ATM

This lecture describes ATM, a transmission and switching technology based on a hybrid of circuit-switching and fixed-length packets. It was meant to integrate data and telephone networks but was not competitive with conventional packet-based networks. Today ATM is primarily used to route packets along virtual circuits in other networks.
After this lecture you should be able to: encapsulate a sequence of bytes into ATM cells using AAL5 SAR and describe the path followed by an ATM cell given the switching table contents for a set of ATM switches.

Introduction

Asynchronous Transfer Mode (ATM) was an attempt by telephone companies to design a network architecture that could efficiently transport both voice and data. It used small packets to minimize queuing delay and virtual circuits to simplify the design of high-speed packet switches.

As data rates on fiber optic links increased, the need for short packets disappeared. Advances in computer hardware also allowed conventional IP routers to keep up with increases in core network data rates. These developments made ATM technology uncompetitive.

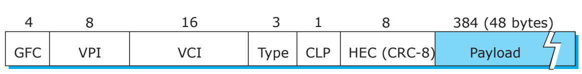
We will study ATM because it is still used for routing packets in ADSL access networks and the concept of virtual circuits is still used by an IP-specific protocol, MPLS.

ATM Cells

ATM breaks up data into fixed-length cells with a 5-byte header and a 48-byte payload. The purpose was to minimized the queuing delay that would be experienced by speech during phone calls.

Exercise 1: How long does it take to transmit a 1500-byte packet over a store-and-forward network with 10 hops at the DS1 rate? At a 1 Gb/s rate? How does this compare to the propagation delay for a 2000 km path?

An ATM cell header needs to be short for efficiency. ATM uses a 5-byte header as shown below[1]:



[1] From L. Peterson, "Computer Networks", 2003. A slightly different header is used between ATM switches.

The meanings of the fields are:

- GFC: flow control, typically set to zero.
- VPI, VCI: virtual path (8/12 bits) and circuit (16 bit) identifiers: the destination address. All connections in the same path flow through the same physical path.
- Payload Type, CLP: four flag bits, the third bit is set to '1' to indicate that this is the last frame of a higher-level frame.
- HEC: header error check, an 8-bit CRC on the header only.

Exercise 2: What fraction of an ATM frame is overhead? How large does the payload of an Ethernet frame need to be to achieve the same efficiency (an Ethernet frame has a 2×6-byte address field, a 2-byte length/type field and a 4-byte CRC)?

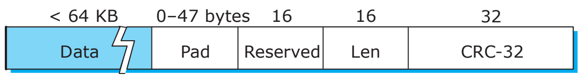
Note that there is no error detection on the payload. ATM is typically operated over wired physical layers such as SONET that have low error rates and error control at the link layer would not improve efficiency. Instead, higher-level protocols do error control (detection and retransmission) if required.

Adaptation Layers

Various ATM Adaptation Layers (AALs) define ways that different types of traffic are converted to and from ATM cells. For example, AAL1 defines how constant bit rate traffic (e.g. a T1) is broken up into ATM cells.

The most widely used AAL is probably AAL5. It is used for segmentation and reassembly (SAR) of data packets such as IP frames. The segmentation process is as follows:

- the last cell is padded to a length of 40 bytes.
- an 8-byte trailer is added that contains a 2-byte length field, a 4-byte CRC and 2 unused bytes. The result is as shown below:



- the packet is then split into 48-byte cells and an ATM header with the appropriate VPI/VCI is added to each cell.
- the last (third) bit of the payload Type field in the header of the last cell is set to 1.

Reassembly reverses the process. Bytes from incoming cells are buffered until the last bit of the Type field is set to 1. Then the length field is used to remove the padding and the CRC is checked before passing the received frame to the next protocol level.

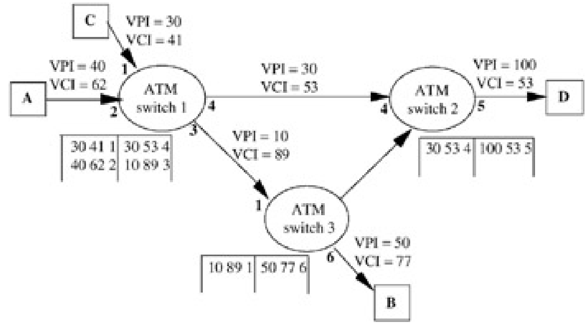
Exercise 3: A 64-byte IP frame is being transmitted over ATM to VPI/VCI 0.33. Calculate the contents of the ATM cell headers (set the CRCs to zero).

ATM Switches

Originally the VPI/VCI were intended to implement flexible routing of frames in a large-scale (global) network. ATM switches (routers) use the VPI/VCI of each incoming frame to look up a replacement VPI/VCI and what port to output the frame on. The VPI/VCI is also replaced ("label swapping") at each switch in case different parts of the network use different sets of addresses. However, in a small network the same VPI/VCI can be retained.

Exercise 4: The diagram below[2] shows the switching tables at each port of a small ATM network. Where do the frames labelled A and C end up?

[2]Taken from Perros, Connection-Oriented Networks: SONET/SDH, ATM, MPLS and Optical Networks, Wiley, 2005.



ATM Signalling

One of the goals of ATM was to replace the PSTN with a network capable of handling both voice and data[3]. A signalling protocol was defined that could set up switching tables in ATM switches so that ATM cells would be correctly routed along this virtual circuit.

There was little interest in this approach and today the majority of ATM applications use "permanent virtual circuits" (PVCs) rather than dynamic "switched virtual circuits" (SVCs).

ATM QoS

At the same time as circuits were being set up, bandwidth resources could be reserved at each switch to ensure Quality of Service (QoS). A flexible mechanism was defined to give different priorities to different types of traffic. For example, delay-sensitive speech packets would be forwarded before data packets. In case of congestion lower-priority packets could be dropped.

For this purpose each connection can specify the type of service required, for example constant or variable bit rate (CBR, VBR), real-time (rt) or non-real-time (nrt), and guaranteed frame rate (

Unfortunately, identifying and prioritizing IP traffic flows is difficult and in many cases the bottleneck is the access network. Thus the QoS feature provided by ATM have not proved to be a significant advantage.

[3]Controlled by the telephone companies, of course!