Payoff

Increased bandwidth and faster transmission are among the attributes that make asynchronous transfer mode (ATM) the emerging technology of choice for LAN backbones, WANs, and campus area networks used for collaborative multimedia and data-rich applications. This article's review of the basics of ATM technology and implementation can help IS professionals decide when and at what pace to adopt ATM technology.

Introduction

As IS professionals continue to transfer mission-critical applications from the mainframe to the distributed, open-systems environment, these applications consume an ever-larger portion of the available bandwidth on Ethernet and Token Ring local area networks (LANs), thereby diminishing the performance of all applications. This situation negates the productivity benefits promised by new and emerging high-bandwidth applications such as collaborative computing, voice mail, document imaging, and desktop videoconferencing.

Benefits of ATM Technology

Asynchronous transfer mode (ATM) technology promises to address this problem of network performance, and others, by providing increased bandwidth, low delay, improved network availability, scalability, and unlimited transmission links.

- **Increased bandwidth.** ATM goes considerably beyond the 10M b/s and 16M b/s offered by legacy Ethernet and Token Ring LANs. To date, there are Asynchronous Transfer Mode standards for transmission at 52M b/s, 100M b/s, 155M b/s, and 622M b/s.

- **Low delay.** Because ATM uses very short, fixed-length packets that can be switched in hardware (instead of in software), there is little delay in transmission. Low delay makes ATM useful for interactive and multimedia applications as well as for voice and video applications, which cannot tolerate delay.

- **Improved network availability.** ATM's increased bandwidth and low delay enable the network to run applications on demand. Control mechanisms at various levels in the network ensure that congestion does not become a problem.

- **Scalability.** ATM is easily scalable. This means that the amount of bandwidth can be tailored to the growing complexity of applications and faster host processors without adversely affecting the performance of other applications and hosts on the network.

- **Unlimited transmission links.** ATM overcomes the distance limitations of Ethernet and Token Ring. In fact, there is no practical limit on the distance of Asynchronous Transfer Mode transmission links.
These attributes make ATM the emerging technology of choice for LAN backbones. Because ATM is also used on Wide Area Network (WANs), LANs can be seamlessly internetworked over great distances. Ultimately, the integration of ATM switching and routing will support large-scale multimedia internetworks that transport all types of traffic. ATM networks will also provide the foundation for Broadband Integrated Services Digital Network (BISDN) services of the future that will support high-speed multimedia traffic at speeds of up to 622M b/s.

**Key Characteristics of ATM**

ATM's key characteristics are cell switching, connection-oriented transmission, and media and rate independence. Together, these characteristics give Asynchronous Transfer Mode networks performance advantages over conventional LANs.

**Cell Switching**

ATM works by breaking data, voice, image, and video traffic into 53-byte cells for simultaneous transmission across the network. By comparison, Ethernet packets are about 1,500 bytes and 16M-b/s Token Ring packets are 4,000 bytes; Fiber Distributed Data Interface networks use packets of up to 4,500 bytes. Because ATM cells are small and fixed in size, the delay between cell transmissions (or latency) is greatly reduced compared to that on legacy networks.

The fixed-size cell format also enables ATM cell switching to be implemented in hardware, as opposed to in software. This results in transmission speeds in the gigabits-per-second range, which is already available in some ATM switches and hubs. In addition, ATM's use of cell switching allows scalable user access to the network, from a few megabits per second to several gigabits per second, depending on the application.

In addition, because cell transmission is asynchronous, ATM cells can send delay-tolerant data traffic intermixed with time-sensitive traffic such as voice and video over the same backbone facility. Various traffic management techniques on the network give time-sensitive traffic priority over delay-tolerant traffic.

**Connection-Oriented Transmission**

ATM is a connection-oriented technology—that is, a connection must be established between two stations before data can be transferred between them. An Asynchronous Transfer Mode connection specifies the transmission path, allowing the cells to self-route through an ATM network.

