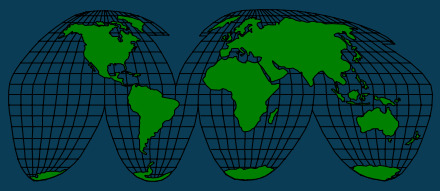


ATM Technology Summary

Akharin Khunkitti

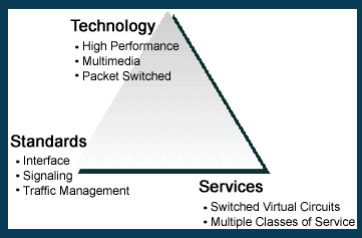
KMITL

Topics

- Introduction
- Benefits of ATM
- ATM Technology
  - ATM Classes of Services
  - ATM Standards
  - ATM LAN Emulation
  - Voice and Video over ATM
  - ATM Traffic Management
- ATM Applications
- The Future and Vision of ATM
- Conclusion

Introduction

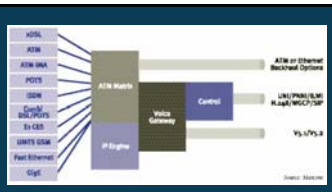
- Changes in the structure of the telecommunications industry and market conditions have brought new opportunities and challenges for network operators and public service providers.
- Networks that have been primarily focused on providing better voice services are evolving to meet new multimedia communications challenges and competitive pressures.
- Services based on asynchronous transfer mode (ATM) and Synchronous Digital Hierarchy (SDH) / Synchronous Optical Network (SONET) architectures provide the flexible infrastructure essential for success in this evolving market



Introduction

- Asynchronous transfer mode (ATM) is a
  - high-performance,
  - cell-oriented switching and
  - multiplexing technology
  - that utilizes fixed-length packets to carry different types of traffic.
- ATM is a technology that will enable carriers to capitalize on a number of revenue opportunities through
  - multiple ATM classes of services;
  - high-speed local-area network (LAN) interconnection;
  - voice, video, and future multimedia applications in business markets in the short term; and
  - in community and residential markets in the longer term.

Definition of ATM



- Asynchronous transfer mode (ATM) is a technology that has its history in the development of broadband ISDN in the 1970s and 1980s.
- Technically, it can be viewed as an evolution of packet switching.
  - Like packet switching for data (e.g., X.25, frame relay, transmission control protocol [TCP]/Internet protocol [IP]),
- ATM integrates the multiplexing and switching functions,
  - is well suited for bursty traffic (in contrast to circuit switching), and
  - allows communications between devices that operate at different speeds.
  - Unlike packet switching, ATM is designed for high-performance multimedia networking.

Definition of ATM

- ATM technology has been implemented in a very broad range of networking devices:
  - PC, workstation, and server network interface cards
  - switched-Ethernet and token-ring workgroup hubs
  - workgroup and campus ATM switches
  - ATM enterprise network switches
  - ATM multiplexers
  - ATM–edge switches
  - ATM–backbone switches

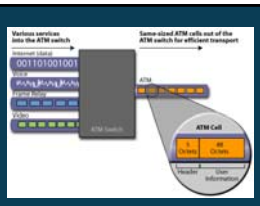
Definition of ATM

- ATM is also a capability that can be offered
  - as an end-user service by service providers (as a basis for tariffed services) or
  - as a networking infrastructure for these and other services.
- The most basic service building block is the ***ATM virtual circuit***, which is an end-to-end connection that has defined end points and routes but does not have bandwidth dedicated to it.
- Bandwidth is allocated on demand by the network as users have traffic to transmit.
- ATM also defines various classes of service to meet a broad range of application needs.

Definition of ATM

- ATM is also a set of international interface and signaling standards defined by the International Telecommunications Union–Telecommunications (ITU–T) Standards Sector (formerly the CCITT).
- The ATM Forum has played a pivotal role in the ATM market since its formulation in 1991.
- The ATM Forum is an international voluntary organization composed of vendors, service providers, research organizations, and users.
- The ATM Forum's purpose is to
  - accelerate the use of ATM products and services through the rapid convergence of interoperability specifications,
  - promotion of industry cooperation, and other activities.
  - Developing multivendor implementation agreements also furthers this goal.

