ATM Technology Prospects: A Review

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Abstract: *The implementation of ATM (Asynchronous Transfer Mode) is needed for quick access to web-based applications and real-time delivery of multimedia transmissions on an integrated network infrastructure. ATM is a high-performance technology that provides bandwidth on-demand for broadband transmissions and hence supports seamless transport of full-motion video, audio, data, animations and still images in local and wider area environments on different data rates. Asynchronous transfer mode (ATM) also known as Cell Relay is a cell-oriented switching and multiplexing technology. It uses fixed-length packets to carry different types of traffic and employs the asynchronous time division multiplexing. This feature will likely to have broad positive impacts on revenue opportunities since multiple types of services like- high speed local-area network (LAN) interconnection, voice, video, and future multimedia applications in business and residential markets will then depend on ATM technology in both short as well as long term of time. ATM will not only reduce the infrastructure costs through efficient bandwidth management, operational simplicity and usage of existing networks but also it will diminish the unacceptable time delay between packets.*

1. Introduction

Asynchronous Transfer Mode (ATM) is the cell relay protocol designed by the ATM Forum and adopted by the ITU-T. The combination of ATM and SONET will allow high-speed interconnection of all the world's networks.

Asynchronous transfer mode (ATM) is a technology that has its history in the development of broadband ISDN. Precisely, it can be observed 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.

2. Design Issues

The design issues which have been considered for the implementation of ATM are:

a) The need for a transmission system to optimize the use of high-data-rate transmission media, in particular optical fiber. In addition to offering large bandwidths, newer transmission media and equipment are dramatically less susceptible to noise degradation. A technology is needed to take advantage of both factors and thereby maximize data rates.

b) The system must interface with existing systems and provide wide-area interconnectivity between them without lowering their effectiveness or requiring their replacements.

c) It must be available at low cost to every user who wants it.

d) The new system must be able to work with and support the existing telecommunications hierarchies like in local loops, local providers, long-distance carriers, and so on.

e) The new system must be connection-oriented to ensure accurate and predictable delivery.

3. Origin

The ATM is needed because of two common problems in associated network

(a) Unsophisticated Frame Networks

Before ATM, data communications at the data link layer had been based on frame switching and frame networks. Different protocols use frames of varying size. The result is larger and larger headers relative to the size of the data unit. Switches, multiplexers, and routers must incorporate elaborate

software systems to manage the various sizes of frames. A great deal of header information must be read, and each bit counted and evaluated to ensure the integrity of every frame. Internetworking is also the typical aspect. As a new initiative some protocols have enlarged the size of the data unit to make header use more efficient (sending more data with the same size header).But many times large data fields create waste if there is not much information to transmit. So to improve utilization, some protocols provide variable frame sizes to users.

(b) Diverged Network Traffic

Another problem is that of providing consistent data rate delivery when frame sizes are unpredictable and can vary dramatically. One of the way to achieve this by transferring traffic onto shared paths by using TDM (Time Division Multiplexing). But because audio and video frames ordinarily are small, mixing them with conventional data traffic often creates unacceptable delays of this type and makes shared frame links unusable for audio and video information. So to fully utilize broad bandwidth links, one need to be able to send all kinds of traffic over the same links.

4. Cell Relay or ATM Technology

A cell is a small data unit of fixed size. In a cell network, which uses the cell as the basic unit of data exchange, all data are loaded into identical cells that can be transmitted with complete predictability and uniformity. As frames of different sizes and formats reach the cell network from a network, they are split into multiple small data units of equal length and are loaded into cells. Because each cell is the same size and all are small, the problems associated with multiplexing different-sized frames are avoided.

Asynchronous TDM

ATM uses asynchronous time-division multiplexing-that is why it is called Asynchronous Transfer Mode-to multiplex cells corning from different channels. ATM multiplexers fill a slot with a cell from any input channel that has a cell; the slot is empty if none of the channels has a cell to send. The figure shows how cells from three inputs are multiplexed. At the first tick of the clock: channel 2 has no cell (empty input slot), so the multiplexer fills the slot with a cell from the third channel. When all the cells from all the channels are multiplexed, the output slots are empty.
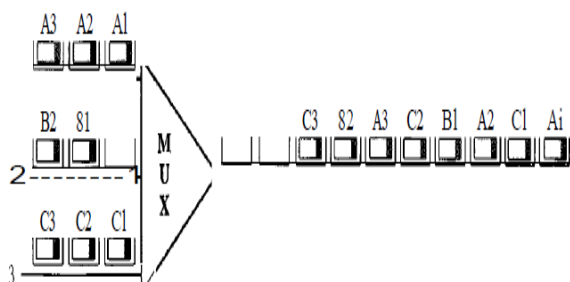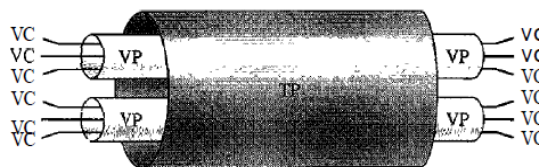