Legacy LANs, on the other hand, are connectionless, which means that the stations transmit data when they have to, without first establishing a specific connection or route to the destination station. This is possible because the LAN is always available; there is no need to set up a special connection between the sending and receiving stations. With Ethernet, all the stations contend for access to the network. With Token Ring, each station in turn is allotted a specific amount of time to use the network.

Since ATM is a connection-oriented protocol, bandwidth is allocated only when a station requests a connection. By allocating bandwidth based on immediate user need, ATM can handle the network's aggregate demand. This allocation can be accomplished without administrative intervention.
Media and Rate Independence

ATM protocols are not tied to a particular transmission rate or physical medium. ATM can therefore operate at whatever rate is appropriate for a given application over whatever facilities are available, including optical fiber, coaxial cable, and certain categories of Unshielded Twisted Pair wiring.

Preserving Investments Through LAN Emulation

Although most of the publicity surrounding Asynchronous Transfer Mode concerns its implementation over Wide Area Network, ATM can also be adapted to local area networks. This is accomplished through LAN emulation.

Generally, users do not view ATM as a replacement for the existing LAN infrastructure—there is just too much money tied up in that. Instead, they are looking at ways to introduce ATM into the existing LAN infrastructure to make it perform better.

Introducing ATM technology into the LAN environment can be quite disruptive and costly because the technology requires altering Network Operating System and applications. The ATM Forum, one of two key standards bodies, is finishing work on a LAN emulation specification that allows standard protocols to run over an ATM network.

LAN emulation will handle such issues as mapping connectionless-oriented LAN routing services into connection-oriented ATM services and giving delay-sensitive traffic priority over other packets that may be sharing the backbone. It will also handle address resolution—changing a LAN packet's address to an Asynchronous Transfer Mode cell's address and back—plus call setup and directory services. LAN emulation will enable ATM to be introduced into the legacy LAN environment transparently, without requiring modifications to existing operating systems and applications.

LAN emulation also will allow Ethernet and Token Ring networks to share the same ATM backbone. Of course, they would not be able to communicate with each other without a translating bridge or router. In the long term, LAN emulation will give way to ATM-aware applications that will be developed using application programming interfaces (APIs). The stumbling block right now is that there are no standards for such APIs.

Using ATM Technology

ATM can be used on Wide Area Network, campus area networks, and local area networks. The ongoing development of standards will eventually allow seamless integration between these domains, which will permit traffic to flow freely among them without the use of special procedures.

The Importance of Network Switches

ATM switches fall into two major categories of use: private enterprise switches and public wide area networks backbone switches. The latter category is the domain of very large wide area networks switches designed for public carriers' Central Office and serving as nodes in nationwide and, eventually global, public wide area backbones.

Somewhat smaller versions of these switches will also be deployed by public carriers to provide access points to the Asynchronous Transfer Mode backbone. These access points will support other transmission technologies and services such as T1, frame relay, and Switched Multimegabit Data Service.
The broad category of private ATM switches has three technical applications for workgroup computing, campus or enterprise backbone networks, and wide area networks access. ATM workgroup switches are designed to be used with ATM adapter cards in PCs and workstations. These switches can also be linked to form a campus ATM backbone. Eventually, they will also be used as wide area networks access switches, linking private campus networks to public-carrier ATM services.

**Premises Switches.**

Smaller, premises ATM switches are designed for workgroups, departments, and backbones. Workgroup ATM switches are suitable for small office or workgroup environments in which communication costs impede the use of new applications. Asynchronous Transfer Mode technology used in this context can be an effective means of integrating voice, data, and legacy applications.

When IS managers upgrade legacy networks, departmental ATM switches provide a larger-capacity, more-flexible ATM premises environment. This environment offers connectivity options to the desktop, servers, workgroup hubs, and backbone links.

The backbone switch aggregates ATM traffic in a campus environment. It also provides bandwidth and network management capabilities to optimize the use of wide area networks services.