Benefits of ATM

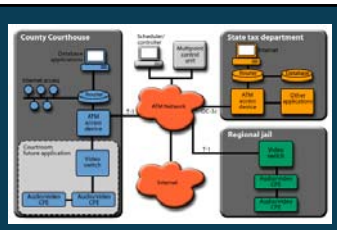


- high performance via hardware switching
  - high performance via hardware switching with terabit switches on the horizon
- dynamic bandwidth for bursty traffic
  - dynamic bandwidth for bursty traffic meeting application needs and delivering high utilization of networking resources; most applications are or can be viewed as inherently bursty; data applications are LAN–based and are very bursty, voice is bursty, as both parties are neither speaking at once nor all the time; video is bursty, as the amount of motion and required resolution varies over time

Benefits of ATM

- class-of-service support for multimedia
  - class-of-service support for multimedia traffic allowing applications with varying throughput and latency requirements to be met on a single network
- scalability in speed and network size
  - scalability in speed and network size supporting link speeds of T1/E1 to OC–12 (622 Mbps) and into the multi–Gbps range;
  - networks that scale to the size of the telephone network (i.e., as required for residential applications) are envisaged

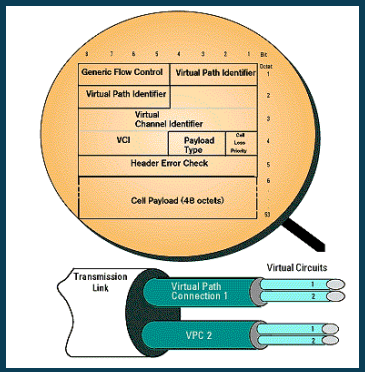
Benefits of ATM



- common LAN/WAN architecture
  - common LAN/WAN architecture allowing ATM to be used consistently from one desktop to another; traditionally, LAN and WAN technologies have been very different, with implications for performance and interoperability
- opportunities for simplification via VC architecture
  - opportunities for simplification via switched VC architecture; this is particularly for LAN–based traffic that today is connectionless in nature; the simplification possible through ATM VCs could be in areas such as billing, traffic management, security, and configuration management
- international standards compliance
  - international standards compliance in central-office and customer-premises environments allowing for multivendor operation

ATM Technology

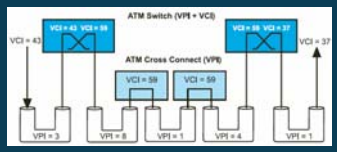
- In ATM networks, all information is formatted into fixed-length cells consisting of 48 bytes (8 bits per byte) of payload and 5 bytes of cell header
- The fixed cell size ensures that time-critical information such as voice or video is not adversely affected by long data frames or packets.
- The header is organized for efficient switching in high-speed hardware implementations and carries payload-type information, virtual-circuit identifiers, and header error check.



ATM Technology

- ATM is connection oriented.
- Organizing different streams of traffic in separate calls
  - allows the user to specify the resources required and
  - allows the network to allocate resources based on these needs.
- Multiplexing multiple streams of traffic on each physical facility
  - (between the end user and the network or between network switches)
  - combined with the ability to send the streams to many different destinations
  - enables cost savings through a reduction in the number of interfaces and facilities required to construct a network.

ATM Technology



- ATM standards defined two types of ATM connections:
  - virtual path connections (VPCs), which contain virtual channel connections (VCCs).
  - A virtual channel connection (or virtual circuit) is the basic unit, which carries a single stream of cells, in order, from user to user.
- A collection of virtual circuits can be bundled together into a virtual path connection.
- A virtual path connection can be created from end-to-end across an ATM network.
  - In this case, the ATM network does not route cells belonging to a particular virtual circuit.
  - All cells belonging to a particular virtual path are routed the same way through the ATM network,
  - thus resulting in faster recovery in case of major failures.

