Chapter 1

1-1. Five routers are to be connected in a point-to-point subnet. Between each pair of routers, the designers may put a high-speed line, a medium-speed line, a low-speed line, or no line. If it takes 100 ms of computer time to generate and inspect each topology, how long will it take to inspect all of them?

Solution: 10 possible links, each with 4 choices, so there are 4^{10}=1048576 topologies.). At 100 ms each, it takes 104857.6 sec, or around 29 hours.

1-2. What are two reasons for using layered protocols? What is one possible disadvantage of using layered protocols?

Solution:

1，模式分解，小模块，易实现易管理。

2，层次架构，层封装，易更换易拼接。

可能缺点：

不同层次间设计与实现的割裂，相比整体化方案可能存在异构对接问题。

1-3. What is the principal difference between connectionless communication and connection-oriented communication? Give one example of a protocol that uses

(i) connectionless communication

(ii) connection-oriented communication

主要的区别有两条。

其一：面向连接通信分为三个阶段，第一是建立连接，在此阶段，发出一个建立连接的请求。只有在连接成功建立之后，才能开始数据传输，这是第二阶段。接着，当数据传输完毕，必须释放连接。而无连接通信没有这么多阶段，它直接进行数据传输。

其二：面向连接的通信具有数据的保序性，而无连接的通信不能保证接收数据的顺序与发送数据的顺序一致。

(i)无连接：UDP；

(ii)面向连接：TCP

1-4. In some networks, the data link layer handles transmission errors by requesting that damaged frames be retransmitted. If the probability of a frame's being damaged is p, what is the mean number of transmissions required to send a frame? Assume that acknowledgements are never lost.

$$\boldsymbol{E(X) = \sum_{k=1}^{\infty} x_k p_k}$$

$$E(X) = \sum_{k=0}^{\infty} k(1-p)p^{k-1} = 1/(1-p)$$

1-5. What is the main difference between TCP and UDP?

Solution:
TCP : connection oriented, reliable service.
UDP: connectionless, unreliable service.

1-6. An image is 1024 X 768 pixels with 3 bytes/pixel. Assume the image is uncompressed. How long does it take to transmit it over a 56-kbps modem channel?
Over a 1-Mbps cable modem?
Over a 10-Mbps Ethernet?
Over 100-Mbps Ethernet?
Over gigabit Ethernet?

Solution: 1024 * 768 * 3 * 8=18,874,368 bits.
At 56,000 bps => 337 sec.
At 1,000,000 bps => 18.874 sec.
At 10,000,000 bps => 1.887 sec.
At 100,000,000 bps => 0.189 sec.
At 1,000,000,000 bps => 19 msec.

1-7. Standardization is very important in the network world. ITU and ISO are the main official standardization organizations. Go to their Web sites, www.itu.int and www.iso.org,respectively,and learn about their standardization work. Write a short report about the kinds of things they have standardized.

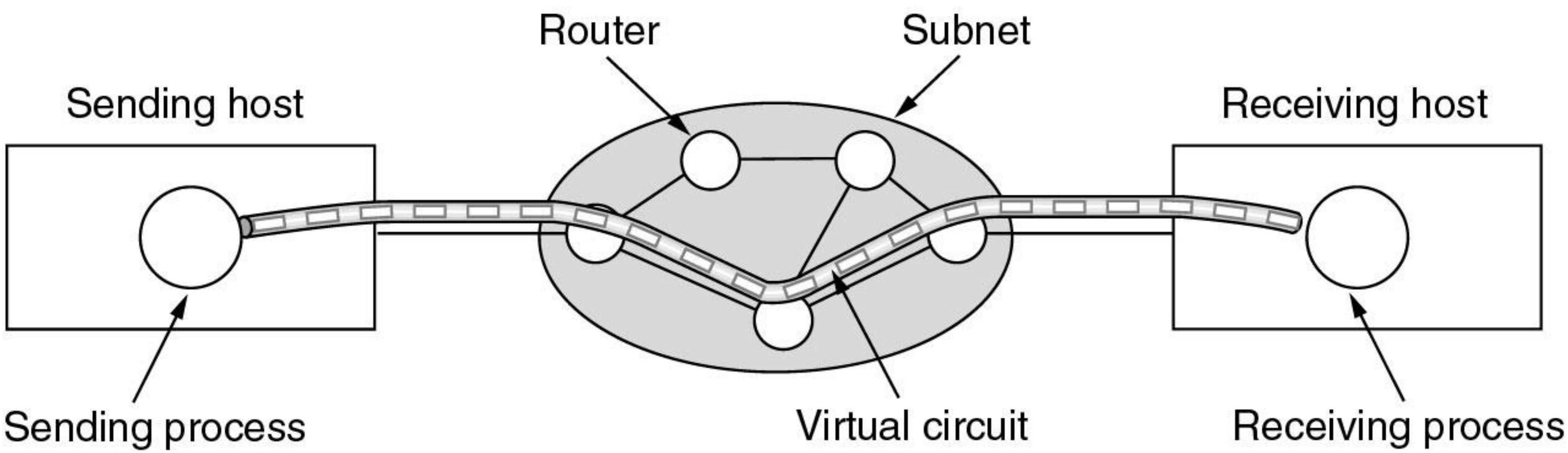
30. What are the disadvantages of using small, fixed-length cells in ATM?