**Enterprise Switches.**

Desktop applications will drive demand for ATM in the future, but for now, bandwidth on the backbone is the biggest selling point. IS professionals are looking to ATM to relieve congestion on campus network backbones and to render the backbones easier to reconfigure and manage. Vendors are addressing these issues by incorporating ATM ports into intelligent hubs and routers, which then use ATM's high bandwidth to increase backbone throughput.

Some vendors are already putting special modules in their hubs and routers that perform frame segmentation and reassembly. These devices segment variable-length Ethernet, Token Ring, or Fiber Distributed Data Interface frames so they can be placed into the smaller, fixed-length ATM cells. The device also reassembles frames from pieces carried in cells coming into its ATM port. Such modules transform hubs and routers into gateways between legacy LANs and campus ATM backbones. Putting ATM interfaces on intelligent hubs and routers lets users migrate from existing shared-media LAN technologies to ATM in manageable stages.

**Carrier-Based ATM Services**

Only a handful of carriers offer Asynchronous Transfer Mode services, and they provide only Permanent Virtual Circuit (PVCs). These ATM connections are set up between a sending and receiving station on the network by a network administrator. They remain up until torn down manually.

Another type of ATM connection, which will be offered in the future, is called the Switched Virtual Circuit. This type of connection is set up and torn down by the ATM network on demand without manual intervention.

PVC connections are more reliable for certain types of mission-critical applications. switched virtual circuit (SVC) connections, which are intended for routine types of applications, can time out and tear down after a brief period without traffic between
resources. When a replacement connection is requested, the network may not be able to provide the same guaranteed bandwidth it had previously allocated to that application. Permanent virtual circuits will stay in place, even if there is no traffic for a prolonged period of time.

Although local and long-distance carriers are just starting to introduce public network ATM services, pricing structures that facilitate comparison shopping are virtually nonexistent. Many carriers prefer to negotiate prices with customers individually because the service must be customized to meet specific needs. From the customer's point of view, this means letting the carrier play a substantial role in planning the network. This process is often followed by considerable sales pressure because the carrier wants to recover its considerable investment in time and expertise.

Some carriers allow customers to integrate their current T1 and T3 lines with the ATM service, thereby protecting investments in equipment. This type of arrangement is especially important if the lines already support frame relay or Switched Multimegabit Data Service, which will soon interoperate with ATM. Interoperability will let customers deploy an enterprisewide network that combines a range of services as needed at individual locations.

If a company decides to use a commercially available ATM service, IS managers must next consider equipment. For those who cannot purchase an ATM premises switch, some carriers lease economical ATM multiplexers, Data Service Unit (DSUs), and routers. These devices bring the traffic to ATM equipment in the carrier's Central Office, where it is routed to its destination over a high-speed backbone network.

Some carriers let customers select bandwidths between 1.5M b/s and 155M b/s in increments as small as 500K b/s. In addition, customers can specify Variable Bit Rate or Constant Bit Rate virtual circuit in accordance with the needs of their applications.

A variable bit rate (VBR) virtual circuit is used to handle intermittent bursts of traffic from such devices as routers, channel extenders, and Frame Relay Access Devices. A Computer-Based Reference virtual circuit is used to support an application such as videoconferencing, which may need 384K b/s or more of reserved bandwidth for the duration of the session.

### Standards Development

Two key bodies work toward developing standards for ATM: the Asynchronous Transfer Mode Forum and the Internet Engineering Task Force (IETF).

The ATM Forum aims to speed the development and deployment of ATM products and services. Its activities include the development and recommendation of interoperability specifications, which are crucial for the widespread acceptance of Asynchronous Transfer Mode. The IETF oversees the development of proposed Internet standards, including the Simple Network Management Protocol management protocol, which is familiar to most network managers. The ATM Forum has chosen SNMP for managing ATM networks.