ATM Technology

- An ATM network also uses virtual paths internally for the purpose of bundling virtual circuits together between switches.
- Two ATM switches may have many different virtual channel connections between them, belonging to different users.
- These can be bundled by the two ATM switches into a virtual path connection.
- This can serve the purpose of a virtual trunk between the two switches.
- This virtual trunk can then be handled as a single entity by, perhaps, multiple intermediate virtual path cross connects between the two virtual circuit switches.

ATM Technology

- Virtual circuits can be statically configured as
  - Permanent Virtual Circuits (PVCs) or
  - dynamically controlled via signaling as Switched Virtual Circuits (SVCs).
- They can also be point-to-point or point-to-multipoint, thus providing a rich set of service capabilities.
- SVCs are the preferred mode of operation because they can be dynamically established, thus minimizing reconfiguration complexity.

ATM Classes of Services

- ATM Service Classes

Service Class	*Quality of Service Parameter*
constant bit rate (CBR)	This class is used for emulating circuit switching. The cell rate is constant with time. CBR applications are quite sensitive to cell-delay variation. Examples of applications that can use CBR are telephone traffic (i.e., nx64 kbps), videoconferencing, and television.
variable bit rate–non-real time (VBR–NRT)	This class allows users to send traffic at a rate that varies with time depending on the availability of user information. Statistical multiplexing is provided to make optimum use of network resources. Multimedia e-mail is an example of VBR–NRT.
variable bit rate–real time (VBR–RT)	This class is similar to VBR–NRT but is designed for applications that are sensitive to cell-delay variation. Examples for real-time VBR are voice with speech activity detection (SAD) and interactive compressed video.
available bit rate (ABR)	This class of ATM services provides rate-based flow control and is aimed at data traffic such as file transfer and e-mail. Although the standard does not require the cell transfer delay and cell-loss ratio to be guaranteed or minimized, it is desirable for switches to minimize delay and loss as much as possible. Depending upon the state of congestion in the network, the source is required to control its rate. The users are allowed to declare a minimum cell rate, which is guaranteed to the connection by the network.
unspecified bit rate (UBR)	This class is the catch-all, other class and is widely used today for TCP/IP.

ATM Classes of Services

- ATM Technical Parameters

Technical Parameter	*Definition*
cell loss ratio (CLR)	CLR is the percentage of cells not delivered at their destination because they were lost in the network due to congestion and buffer overflow.
cell transfer delay (CTD)	The delay experienced by a cell between network entry and exit points is called the CTD. It includes propagation delays, queuing delays at various intermediate switches, and service times at queuing points.
cell delay variation (CDV)	CDV is a measure of the variance of the cell transfer delay. High variation implies larger buffering for delay-sensitive traffic such as voice and video.
peak cell rate (PCR)	The maximum cell rate at which the user will transmit. PCR is the inverse of the minimum cell inter-arrival time.
sustained cell rate (SCR)	This is the average rate, as measured over a long interval, in the order of the connection lifetime.
burst tolerance (BT)	This parameter determines the maximum burst that can be sent at the peak rate. This is the bucket-size parameter for the enforcement algorithm that is used to control the traffic entering the network.

ATM Classes of Services

- ATM Classes of Services

Class of Service	*CBR*	*VBR-NRT*	*VBR-RT*	*ABR*	*UBR*
CLR	Yes	Yes	Yes	Yes	No
CTD	Yes	No	Yes	No	No
CDV	Yes	Yes	Yes	No	No
PCR	Yes	Yes	Yes	No	Yes
SCR	No	Yes	Yes	No	No
BT@PCR	No	Yes	Yes	No	No
Flow control	No	No	No	Yes	No

ATM Standards

- The ATM Forum has identified a cohesive set of specifications that provide a stable ATM framework.
- The first and most basic ATM standards are those that provide the end-to-end service definitions.
- An important ATM standard and service concept is that of service interworking between ATM and frame relay (a fast-growing pervasive service),
  - whereby ATM services can be seamlessly extended to lower-speed frame-relay users.
  - Frame relay is a network technology that is also based on virtual circuits using variable-length frame transmission between users.

