ASYNCHRONOUS TRANSFER MODE (ATM)

Its Development and Adoption: Migrating towards cable

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ABSTRACT

Asynchronous Transfer Mode (ATM) has taken the telecommunications and cable television world by storm. It is widely recognized to be the only technology that bridges each element of the emerging National Information Infrastructure (NII); *i.e.,* interoperability between telephone, data and computer networks and cable television and multimedia networks. For the management executive, this paper will explore the various business applications and benefits of ATM along with a contrasting historical perspective of other technologies. The engineer will be presented with the technical aspects of the medium, from network applications and network architecture to basic details of the ATM protocol layers. In summary the paper will examine where the applications of the technology for cable television industry (*e.g.,* video-on-demand or multimedia), and ATM integrate various network architecture's.

INTRODUCTION

The emergence of a large number of new telecommunications services has influenced the growth of new communications protocols that will provide ever increasing speed and network flexibility. ATM is an enabling technology that process data, video, voice and image information simultaneously. It is one of a general class of packet technologies that relay data via an address contained within the packet, which provides this speed and network flexibility. First and foremost ATM is a high bandwidth, implying high data rate, switching and multiplexing <u>technology</u> [1]. ATM is not a <u>service</u> that can be compared to interactive multimedia, for example. It is a technology which will deploy most all of the advanced services, such as video-on-demand, HDTV, videophones and high speed data transfer for example, within a full service network. It is an outgrowth of B-ISDN[2] and is intended to be carried on a synchronous fiber or coaxial network.

Future market expectation can clearly delineate two categories of customers for high speed communications networks using ATM: the home and the office or business. Each has its own separate and distinct network service requirements. The home is mostly interested in entertainment type services and the office, especially health-care and education, is concerned with increased efficiency and productivity. However, as increased network capacity becomes available the home is ever more so interested in data services as well.

ATM is foreseen by the cable industry as a technology that may allow cable to fulfill its potential of performing to the standards of a broadband-switched network[3]. Indeed, many communications companies are exploring the inherent advantage of ATM over existing technologies as an efficient means of provisioning advanced data and video services.

HISTORY

Asynchronous Transfer Mode is really not a new technology, but an outgrowth of Asynchronous Time Division Multiplex (ATDM) networks which have been extensively studied at Bell Labs since 1969 [4]. The imminent confluence of computing and communications resulted in a need to interconnect several computers and peripherals together at widely separated physical locations with a high-speed data network. Packet switched networks were just beginning to emerge in 1969 and time sharing was in its infancy. The need to connect computers called for a high-speed network which would strive for efficiency, economy, and full instantaneous benefit of the bursty nature of communications required. Synchronous communications platforms, of the day envisioned for future digital telephone services did not fulfill the requisite technical needs. By 1975, research progressed to the point where the ATDM communications requirements had out-grown the present synchronous switches. There are three inherent problems with synchronous network switch designs: lack of flexibility, unnecessarily high switch speed, and synchronization of the sending, receiving computer and any intermediate switch node. Further research developed the ATM concept and in December of 1983, AT&T introduced the first commercial ATM product: Datakit VCS. From its start in 1985, B-ISDN has encompassed circuit and packet switching technologies. ATM is a derivative B-ISDN since its cell structure enables it to work in partnership with circuit switching in the same network[5]. 1984 saw the first ATM product and service availability and since that time has grown into the technology we know today and which in 1992, exploded from virtual obscurity to general awareness. This recent volcanic awareness is driven by the response of ATM meeting the users changing needs rather than being network standards driven.

ATM OVERVIEW

It is important to understand the reasons why the technology has so rapidly come from obscurity to communications hottest commodity. ATM is:

- ***bandwidth efficient***
  Low header overhead and variable length data packets form the ATM cell. This ratio provides high bandwidth utilization.
- ***scalable***
  ATM is capable of simultaneous carriage of data streams of varying rates. Video, voice and computer data require vastly different rates of data transmission and each are equally accommodated within ATM.
- ***transparent***
  Some networks require guarantee of timely delivery of information at the receiving point. Real time services such as telephony and video demand must have minimal end-to-end transmission delay. Packet switching and frame relay cannot guarantee such timely delivery[6].
- ***network flexible***
  The ATM network need not be modified or suffer efficiency losses in order to accept new and different

service characteristics. It is also capable of multicast functionality; *i.e.*, broadcast or point-to-point.