Solution:

Small-sized cells => large header-to-payload overhead.

Fixed-size cells => high wastage of unused bytes in the payload.

ATM Virtual Circuits

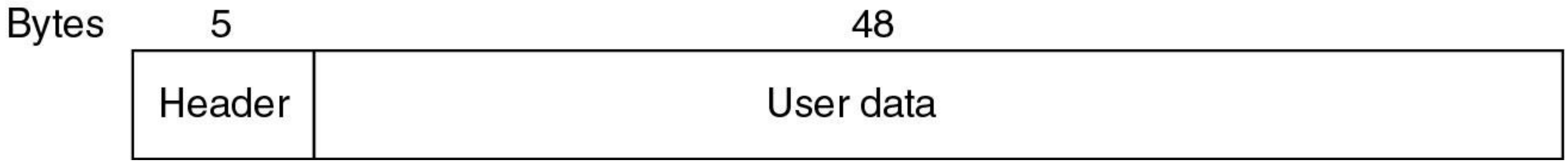


ATM (Asynchronous Transfer Mode异步传输模式)

A virtual circuit.

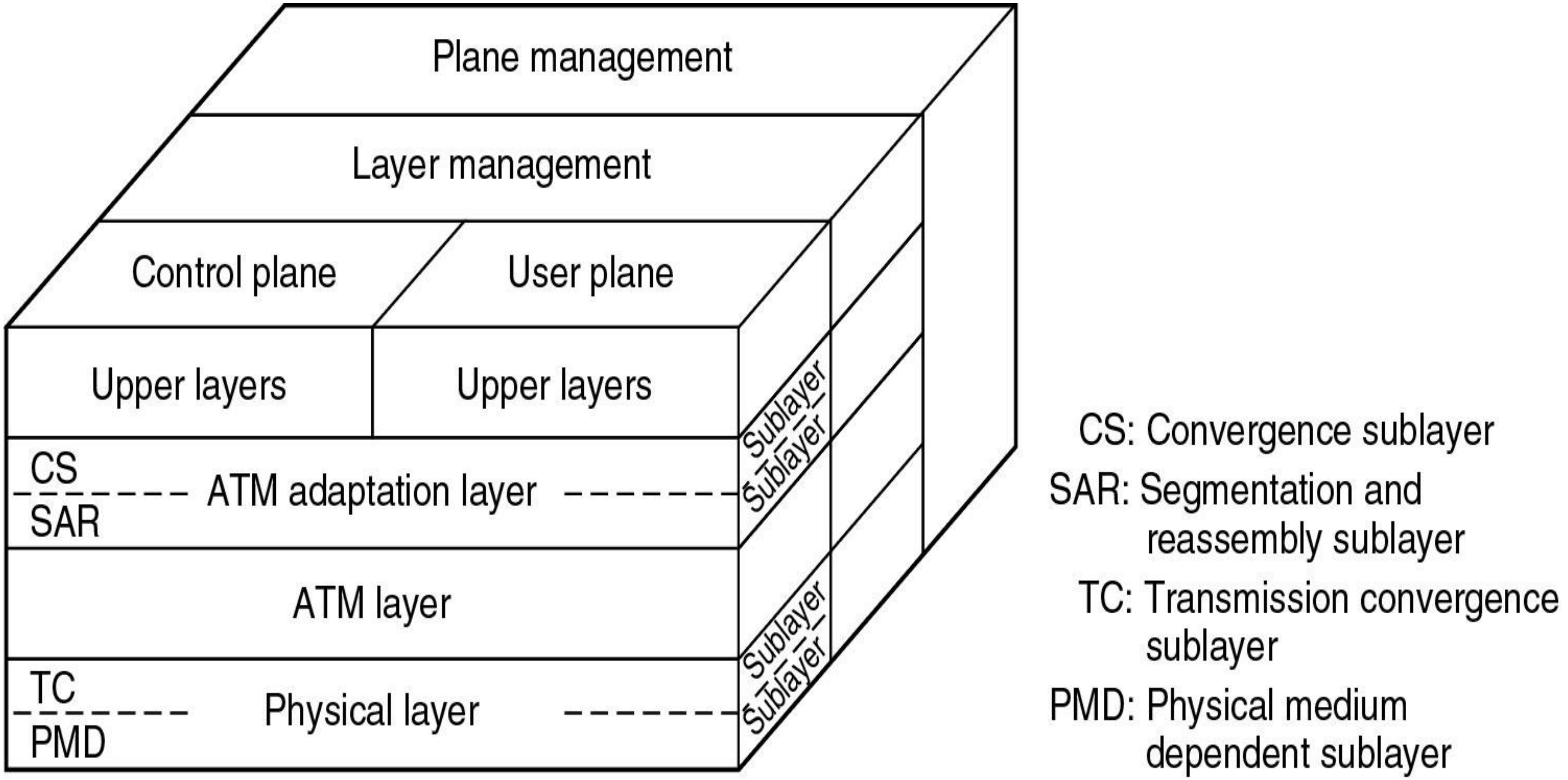
Automatic Teller Machine

ATM Virtual Circuits (2)



An ATM cell.

The ATM Reference Model



The ATM reference model.

The ATM Reference Model (2)

OSI layer	ATM layer	ATM sublayer	Functionality
3/4	AAL	CS	Providing the standard interface (convergence)
		SAR	Segmentation and reassembly
2/3	ATM		Flow control Cell header generation/extraction Virtual circuit/path management Cell multiplexing/demultiplexing
2	Physical	TC	Cell rate decoupling Header checksum generation and verification Cell generation Packing/unpacking cells from the enclosing envelope Frame generation
1		PMD	Bit timing Physical network access