ATM Standards

- ATM user network interface (ATM UNI) standards specify how a user connects to the ATM network to access these services.
- A number of standards have been defined for
  - T1/E1,
  - 25 Mbps,
  - T3/E3,
  - OC–3 (155 Mbps)
  - OC–12
  - OC–48 (2.4 Gbps)
- OC–3 interfaces have been specified for use
  - over single-mode fiber (for wide-area applications) and
  - over unshielded twisted pair or multimode fiber for lower-cost, in-building applications.

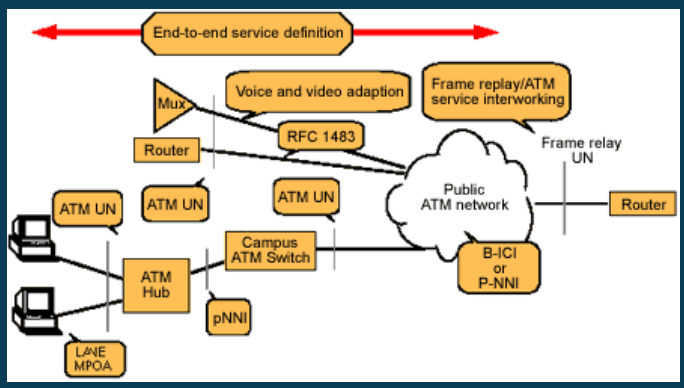
ATM Standards

- The following two ATM networking standards have been defined that provide connectivity between network switches and between networks:
  - broadband intercarrier interface (B–ICI)
  - public network-to-network interface (P–NNI)
- P–NNI is the more feature-rich of the two and supports class of service-sensitive routing and bandwidth reservation

ATM Standards

- All ATM traffic is carried in cells, yet no applications use cells. So, specific ways of putting the data into cells are defined to enable the receiver to reconstruct the original traffic.
- Three important schemes are highlighted
  - RFC1483, which specifies how interrouter traffic is encapsulated into ATM using ATM adaptation Layer 5 (AAL–5); AAL–5 is optimized for handling framed traffic and has similar functionality to that provided by HDLC framing in frame relay, SDLC, and X.25
  - ATM LAN emulation (LANE) and multiprotocol over ATM (MPOA), which are designed to support dynamic use of ATM SVCs primarily for TCP/IP; LANE, which is a current standard that is widely deployed and will be a subset of the MPOA standard (which is targeted for standardization only in mid-1997), will be discussed later in the tutorial
  - voice and video adaptation schemes that can use AAL–1, which is defined for high efficiency—for traffic that itself has no natural breaks, such as a circuit carrying bits at a fixed rate

ATM Standards

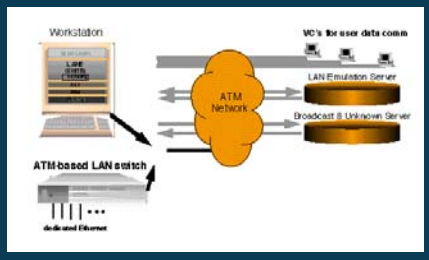


ATM LAN Emulation

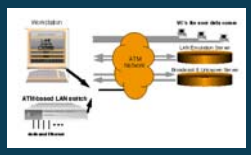
- ATM–based Ethernet switches and ATM workgroup switches are being deployed by end users at various corporate sites.
- The most widely used set of standards in local ATM environments is ***ATM LAN emulation (LANE)***.
- ATM LAN emulation is used to make the ATM SVC network appear to be a collection of virtual-Ethernet/IEEE 802.3 and token-ring/IEEE802.5 LANs.
- The replication of most of the characteristics of existing LANs means that LAN emulation enables existing LAN applications to run over ATM transparently, this latter characteristic leading to its wide deployment.

ATM LAN Emulation

- In ATM LAN emulation,
  - most unicast LAN traffic moves directly between clients over direct ATM SVCs,
  - while multicast traffic is handled via a server functionality.
- Bridging is used to interconnect real LANs and emulated LANs running on ATM,
- while routing is used to
  - interconnect ATM–emulated LANs and other WAN or LAN media for purposes of routing scalability, protocol spoofing, or security firewalls.

