportion to the SCR of the connection.

The ReliaBURST traffic management scheme for VBR connections operates on the "dual leaky bucket" policing model shown in Figure 3. Two "buckets" provide the mechanism for identifying traffic exceeding the SCR/CBS and for deciding whether the excess traffic should be admitted to the network. Buckets are filled each time a cell is admitted to the network and drained at the rate the network can transport the cells.

For Bucket 1, the first step is to examine the cell loss priority (CLP) bit in the header of the incoming cell. Cells marked by the customer with $CLP=0$ have the highest priority and should conform to the SCR/CBS contract. These cells are offered to the first bucket, which has a fixed size equal to the CBS and drains at the SCR. If the bucket is not full, then the traffic conforms to the SCR/CBS contract, the cell is admitted to the network, and the bucket occupancy is incremented. If the cell
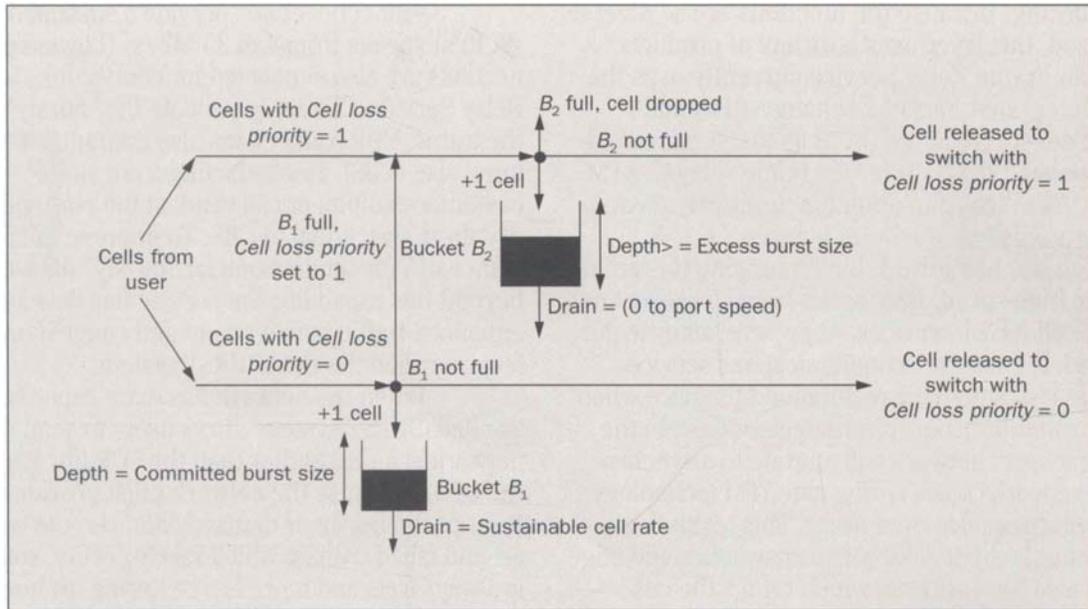
Figure 3. Dual leaky bucket traffic management for the ReliaBURST system.

finds the bucket full, the traffic is "excess," so the CLP bit is set and the cell is forwarded to the second bucket.

All cells marked *CLP*=1 (whether marked by the customer or at the first bucket) are policed by the second bucket. This traffic should only be admitted if the network has enough spare capacity to transport it successfully. Because the network loading is highly dynamic, this bucket is also highly dynamic, with both the drain rate and the bucket capacity controlled by network congestion feedback from the network. It drains at a rate between zero (if there is congestion) and the port speed, which is the PCR that the customer can offer to the network. The size of this bucket expands from the excess burst size as the drain rate expands, allowing larger bursts when the cell rate is high. If this bucket is not full, the capacity in the network is sufficient to carry the cell. The cell is admitted to the network and the bucket occupancy is incremented. If the bucket is full, then the cell is dropped.

The ReliaBURST system is consistent with standards for VBR service, which define the traffic contract in terms of a sustainable cell rate and maximum burst size (equivalent to the CBS above) for guaranteed traffic, and

a peak cell rate constraint for the aggregate traffic (guaranteed and nonguaranteed). As a closed-loop, rate-based scheme, the ReliaBURST system is similar to the available bit rate (ABR) service under development in the ATM Forum. As soon as the ABR protocol is completed and implemented, ReliaBURST ABR service will be introduced to extend the control loop to customer premises equipment. (Reference 6 presents an excellent discussion of ABR standards.)