The ATM layers and sublayers and their functions.

Chapter 2

2-1. If a binary signal is sent over a 3-kHz channel whose signal-to-noise ratio is 20 dB, what is the maximum achievable data rate?

Solution:

SNR=20 dB => S/N = 100.

•Nyquist's theorem

maximum data rate = $2H \log_2 V$ bits/sec

=> 6 kbps for a binary signal (with 1 bit per symbol).

•Shannon's theorem

maximum data rate = $H\log_2 (1+S/N)$ bits/sec

$\log_2 101 = 6.658$ => 19.975 kbps.

=>maximum channel capacity is 6 kbps.

The Maximum Data Rate of a channel

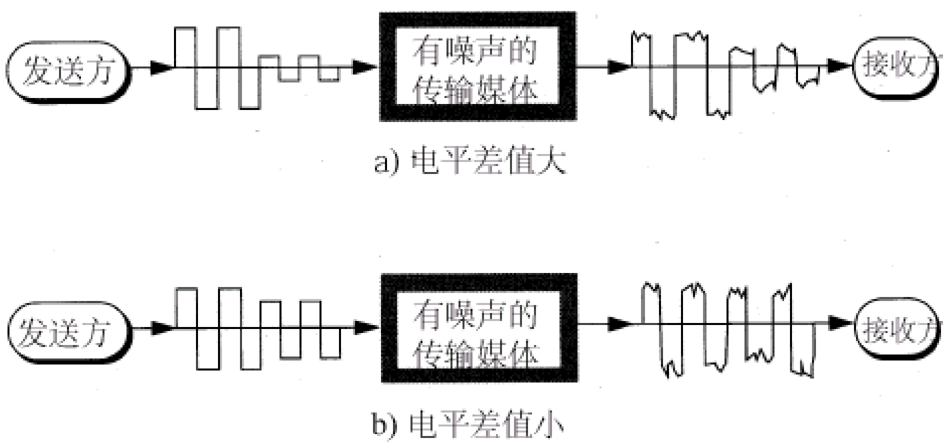
- **Bandwidth limited data rate**

•Nyquist's theorem

maximum data rate = $2H \log_2 V$ bits/sec

•Shannon's theorem

maximum data rate = $H\log_2 (1+S/N)$ bits/sec



噪声对数字信号的影响

How many levels we can distinguish depends on S/N

2-2. What signal-to-noise ratio is needed to put a T1 carrier on a 50-kHz line?