Network Design

The user access devices, called the endpoints, are connected through a user-to-network interface (UNI) to the switches inside the network. The switches are connected through network-to-network interfaces (NNIs).
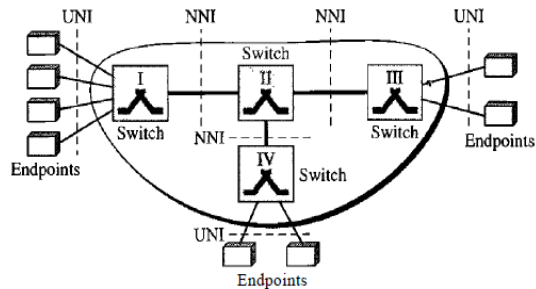
Virtual Connection

Connection between two endpoints is accomplished through transmission paths (TPs), virtual paths (VPs), and virtual circuits (VCs). A transmission path (TP) is the physical connection (wire, cable, satellite, and so on) between an endpoint and a switch or between two switches. A transmission path is divided into several virtual paths. A virtual path (VP) provides a connection or a set of connections between two switches. Cell networks are based on virtual circuits (VCs). All cells belonging to a single message follow the same virtual circuit and remain in their original order until they reach their destination.

Identifiers

In a virtual circuit network, to route data from one endpoint to another, the virtual connections need to be identified. For this purpose, the designers of ATM created a hierarchical identifier with two levels: a virtual path identifier (VPI) and a virtual-circuit identifier (VCI). The VPI defines the specific VP, and the VCI defines a particular VC inside the VP. The VPI is the same for all virtual connections that are bundled (logically) into one VP.

Cells

The basic data unit in an ATM network is called a cell. A cell is only 53 bytes long with 5 bytes allocated to the header and 48 bytes carrying the payload (user data may be less than 48 bytes). 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.

Virtual Circuits

In a virtual circuit network, to route data from one endpoint to another, the virtual connections need to be identified. For this purpose, the designers of ATM created a hierarchical identifier with above said levels: a virtual path identifier (VPI) and a virtual-circuit identifier (VCI). The VPI defines the specific VP, and the VCI defines a particular VC inside the VP. It should be noted that the VPI is the same for all virtual connections that are bundled (logically) into one VP.

Virtual circuits can be statically configured as Permanent Virtual Circuits (PVCs- A permanent virtual-circuit connection

is established between two endpoints by the network provider. The VPIs and VCIs are defined for the permanent connections, and the values are entered for the tables of each switch.) or dynamically controlled via signaling as Switched Virtual Circuits (SVCs- In a switched virtual-circuit connection, each time an endpoint wants to make a connection with another endpoint, a new virtual circuit must be established. ATM cannot do the job by itself, but needs the network layer addresses and the services of another protocol (Such as IP). The signaling mechanism of this other protocol makes a connection request by using the network layer addresses of the two endpoints. The actual mechanism depends on the network layer protocol.). SVCs are the preferred mode of operation because they can be dynamically established, thus minimizing reconfiguration complexity.

Virtual Circuits can also be point-to-point or point-to-multipoint, thus providing a rich set of service capabilities.
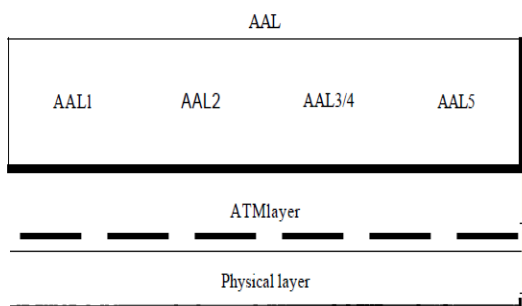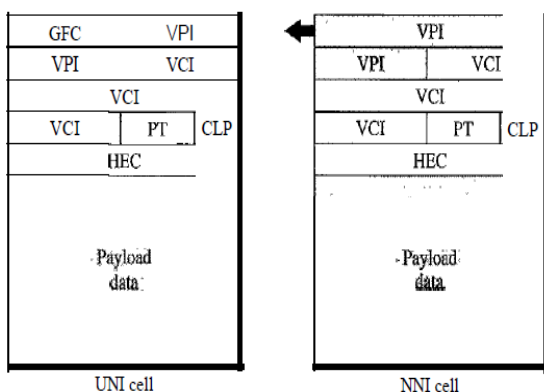

ATM Stack

The ATM standard defines three layers. They are, from top to bottom, the application adaptation layer, the ATM layer, and the physical layer.

Physical Layer

Like Ethernet and wireless LANs, ATM cells can be carried by any physical layer carrier.

ATM Layer

The ATM layer provides routing, traffic management, switching, and multiplexing services. It processes outgoing traffic by accepting 48-byte segments from the AAL sub layers and transforming them into 53-byte cells by the addition of a 5-byte header.

Header Format: ATM uses two formats for this header, one for user-to-network interface (UNI) cells and another for network-to-network interface (NNI) cells.