Frame Relay-to-ATM Interworking. Figure 2 also shows customers accessing the network using the frame relay protocol at speeds between 56 Kb/s and 1.5 Mb/s (DS-1), with interworking between frame relay edge vehicles and ATM switches. This allows customers whose locations require network access bandwidths of DS-3 or greater to work with regional and branch offices that require network access bandwidths at lower speeds. Further, it allows customers to migrate from frame relay to ATM as needed, as their bandwidth requirements increase.

The ITU-T standard I.555 defines two methods of interworking ATM and frame relay endpoints: network interworking and service interworking. *Network interworking* defines the capability of carrying frame relay con-

nections over an ATM connection. *Service interworking* defines a translation between ATM and frame relay connections. Network interworking requires the ATM customer premises equipment to implement a different protocol stack to send data to a frame relay endpoint. However, the functions in the network are relatively simple. Service interworking does not require any specialized processing by the ATM customer premises equipment, but is more complex for the service provider to implement.

Because the network interworking standard was available first, the InterSpan Frame Relay and ATM Services will initially support the network interworking option through gateways between the AT&T Network Systems GlobeView-2000 ATM switch and the Stratacom BPX frame relay switch. Here the BPX maps the frames onto an ATM cell stream, as specified in the standards. The network-to-network interface (NNI) between the BPX and the GlobeView-2000 provides enhanced link management, traffic management, and congestion control over a standard NNI. The ReliaBURST capability operates end-to-end over the connection. Service interworking, recently standardized, will be provided in the future.

Customer Network Management Service. The InterSpan ATM Customer Network Management (CNM) Service provides customers with a management "window" into their portion of the InterSpan ATM network from standards-compliant management stations located on their premises. In the CNM model, the objects the customer can view through this window are the ATM ports and PVCs that provide connectivity between customer sites.

Customer needs for network management span a broad spectrum. In a network service environment, where the service provider is responsible for the overall network management and resolving customer troubles, the customer still needs access to management information from the service provider. At a basic level, customers need real-time access to fault and performance information that allows them to diagnose, isolate, and resolve problems. Among these problems are slow response time and host unreachability. On a longer-term basis, customers need access to processed information to allow them to engineer and plan their networks proactively.

The InterSpan CNM Service combines the use of sophisticated management applications with partitioning and proxy agent capabilities to provide customers with real-time network management and processed reports.

The real-time network management is provided by SNMP, which has become the defacto industry standard for managing a number of premises devices, including bridges, routers, and LAN switches. SNMP has pervaded the customer's management environment, and therefore, including SNMP management for the carrier component of a customer's enterprise network becomes an important requirement. SNMP service provides real-time management support that integrates easily with the customer's premises management infrastructure, thereby facilitating seamless end-to-end management of the customer's enterprise network. The Advanced Reports Service, which gives customers access to processed reports, is supported by the Internet-standard file transfer protocol (FTP). It contains summarized and thresholded information that customers can use to ensure that service ports and PVCs are sized properly and that application parameters are tuned. The InterSpan CNM Service has evolved from its initial support of the frame relay service to additional support of the ATM service on a common architecture and platform.

CNM architecture. The CNM architecture's two main components are the repository of CNM information and the customer premises workstation. The *customer premises workstation* initiates requests for transferring management information. The Customer Network Management System and database, henceforth referred to as the *CNM server*, resides in the InterSpan ATM Service Network Operations Center (NOC), as shown in Figure 2. The customer's applications access the CNM server through an in-band PVC established between the customer location and the NOC. The CNM server resides on a Sun SparcCenter* 2000 hardware platform and supports:

- An SNMP agent that supports the Internet-standard Management Information Base (MIB) II and the specific InterSpan ATM Service MIB. These MIBs provide for real-time access to alarm, performance, and configuration information;
- A relational database that stores customer profile information, network topology and configuration information, and processed historical measurements; and
- FTP access to processed management reports stored in a partitioned file system on a per-customer basis.