Solution:

T1 signal => H log2(1 + S/N) = 1. 544 *10^6 , H = 50,000.

=> S/N = 2^30.88 - 1

=> 93 dB.

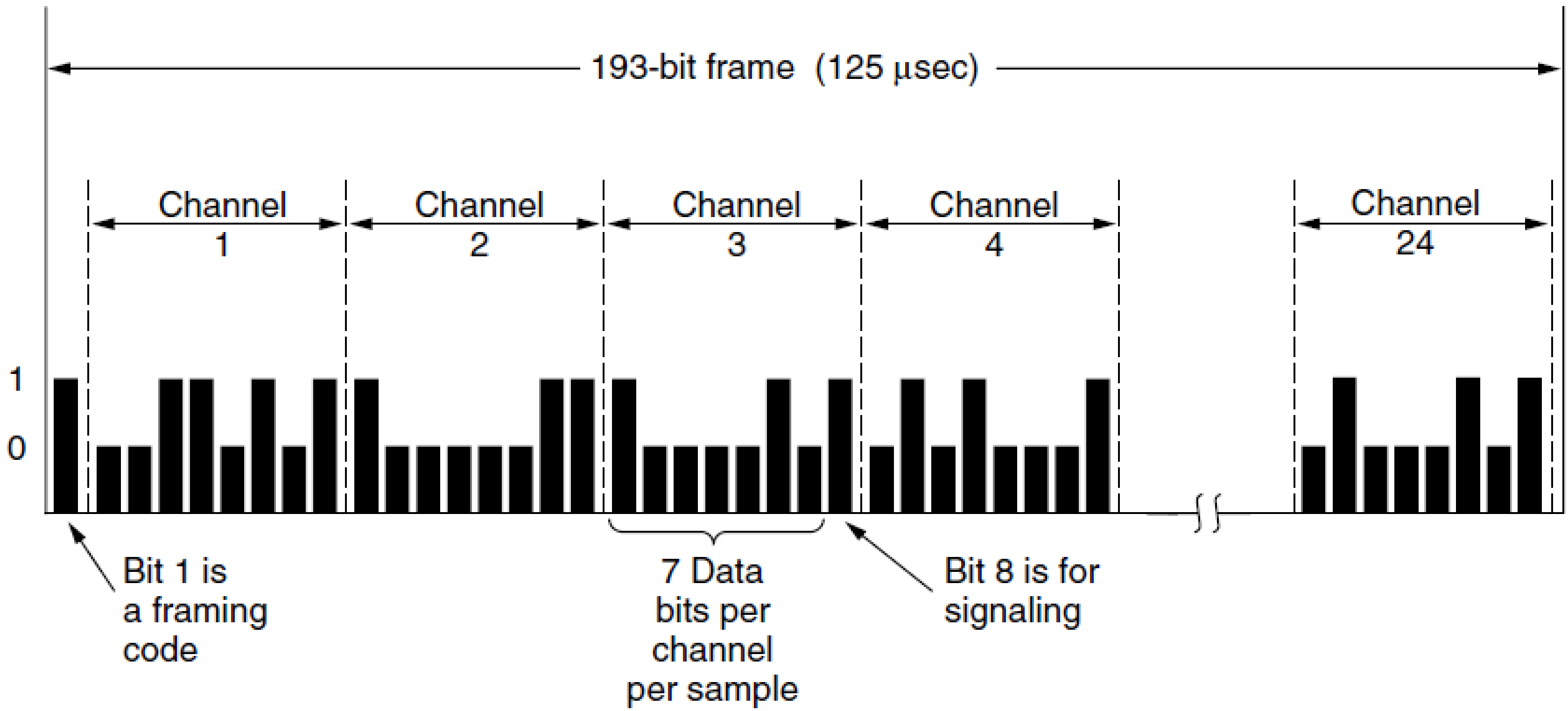


Figure 2-37. The T1 carrier (1.544 Mbps).

A frame consists of $24 \times 8 = 192$ bits plus one extra bit for control purposes, yielding 193 bits every 125 μsec. This gives a gross data rate of 1.544 Mbps, of which 8 kbps is for signaling. The 193rd bit is used for frame synchronization and

2-3. How much bandwidth is there in 0.1 microns of spectrum at a wavelength of 1 micron?