The ATM Forum and IETF cooperate on the development of mutual standards. Such standards ensure that buyers do not become locked into a single vendor's proprietary technology and that the equipment can be easily connected to LAN backbones and carrier-provided ATM services. For this reason, companies considering the purchase of ATM equipment should make sure that the vendor supports ATM Forum and IETF standards.
Guidelines for Selecting an ATM Vendor

The following guidelines can help IS and network managers make the transition to Asynchronous Transfer Mode technology.

**Identifying Bus Architectures**

Before approaching vendors about their ATM offerings, IS and network managers should find out which bus architectures are supported in the various computers, workstations, and servers on the LAN. The most common bus architectures are the Industry Standard Architecture (ISA), Extended Industry Standard Architecture (EISA), Peripheral Component Interconnect (PCI), and IBM's Micro Channel Architecture (MCA).

Knowing the bus architectures is important because vendors typically provide ATM adapters for only the highest-performing architectures. The throughput of the PCI bus, for example, is 20 times faster than that of an ISA bus and four times faster than that of an EISA bus. This means that machines based on the Industry Standard Architecture bus will benefit the least from high-speed ATM connections.

If the architecture used by most computers on the LAN is predominantly ISA, IS managers should seriously consider postponing ATM implementation until they have replaced the ISA-based machines. In the interim, scarce IS dollars can be used more advantageously elsewhere. Alternatively, instead of waiting to replace ISA-based machines, IS managers can implement a proprietary low-speed ATM solution that tops out at 25M b/s.

IBM Corp. and other companies advocate a competing alternative to provide low-speed ATM at 25M b/s.

IS staff must also determine how many vacant slots are available on each computer, workstation, and server. Some ATM adapters require the use of two slots. Many devices on the LAN might not have two vacant slots; those that do might have to forgo other add-on capabilities in the future to accommodate Asynchronous Transfer Mode now.

**Determining Interoperability**

When evaluating an ATM product, IS managers should find out whether the product has been tested against others for interoperability. ATM adapter cards, for instance, should be compatible with a range of ATM switches and hubs from other vendors. If not, buyers may find themselves committing to a single vendor for the life of the network. Most innovative companies offering economical Asynchronous Transfer Mode solutions today are new and may still lack a sound financial foundation, so committing to a single vendor can be a risky proposition.

**Evaluating Network Management Capability and SNMP Agents**

Another consideration concerns network management; specifically, the vendor's support for Simple Network Management Protocol. The latest trend in network management is to manage an ATM network all the way down to the server and desktop computer. To do this, the ATM adapter should come equipped with special software called an SNMP agent. Under the direction of the SNMP management station, the SNMP agent collects information about the ATM adapter's performance and sends it to the management station. This information is used to pinpoint problems on the network.
However, ATM's switched, connection-oriented environment greatly complicates management. For example, most SNMP-based management systems cannot handle large amounts of ATM traffic. Because of ATM's characteristics, a network failure could result in the simultaneous reporting of a very large number of faults. When this happens, the management system can easily become overtaxed and unable to react in real time. In extreme cases, the management system can fail, bringing down the entire internetwork.

Fortunately, vendors are enhancing their management platforms to handle higher traffic volumes through distributed capabilities. With the management information processing load balanced among several systems, these new SNMP-based platforms will be better able to keep up with and respond to faults in real time. When assessing a vendor's Asynchronous Transfer Mode products, IS managers should pay particular attention to the management system and how its capabilities are distributed. A distributed management system will be more reliable in the ATM environment than a centralized system.

**Implementation Costs**

As is the case with most new technologies, Asynchronous Transfer Mode implementation involves an up-front cost, as well as hidden and ongoing costs.

**Initial and Ongoing Costs**

An obvious concern about implementing ATM on the LAN backbone is the up-front cost. An enterprise ATM switch or hub can cost between $70,000 and $150,000. Workgroup switches typically are priced between $12,000 and $25,000. Unlike the larger switches, they offer rudimentary management and little or no fault tolerance.