- *protocol optimized*

  Each ATM cell is fixed at 53 octets (bytes): 5-octet header for identification and 48 octets for information. The allocated information octets are commonly called the payload. This particular equation of header to payload ratio provides particularly jitter free transmission characteristics which is especially important for voice networks.

Now that it is known what ATM is and what it can do it is also important to understand what ATM is not. The comparison with other transmission systems such as PACKET, FRAME RELAY, and SONET will provide a little insight to these differences.

PACKET

Packet systems such as X.25 and other closely related X.? packet protocols were first developed for use over noisy error prone analog transmission channels such as radio or telephone lines. The protocol for these noisy channels was necessarily robust and bandwidth inefficient. Hence it is slow. DS-1 performance is about all that can be expected of packet systems. Another difficulty with packet is its time insensitivity. X.25, in particular was designed to allow data packets to arrive at a receiving location out-of-sequence and then be reassembled in proper order at the destination. This is not suitable for data such as video and voice because of the inherent delay[7].

FRAME RELAY

A fairly recent development, frame relay, is more efficient than packet in carrying data traffic because it was developed to operate over fiber optic data channels that are virtually error free. It provides higher throughput, higher bandwidth and more cost effective transport than does standard X.? packet technologies. However, this strength is its downfall. Frame relay is too inflexible to cope with changing traffic rates such as video and voice which in the future will be mixed into today's purely data networks. Frame relay can be approached in three separate defined implementations: an interface, a network signaling protocol and as a network-provided service[8]. Some of the benefits of using frame relay as an interface are:

- true international network interface standard
- multiple users per physical interface access line
- high speed of access due to low packet overhead
- higher throughput to high-speed applications

The benefits of using frame relay as a protocol are:

- various size frame transport
- increased performance over older packet technologies
- reduced overhead for backbone networks
- maximum link efficiency
- performs multiplexing functions
- reduces nodal latency
- improved bandwidth utilization

The benefits of using frame relay as a service are:

- cost effective because of network efficiencies
- transport speeds of up to T3
- utilizes all available bandwidth
- provides first true bandwidth on
- high speed - low delay
- fills gaps between X.25 and broad-band services
- "any-to-any" connectivity

Frame relay is sometimes confused with the term "fast packet." Fast packet is a generic term used for many high-speed packet technologies such as frame relay and cell relay. Frame relay and frame switching are synonymous only with CCIT switching implementation of Type II frame relay where it is defined as an end-user service under ISDN service standards.

SONET

SONET, Synchronous Optical Network, is a Bellcore term for the Synchronous Digital Hierarchy standardized by the CCITT in Europe and Asia[9]. It was conceived as a method of providing a high-speed international fiber optic transmission standard interface between disparate standards of various countries. SONET is a transport interface and method of transmission only and is not a network unto itself. SONET is planned to eliminate the different transmission schemes between countries.

SONET uses both synchronous and asynchronous transfer modes through he use of a fixed data transfer frame format. Using a unique framing format, SONET relies upon timing as the most critical element. Frame payloads of SONET are not synchronized by a common clock even though it is a synchronous technology. The actual data payload of SONET can take many forms such as DS3, FDDI or SMDS. Some of the benefits of SONET are:

- true fractional DS3 demand service specifications
- aggregation of low-speed data transport channels into common high-speed backbone trunk trans-port
- increased bandwidth management
- reduced overall network transport delay
- supports B-ISDN, SMDS, and other high bandwidth services
- add/drop channels without the need to demultiplex or remultiplex

As a communication process between two end systems, ATM like frame relay, relies only on a two layer protocol stack (header and payload). At every point in the network, therefore, processing is done only on each ATM cell individually without consideration of any other cell. The network is not concerned with the arrival of groups of cells , sequencing, or acknowledging, as is X.? packet transmissions, therefore forwarding the cell is much faster[10]. No processing is of data is done in the information field of the cell. Unlike packet, ATM assumes one and only one defined path exists through the network for the transport of cells.

ARCHITECTURE STANDARDS

Standards for ATM developed as part of the overall B-ISDN evolution. It is based upon a layered architecture similar in concept to that used by the International Standards Organization (ISO). The seven layer open systems interconnection (OSI) model is explained in many reference texts and will not be discussed in detail here. Basically, such models divide any communications process into subprocesses, called layers, arranged in a hierarchical stack, *Figure 1.* Each layer provides services to the layers above to aid in communications between the top layer processes. Another important concept behind layering is the ability to revise or change a layer without impacting the protocol layers above and below. For example the physical layer for ATM may be changed from SONET to DS3 without impact on the ATM layer above or the services provided to higher layers.