Frequency and wave length $\lambda f=c$

Solution:

f_l= 3 *10^8 / (1. 05 *10^-6) = 3*10^14/1. 05.

f_h = 3*10^14/0. 95.

$\Rightarrow$ f = (3/0. 95 - 3/1. 05) *10^14 = 3 *10^13 = 30,000 GHz.

~~f = 3 *10^8 / (0. 1 *10^-6) ?~~

2-4. It is desired to send a sequence of computer screen images over an optical fiber. The
screen is 2560 $\times$ 1600 pixels, each pixel being 24 bits. There are 60 screen images per
second. How much bandwidth is needed, and how many microns of wavelength are
needed for this band at 1.30 microns?

(1) The data rate is $2560 \times 1600 \times 24 \times 60$ bps, which is 5898 Mbps.

(2) For simplicity, let us assume 1 bps per Hz. From Eq. 2-4, we have $\Delta\lambda = \lambda^2 \Delta f / c$. Since 1.3 microns are 1.3×10^{-6}, and $\Delta f = 6 \times 10^{9}$, so $\Delta\lambda = 1.69 \times 10^{-12} \times 6 \times 10^{9} / (3 \times 10^{8}) = 3.3 \times 10^{-11}$ meters $= 3.3 \times 10^{-5}$ microns. The range of wavelengths used is very short.

2-5. Radio antennas often work best when the diameter of the antenna is equal to the wavelength of the radio wave. Reasonable antennas range from 1 cm to 5 meters in diameter. What frequency range does this cover?

Solution:

For $\lambda = 1$ cm, $\lambda f=c$ =>30GHz.

For $\lambda = 5$ m , $\lambda f=c$ => 60 MHz.

Thus, frequency range is 60 MHz to 30GHz.

2-6. Ten signals, each requiring 4000 Hz, are multiplexed onto a single channel using FDM. What is the minimum bandwidth required for the multiplexed channel? Assume that the guard bands are 400 Hz wide.

Solution:

10×4000 Hz for signals.

400×9 Hz for guard bands.

In total we need $4000 \times 10 + 400 \times 9 = 43,600$ Hz.

2-7. Why has the PCM sampling time been set at 125 μsec?

Solution:

A sampling time of 125 μsec makes 8000 samples per second , the Nyquist theorem says that this is sufficient to capture all the information from the 4-kHz telephone channel bandwidth. At a lower sampling rate, information would be lost; at a higher one, no extra information would be gained.

2-8. Compare the maximum data rate of a noiseless 4-kHz channel using
(a) Analog encoding (e.g., QPSK) with 2 bits per sample.
(b) The T1 PCM system.

Solution:
4-kHz channel => 8000 samples/sec by Nyquist theorem.

QPSK encoding with 2 bits per sample => 16 kbps .

T1 PCM with 8 bits per sample => 64 kbps. (Page 153)

2-9. A CDMA receiver gets the following chips: (-1 +1 -3 +1 -1 -3 +1 +1). Assuming the chip sequences defined in Fig. 2-28(a), which stations transmitted, and which bits did each one send?

Solution:

Just compute the four normalized inner products:

$$(-1\ +1\ -3\ +1\ -1\ -3\ +1\ +1) \bullet (-1\ -1\ -1\ +1\ +1\ -1\ +1\ +1)/8 = 1$$
$$(-1\ +1\ -3\ +1\ -1\ -3\ +1\ +1) \bullet (-1\ -1\ +1\ -1\ +1\ +1\ +1\ -1)/8 = -1$$
$$(-1\ +1\ -3\ +1\ -1\ -3\ +1\ +1) \bullet (-1\ +1\ -1\ +1\ +1\ +1\ -1\ -1)/8 = 0$$
$$(-1\ +1\ -3\ +1\ -1\ -3\ +1\ +1) \bullet (-1\ +1\ -1\ -1\ -1\ -1\ +1\ -1)/8 = 1$$

The result is that *A* and *D* sent 1 bits, *B* sent a 0 bit, and *C* was sile

2-10. A cable company decides to provide Internet access over cable in a neighborhood consisting of 5000 houses. The company uses a coaxial cable and spectrum allocation allowing 100 Mbps downstream bandwidth per cable. To attract customers, the company decides to guarantee at least 2 Mbps downstream bandwidth to each house at any time. Describe what the cable company needs to do to provide this guarantee.

Solution:

Each cable can afford 50 houses, in total we need 100.