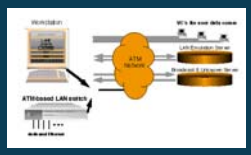


ATM LAN Emulation



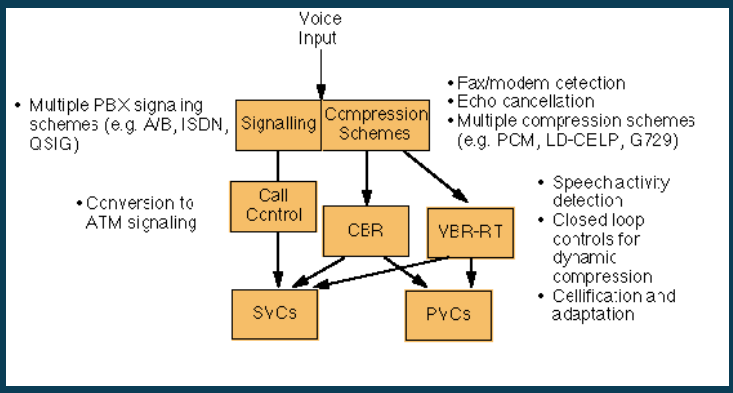
- The ATM Forum LANE implementation agreement specifies two types of LANE network components connected to an ATM network.
  - ***LANE clients*** which function as end systems, such as computers with ATM interfaces that operate as file servers; end-user workstations or personal computers; Ethernet or token-ring switches that support ATM networking; and routers, bridges, and ATM ENS with membership in an emulated ATM LAN
  - ***LANE servers*** that support ATM LANE service for configuration management, multicast support, and address resolution

ATM LAN Emulation



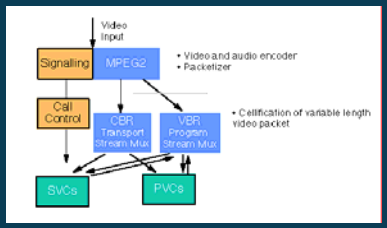
- The LAN–emulation service may be implemented in the same devices as clients or involve other ATM network devices.
- The communications interface, LAN emulation user-network interface (LUNI), is the sequence and contents of the messages that the clients ultimately use to transfer traffic of the type expected on IEEE 802.3/5 LANs.
- The component of the LAN–emulation service that deals with initialization (i.e., emulates plugging the terminal into a LAN hub), is the ***LAN emulation configuration server (LECS)***. It directs a client to connect to a particular ***LAN emulation server (LES)***.
- The LES is the component of the LAN–emulation service that performs the address registration and resolution. The LES is responsible for mapping IEEE 48-bit MAC addresses and token-ring route descriptors to ATM addresses.
- One very important MAC address for clients is the MAC–layer broadcast address that is used to send traffic to all locations on a LAN.
- In LAN emulation, this function is performed by the ***broadcast and unknown server (BUS)***.
- ATM LANE is a comprehensive set of capabilities which has been widely deployed in ATM networks.

Voice over ATM



Video over ATM

- MPEG is a set of standards addressing coding of video and surround-sound audio signals and synchronization of video and audio signals during the playback of MPEG data.
- It runs in the 2 Mbps to 15 Mbps range (with bursts above these rates) corresponding to VCR and broadcast quality respectively.
- The initial MPEG standard (MPEG1) was targeted at VHS–quality video and audio.
- MPEG2 targets applications requiring broadcast-quality video and audio and HDTV.
- MPEG2 coding can result in one of the following two modes:
  - program streams—variable-length packets that carry a single program or multiple programs with a common time base
  - transport streams—188-byte packets that contain multiple programs (for examples, see Figure).



ATM Traffic Management

- Broadly speaking, the objectives of ATM traffic management are to deliver quality-of-service (QoS) guarantees for the multimedia applications and provide overall optimization of network resources.
- Meeting these objectives enables enhanced classes of service and offers the potential for service differentiation and increased revenues, while simplifying network operations and reducing network cost.