Partitioning ensures privacy by allowing individual customers to view management information on
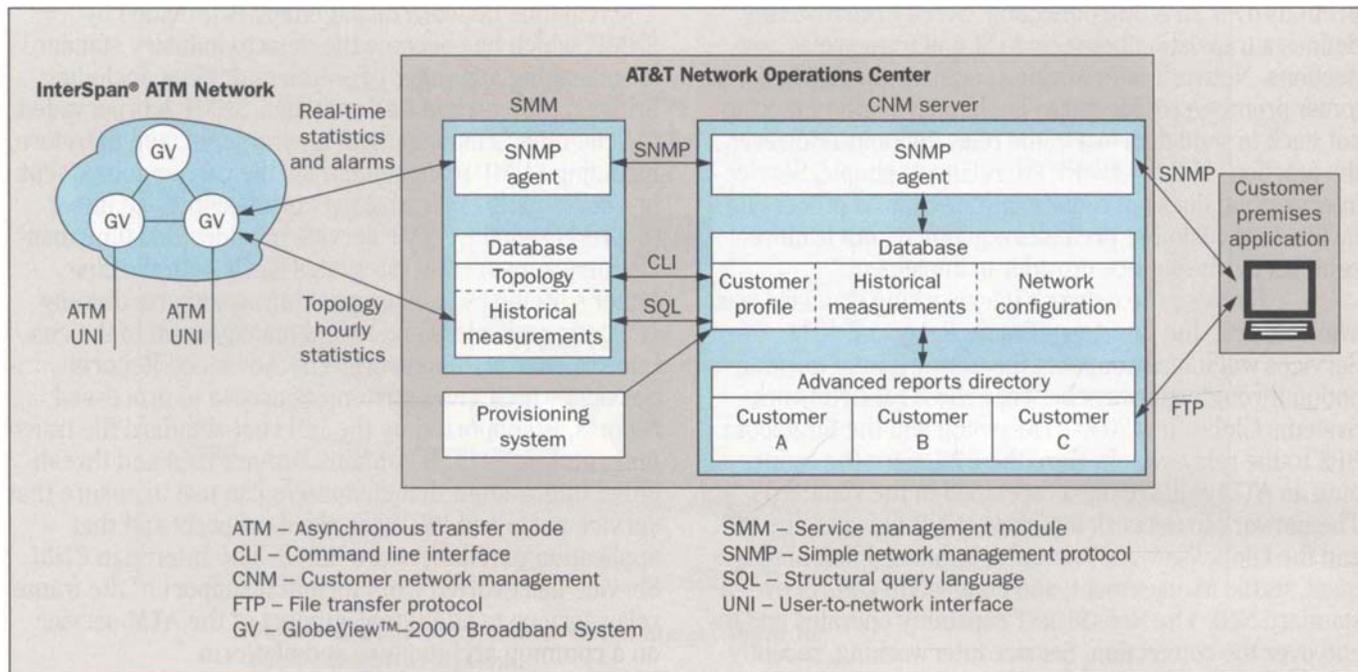
Figure 4. CNM functional architecture.

ATM – Asynchronous transfer mode
CLI – Command line interface
CNM – Customer network management
FTP – File transfer protocol
GV – GlobeView™–2000 Broadband System

SMM – Service management module
SNMP – Simple network management protocol
SQL – Structural query language
UNI – User-to-network interface

their portion of the InterSpan ATM network only. The InterSpan provisioning system periodically sends the CNM server customer-level partitioning information, which provides the mapping between customer-owned logical ports and the physical ports in the ATM network.

The back end of the CNM server interfaces with the Service Management Module (SMM), which is the element management system for the GlobeView-2000-based ATM network (see Figure 4). The SMM supports three different interfaces to the CNM server:

– An SNMP interface that allows the SNMP agent in the CNM server to receive traps, real-time performance, and configuration information requested by customers using the SNMP service,

– A command line interface (CLI) for extracting network-wide topology information used by the Advanced Reports application, and

– A structured query language (SQL)-based database interface for retrieving historical measurements—used by the Advanced Reports application—from the SMM database.

SNMP service. SNMP access allows customers to interactively monitor information useful for day-to-day problem management. The SNMP service supports two MIB modules: MIB-II and the InterSpan ATM Service MIB. The InterSpan ATM Service MIB provides customers with management information unique to their use of the InterSpan ATM Service. The MIB-II module only supports the system, interfaces, and snmp groups. The InterSpan ATM Service MIB defines five groups: the Administrative group, the Port Configuration group, the Port Performance group, the PVC Configuration group, and the PVC Performance group.

The *Administrative* group provides static information, such as the number of ports and PVCs owned by the customer. The *Port Configuration* group contains configuration information on customer ports. This includes port speed, type, and location, as well as the number of configured PVCs. The *Port Performance* group also provides information such as cells received and transmitted, cells discarded because of policing violations, and cells discarded because of errors.

The *PVC Configuration* group contains configuration information on customer PVCs, including bandwidth

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parameters such as SCR and PCR, classes of service such as CBR or VBR, and the operational status. The *PVC Performance* group contains information about cells received and transmitted with cell loss priority $CLP=0$ and $CLP=1$, cells marked owing to SCR violation, cells dropped owing to PCR violation, and cells transmitted with the explicit forward congestion indicator (EFCI) bit set.