ATM cards that support data rates up to 155M b/s are available for workstations and servers. They currently cost between $1,000 and $2,000 each. The new cards include all the necessary Asynchronous Transfer Mode drivers and User-to-Network Interface software. Depending on the vendor, the Asynchronous Transfer Mode adapter may even come with an Simple Network Management Protocol agent at no additional charge. The price for ATM adapter cards is expected to drop to $600 by mid-1996. Some vendors already offer cards priced at only $400, but these are based on proprietary technologies.

The hidden costs of ATM implementation involve network management tools, wire and cabling, test equipment, and training. Ultimately, it can cost $15,000 to $20,000 per port to implement a standards-based Asynchronous Transfer Mode LAN.

Despite the high cost, ATM can be justified if the new network is used to consolidate multiple types of traffic: video, image, data, and voice. If consolidating such traffic is not a requirement now or even in the near future, IS managers can safely postpone the move to Asynchronous Transfer Mode. Postponing implementation can realize substantial cost savings as prices continue to plummet and standards start to solidify.

IS managers who opt for immediate ATM implementation should be aware that the initial outlays for hardware and software must be matched by an ongoing financial commitment to maintain the new network. For example, one of the primary costs of ATM today is for frequent updates to equipment. To incorporate changing standards, it may be necessary to update software—and sometimes hardware—every few months.

**Pros and Cons of Low-Cost Proprietary Solutions**

Vendors continue to develop new (i.e., proprietary) implementation strategies that can drive the cost of ATM down to conventional Ethernet and Token Ring prices. One
approach entails equipping PCs with a $300 ATM adapter card. The PCs are then disconnected from an existing hub and tied into an ATM switch, which costs $200 to $400 per port. The ATM switch is then linked to the existing hub. This approach delivers ATM to the desktop for as little as $500 per seat.

Despite the higher price of ATM technology, ATM products can actually be more economical than Ethernet. The adapters in both types of networks represent the largest cost, since they must be installed in every machine on the network. While an Ethernet adapter can be purchased for as little as $99, it supports only 10M b/s. An ATM adapter costing as little as $300 can support up to 155M b/s. If the price of Ethernet adapters were adjusted to reflect the offered bandwidth, they would cost nearly $1,535. In terms of bandwidth supported, ATM can represent a real bargain in comparison to Ethernet.

However, potential buyers should be aware that many of these low-priced ATM products are proprietary implementations, requiring that all the ATM components come from the same vendor.

Although it is preferable to choose ATM products that adhere to industry standards, ensuring multivendor interoperability, IS managers can use these low-cost proprietary solutions to test the feasibility of enterprisewide Asynchronous Transfer Mode deployment before committing to a large investment. In this way, IS and network managers can pilot test the products at the workgroup level with existing applications and network loads and start planning more extensive use of ATM in the future. This stage promotes better understanding of ATM among IS staff and allows managers to gain expertise in evaluating vendor offerings. Such expertise will prove useful when the commitment is finally made for wider ATM deployment.

**Conclusion**

ATM is becoming popular because of its speed and flexibility. It does not rely on any one media or topology and was designed with interactive, multimedia applications in mind. High-speed Asynchronous Transfer Mode equipment links, switches, and adapters are already available in quantity, and carriers such as AT&T, MCI, and some of the regional Bell operating companies are currently offering ATM-based services. Large corporations are going in the same direction with their LANs and private network. The real growth in Asynchronous Transfer Mode will come at the workgroup level as the prices for adapters continue to plummet and LAN emulation emerges as the way to consolidate traffic from legacy LANs over Asynchronous Transfer Mode backbones.

There is plenty of room for innovation in ATM technology. For example, AT&T Bell Laboratories has demonstrated 622M-b/s transmission over category 5 Unshielded twisted pair cable copper cable. This speed is the equivalent of sending 2 billion typed pages of text per day or 22,000 pages of text per second. AT&T's demonstration shows the robustness of UTP cable for desktop computer and communications infrastructure applications as well as ATM's potential to provide the foundation for networks well into the twenty-first century.

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