ATM Traffic Management

- ATM traffic management and its various functions can be categorized into three distinct elements based on timing requirements.
  - Nodal-Level Controls
  - Network-Level Controls
  - Network Engineering Capabilities

ATM Traffic Management

- Nodal-Level Controls operate in real time.
- Implemented in hardware and include queues supporting different loss and delay priorities, fairly weighted queue-servicing algorithms, and rate controls that provide policing and traffic shaping.
- Well-designed switch-buffer architectures and capacity are critical to effective network operation.
- Actual network experience and simulation has indicated that large, dynamically allocated output buffers provide the flexibility to offer the best price performance for supporting various traffic types with guaranteed QoS.
- Dynamically managing buffer space means that all shared buffer space is flexibly allocated to VCs on an as-needed basis.
- Additionally, per virtual connection (VC) queuing enables traffic shaping, and early and partial packet-level discard have been shown to improve network performance significantly.

ATM Traffic Management

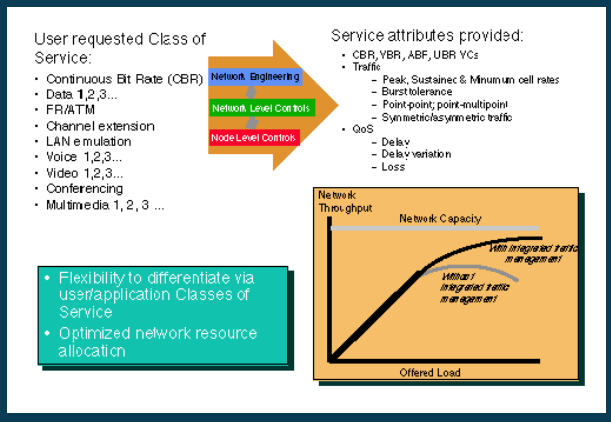
- Network-Level Controls operate in near real time.
- These are typically, but not exclusively, implemented in software including connection admission control (CAC) for
  - new connections, network routing and rerouting systems, and flow-control-rate adaptation schemes.
- Network-level controls are the heart of any traffic-management system.
- Connection admission controls support sophisticated equivalent-bandwidth algorithms with a high degree of configuration flexibility, based on
  - the cell rate for CBR VCs,
  - average cell rate plus
  - a configurable increment for VBR VCs, and
  - minimum cell rate for ABR VCs.
- Dynamic class-of-service routing standards define support for fully distributed link-state routing protocols, auto-reconfiguration on failure and on congestion, and dynamic load spreading on trunk groups.

ATM Traffic Management

- Flow control involves adjusting the cell rate of the source in response to congestion conditions and requires the implementation of closed loop congestion mechanisms.
- This does not apply to CBR traffic.
- For VBR and UBR traffic, flow control is left as a CPE function.
- With ABR, resource management (RM) cells are defined, which allow signaling of the explicit rate to be used by traffic sources.
- This is termed rate-based flow control.
- ABR is targeted at those applications that do not have fixed or predictable bandwidth requirements and require access to any spare bandwidth as quickly as possible while experiencing very low cell loss.
- This allows network operators to maximize the bandwidth utilization of their network and sell spare capacity to users at a substantial discount while still providing QoS guarantees.
- To enhance the effectiveness of network-resource utilization, the ABR standard provides for end-to-end, segment-by-segment, and hop-by-hop service adaptation.

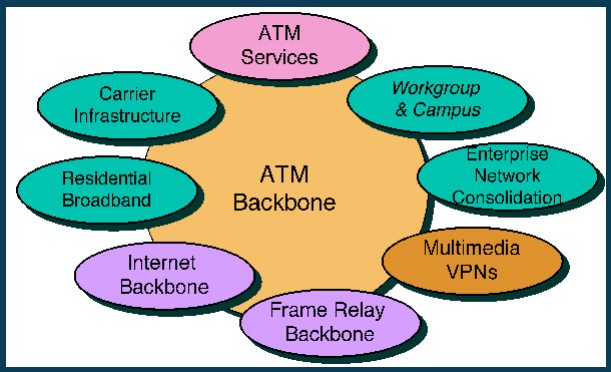
ATM Traffic Management

- Network Engineering Capabilities operating in nonreal time support data collection, configuration management, and planning tools



ATM Applications

- ATM technologies, standards, and services are being applied in a wide range of networking environments, as described briefly below