In addition to the above information, which the customer can request, the service also transmits asynchronous events called *traps* to alert the customer about port and PVC up/down status changes.

Advanced reports service. Information in the Advanced Reports Service allows the customer to engineer port and PVC bandwidth accurately. On an hourly basis, the Customer Network Management System extracts traffic and performance measurements from the SMM, which include hourly averages, as well as 5-minute peaks. The CNM server processes these measurements to compute statistics meaningful to customers. Weekly and monthly reports are produced from these processed measurements and placed in customer-specific FTP-accessible directories.

The PVC reports contain information on utilization and cell discards, and port reports list utilization and errored cells. A network configuration report is also produced.

The system generates four types of reports: Summary, Exception, Profile, and Distribution. The Summary and Exception reports are ASCII reports in a table format, while the Profile and Distribution reports are graphical reports produced in a PostScript* format.

The *Summary* report shows the average and worst-case information for each port or PVC. It also flags those objects for which the reported metric (such as utilization and discards) has exceeded the engineering threshold for acceptable performance. The *Exception* report contains more detailed information on objects that have exceeded the engineered thresholds, including the number of times and the hours during which the thresholds were exceeded. This information is useful to gauge the severity of the exception condition and to assess whether any immediate action is required.

The Profile and Distribution reports are produced for port and PVC utilization. The *Profile* report shows the hourly minimum, average, maximum, and the 5-minute peak information for each of the 24 hours aggregated over

the weekly or monthly period. This report helps customers understand the traffic variability and busy-hour usage patterns. The *Distribution* report provides a complete statistical distribution of the hourly and peak 5-minute utilization samples over the weekly or monthly period. It contains the most detailed information on the overall usage and the frequency of engineered threshold crossings.

Using the combined information in these reports, customers can determine usage trends, identify possible areas of overuse or underuse, resize the PVC traffic parameters, and optimize port capacity.

Premises applications support. The InterSpan CNM Service supports open, standards-based access. The InterSpan ATM MIB can be compiled on any standards-compliant SNMP management station from which customers can poll for information. Similarly, the advanced reports can be accessed from any UNIX* workstation that supports FTP. In addition, premises applications for using both the SNMP and Advanced Reports Services are provided on the SunNet* Manager platform. These graphical user interface-based applications are designed to make the CNM service easy to use. The SNMP application has a novel AutoConfigure feature, which allows customers to dynamically build a graphical image of their network topology. It also includes support for graphical display of port and PVC object status information. The FTP application allows customers to download selected reports automatically through point-and-click operations. Both of these applications will be supported on AT&T's OneVision™ platform in the near future.

Future Features

This paper describes many future capabilities; others are in the planning stage, including:

- Switched virtual circuits (SVCs). Today's virtual connections are "permanent," in that the customer must order them and only the NOC can establish them. In the future, SVCs will allow connection set-up between any ports on the network on demand, using call set-up request messages. This capability not only allows economical any-to-any connectivity between a larger number of locations, but also enables a new generation of high-speed multimedia applications.
- Point-to-multipoint connections. Today, all connections are between only two ports. Standards have

now been defined to allow for multipoint broadcast of information over ATM.

- Bit-stream adaptation. In today's architecture, customer premises equipment adapts non-ATM equipment to ATM protocol. In the future, bit-stream adaptation will be performed in the network. As with frame relay-to-ATM interworking, introducing this capability into the network will allow access for a wider range of customer locations, and provide a smooth evolution to ATM technology.
- Interconnection with other ATM networks. Network-to-network interfaces will allow connections to locations on other networks.
- Customer control. Today's "window" into the network via the CNM Service will, over time, enable the customer to control management operations on connections as well. Capabilities to allow creation and deletion of connections, as well as changes to a connection's grade of service (for example, SCR), are under consideration.
- Global scope. In conjunction with our world-wide partners, AT&T intends to extend the reach of the service to provide a seamless, global service to support the demands of our multinational customers.

Conclusion

The InterSpan ATM Service is only the beginning of AT&T's use of ATM. AT&T and its industry partners share a vision of ATM as the fundamental basis of high-speed, multimedia capabilities for users in both the local and wide area. In fact, AT&T recently announced an extensive set of enhancements to its core network, including SONET transmission equipment and ATM infrastructure for all data services. ATM switching technology, currently supporting AT&T's InterSpan ATM Service, will be expanded to serve as the foundation of this new network infrastructure.

Acknowledgments

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