For each plane, a layered approach as in OSI is used with independence between layers[11]. According to CCITT, the layers can be further divided into a physical layer which mainly transports information (cells), the ATM layer which performs mainly switching/routing and the AAL (ATM Adaption Layer) which is mainly responsible for adapting service information into sublayers. The ATM layer is fully independent of the physical medium used to transport the ATM cells. The cell, as mentioned earlier fixed in length at 53 bytes total with a 48 byte payload and a 5 byte header. The six different functions:

- Virtual path ID
- Virtual channel ID

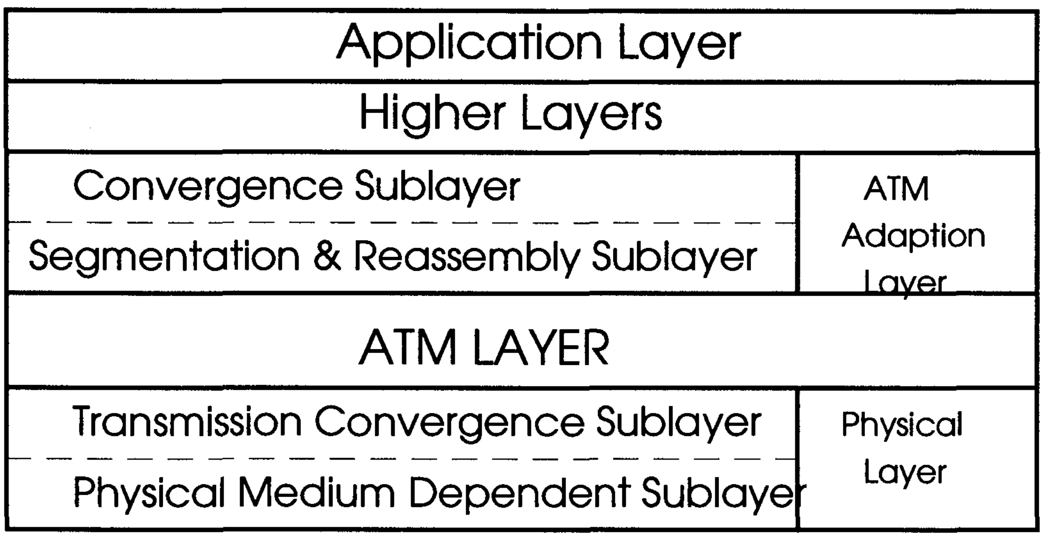

Figure 1

- Payload type
- Reserved
- Cell loss priority
- Header error control

The ATM protocol model can be divided into three phases:

- a user plane to transport user information
- a control plane composed of signaling information
- a management plane used to maintain the network

One of the most important functions of ATM is its ability to integrate and transport data services of varying rates: voice at 64 kbps to multiplexed video channels at 30+ Mbps to data information transfer at 100+ Mbps.

VALUE TO NETWORKS

Businesses today have been building private ATM networks with great success. These users are interested in high speed data transfer and are increasingly demanding desktop video telephony. Residential customers are mostly interested in plain old telephone service and TV distribution. The proposed architecture will offer increasingly high speed connectivity for all customers. It is foreseen that the terminal equipment installed at both the residential and business customers can be modularly upgraded as new services are introduced.

ATM is not without its detractions. ATM is not yet a fully accepted standard. There are various portions of the ATM OSI model that have not totally evolved out of the standards committees. ATM is not ubiquitous in that there are very few public networks with ATM capable switching apparatus. ATM does not have global acceptance. Although the CCITT sponsors further international standards development of ATM not all participating nations agree on the finer details of deployment.

HDTV transport layer work by the Grand Alliance (GA) has ensured interoperability with two of the most important alternative transport systems, namely, MPEG-2 and ATM. The GA transport packet size has been selected to ease transferring ATV transport packets in a link layer that supports ATM. Three techniques have been developed that are fully interoperable[12]. Since several of the CATV and DBS systems being designed are considering using a variant of the MPEG-2 transport layer the degree of interoperability will remain high for some future period of time.

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