ATM Applications

- **ATM services** —Service providers globally are introducing or already offering ATM services to their business users.
- **ATM workgroup and campus networks** —Enterprise users are deploying ATM campus networks based on the ATM LANE standards. Workgroup ATM is more of a niche market with the wide acceptance of switched-Ethernet desktop technologies.
- **ATM enterprise network consolidation** —A new class of product has evolved as an ATM multimedia network-consolidation vehicle. It is called an ATM enterprise network switch. A full-featured ATM ENS offers a broad range of in-building (e.g., voice, video, LAN, and ATM) and wide-area interfaces (e.g., leased line, circuit switched, frame relay, and ATM at narrowband and broadband speeds) and supports ATM switching, voice networking, frame-relay SVCs, and integrated multiprotocol routing.

ATM Applications

- **multimedia virtual private networks and managed services** —Service providers are building on their ATM networks to offer a broad range of services. Examples include managed ATM, LAN, voice and video services (these being provided on a per-application basis, typically including customer-located equipment and offered on an end-to-end basis), and full-service virtual private-networking capabilities (these including integrated multimedia access and network management).
- **frame-relay backbones** —Frame-relay service providers are deploying ATM backbones to meet the rapid growth of their frame-relay services to use as a networking infrastructure for a range of data services and to enable frame relay to ATM service interworking services.
- **Internet backbones** —Internet service providers are likewise deploying ATM backbones to meet the rapid growth of their frame-relay services, to use as a networking infrastructure for a range of data services, and to enable Internet class-of-service offerings and virtual private intranet services.

ATM Applications

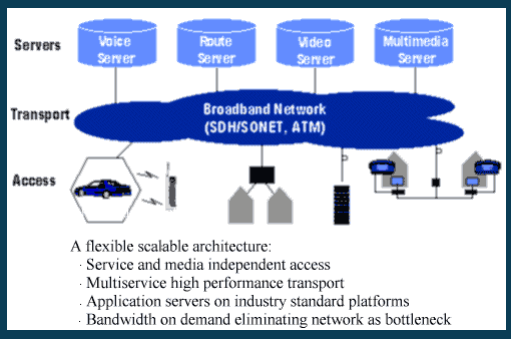
- **residential broadband networks** —ATM is the networking infrastructure of choice for carriers establishing residential broadband services, driven by the need for highly scalable solutions.
- **carrier infrastructures for the telephone and private-line networks** —Some carriers have identified opportunities to make more-effective use of their SONET/SDH fiber infrastructures by building an ATM infrastructure to carry their telephony and private-line traffic.

The Future of ATM

- The versatility of ATM will factor greatly in future application deployment, particularly for converged wide area voice, video and data services
- Open standards will continue to ensure a competitive marketplace and the smooth cut-over of ATM enhancements into every day deployment
- Scalability will permit the present and future data networks to be designed with assurances that future requirements will be met
- Packet-switched, cell-based networks will become the preferred technology for data communications needs in the converged network of the future.
- There is no longer any debate about the effectiveness and versatility of ATM as a networking infrastructure.

ATM Vision

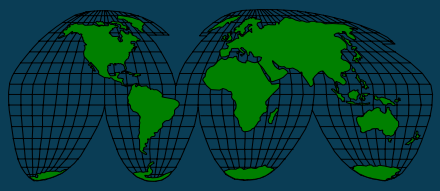
- Believes that ATM is the only viable backbone networking technology that can meet the objective of making multimedia calls as easy, reliable, and secure as voice calls are today.



A flexible scalable architecture:
- Service and media independent access
- Multiservice high performance transport
- Application servers on industry standard platforms
- Bandwidth on demand eliminating network as bottleneck

Conclusion

- ATM is a high-bandwidth technology that transfers content using fixed-sized cells.
- ATM technology, with its scalability, flexibility and Quality of Service (QOS) parameters, is proving to be the most versatile, standards-based Wide Area Network (WAN) transport solution for voice, data, and video and is highly in demand in today's marketplace.
- Essentially, ATM is a total solution. It can meet enterprise customers' present and future end-to-end network requirements, including transport of IP.
- These advantages assure ATM a future



Thank you

Questions & Comments