➤ Generic flow control (GFC). The 4-bit GFC field provides flow control at the UNI level. The ITU-T has determined that this level of flow control is not necessary at the NNI level. In the NNI header, therefore, these bits are added to the VPI. The longer VPI allows more virtual paths to be defined at the NNI level. The format for this additional VPI has not yet been determined.

➤ Virtual path identifier (VPI). The VPI is an 8-bit field in a UNI cell and a 12-bit field in an NNI cell (see above).

➤ Virtual circuit identifier (VCI). The VCI is a 16-bit field in both frames.

➤ Payload type (PT). In the 3-bit PT field, the first bit defines the payload as user data or managerial information. The interpretation of the last 2 bits depends on the first bit.

➤ Cell loss priority (CLP). The 1-bit CLP field is provided for congestion control. A cell with its CLP bit set to I must be retained as long as there are cells with a CLP of 0 bit.

➤ Header error correction (HEC). The HEC is a code computed for the first 4 bytes of the header. It is a CRC with the divisor $x8 + x2 + x + 1$ that is used to correct single-bit errors and a large class of multiple-bit errors.

Application Adaptation Layer

The application adaptation layer (AAL) was designed to enable two ATM concepts. First, ATM must accept any type of payload, both data frames and streams of bits. A data frame can come from an upper-layer protocol that creates a clearly defined frame to be sent to a carrier network such as ATM. A good example is the Internet. ATM must also carry multimedia payload. It can accept continuous bit streams and break them into chunks to be encapsulated into a cell at the ATM layer. AAL uses two sub layers to accomplish these tasks. Whether the data are a data frame or a stream of bits, the payload must be segmented into 48-byte segments to be carried by a cell. At the destination, these segments need to be reassembled to recreate the original payload. The AAL defines a sub layer, called a segmentation and reassembly (SAR) sub layer, to do so. Segmentation is at the source; reassembly, at the destination. Before data are segmented by SAR, they must be prepared to guarantee the integrity of the data. This is done by a sub layer called the convergence sub layer (CS).

ATM defines four versions of the AAL: AAL1, AAL2, AAL3/4, and AAL5 which are briefly defined as under-

AAL1 supports applications that transfer information at constant bit rates, such as video and voice. It allows ATM to connect existing digital telephone networks such as voice channels.

AAL2 is used for low-bit-rate traffic and short-frame traffic

such as audio (compressed or uncompressed), video, or fax. A good example of AAL2 use is in mobile telephony. AAL2 allows the multiplexing of short frames into one cell.

AAL3/4 is intended to support both connection-oriented data services and AAL4 to support connectionless services.

AAL5 is used for the applications that do not require comprehensive sequencing and error control mechanisms that are not necessary for every application. This fifth AAL sub layer, called the simple and efficient adaptation layer (SEAL). AAL5 assumes that all cells belonging to a single message travel sequentially and that control functions are included in the upper layers of the sending application.

5. Conclusion

ATM technology is uniquely suited for supporting error-free multimedia transport in high-speed network configurations. Moreover, ATM is an enabler of network traffic consolidation, thereby streamlining network management operations and optimizing utilization of high-speed network connections. In addition, ATM provisions networking services via twisted copper pair, optical fiber, and hybrid optical fiber and coaxial cable (HFC) wire line media and wireless technical solutions. National and international standards organizations such as the ITU-T, the Institute of Electrical and Electronic Engineers (IEEE), the American National Standards Institute (ANSI), and the European Telecommunications Standards Institute (ETSI) endorse ATM specifications. ATM networks offer a specific set of service classes, and at connection set-up, the user must request a specific service class from the network for that connection. Service classes are used by ATM networks to differentiate between specific types of connections, each with a particular mix of traffic and QoS parameters, since such traffic may need to be differentiated within the network, for instance, by using priorities to allow for the requested behavior. One of the primary benefits of ATM networks is that they can provide users with a guaranteed Quality of Service (QoS). To do this, the user must inform the network, upon connection set-up, of both the expected nature of the traffic that will be sent along the connection, and of the type of quality of service that the connection requires. The former is described by a set of traffic parameters, while the latter is specified by a set of desired QoS parameters. The source node must inform the network of the traffic parameters and desired QoS for each direction of the requested connection upon initial set-up; these parameters may be different, however, in each direction of the connection.

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Author Profile
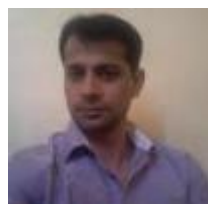
Deepak Kumar received the B.Tech. Degree in Computer Science & Engineering from Kurukshetra University and M.Tech. Degree in Computer Science & Engineering from M.D. University in 2006 and 2008 respectively. He has qualified for National Eligibility Test (NET)/JRF for teaching in Computer Science & Applications conducted by University Grant Commission (UGC). He has also passed Graduate Aptitude Test in Engineering (GATE) and has been awarded Ministry of Human Resource Development (MHRD) Scholarship. He has also been associated with Ministry of Information & Technology (MIT), New Delhi for 6 months.