Advanced Computer Architecture

Lecture No. 44

Reading Material

Patterson, D.A. and Hennessy, J.L. Chapter 8
Computer Architecture- A Quantitative Approach

Summary

- Physical Media (Continued)
- Shared Medium
- Switched Medium
- Connection Oriented vs. Connectionless Communication
- Network Topologies
- Seven-layer OSI Model
- Internet and Packet Switching
- Fragmentation
- Routing

Modem

To interconnect different computers by using twisted pair copper wire, an interface is used which is called modem. Modem stands for modulation/demodulation. Modems are very useful to utilize the telephone network (i.e. 4 KHz bandwidth) for data and voice transmission.

Quality of Telephone Line

Data transfer rate depends upon the quality of telephone line. If telephone line is of fine quality, then data transfer rate will be sufficiently high. If the phone line is noisy then data transfer rate will be decreased.

Classification of Fiber Optic Cables

Fiber optic cables can be classified into the following types.

Multimode fiber

This fiber has large diameter. When light is injected, it disperses, so the effective data rate decreases.

Mono mode Fiber

Its diameter is very small. So dispersion is small and data rate is very high.

Wavelength –Division Multiplexing (WDM)

Waves of different wavelengths are simultaneously sent through fiber. So as a result, throughput increases.

Wireless Transmission

This is another effective medium for data transfer. Data is transferred in the form of electromagnetic waves. It has the following features:

- Data rate is in Mbits/Sec.
- Very effective because of flexibility.
- Band width is much less than fiber.

Example 1

Suppose we have 20 magnetic tapes, each containing 40GB. Assume that there are enough tape readers to keep any network busy. How long will it take to transmit the data over a distance of 5Km? The choices are category 5 twisted-pair wires at 100Mbits/sec, multimode fiber at 1500Mbits/sec and single-mode fiber at 3000Mbits/sec. (Adapted from CA3: H&P)

Solution

The total amount of data
= total no. of mag. tapes x capacity of each tape
= 20 x 40GB= 800GB

The time for each medium:
Twisted pair = 800GB/100Mbits/sec
= 65536 sec = 18.2 hr
Multimode Fiber = 800GB/1500Mbits/sec
= 4369.06sec = 1.213 hr

Single mode Fiber = 800GB/3000Mbits/sec
= 2184.55sec
= 0.66hr

Car = time to load car + transport time + time to unload car
= 250sec + 5Km/30Kph + 250sec
= 500.16 sec = 0.13hr

Shared/Switched Medium

Shared Medium

If a number of computers are connected with a single physical medium (i.e. coaxial or fiber), this situation is called shared medium. Because of many computers, collision takes place and affects the data transfer rate. As the number of machines on a physical medium increases, the data transfer rate decreases.

Switched Medium

To increase the throughput, a switched medium is used.

Example 2

Compare 20 nodes connected in three different ways: a single 100Mbits/sec shared medium; a switch connected via cat5, each segment running at 100Mbits/sec; and a switch connected via optical fiber, each segment running at 1500Mbits/sec. The shared medium is 700m long, and the average length of each segment to a switch is 55m. Both switches can support full bandwidth. Assume each switch adds 6µsec to the latency, and the average message size is 200bytes. Ignore the overhead of sending or receiving a message and contention for the network.

Solution

First we will calculate the aggregate bandwidth:
<u>For shared medium</u>

Aggregate bandwidth = 100Mbits/sec
<u>For switched twisted pair</u>

Aggregate bandwidth = 20 x 100Mbits/sec
= 2000Mbits/sec
<u>For switched optical fiber</u>

Aggregate bandwidth = 20 x 1500Mbit/sec
= 30,000Mbits/sec

Transport time = Time of flight + (message size/BW)

$$\text{Transport time shared} = \frac{(700/1000)\text{Km}}{(2/3 \times 300{,}000)\text{Km}} \times 10^6 \mu\text{sec} + (200 \times 8\text{bits} / 100\text{Mbits/sec})$$

$$= 3.5\mu\text{sec} + 16\mu\text{sec} = 19.5\mu\text{sec}$$

For the switches, the distance is twice the average segment. We must also add latency for the switch.

$$\text{Transport time switch} = 2\text{x} \frac{(55/1000)\text{Km}}{(2/3 \times 300{,}000)\text{Km}} \times 10^6 \mu\text{s} + 6\mu\text{sec} + (200 \times 8\text{bits} / 100\text{Mbits/sec})$$

$$= 0.55\mu\text{sec} + 6\mu\text{sec} + 16\mu\text{sec}$$
$$= 22.55\mu\text{sec}$$

$$\text{Transport time fiber} = 2x \frac{(55/1000)\text{Km}}{(2/3 \times 300{,}000)\text{Km}} \times 10^6 \mu s$$
$$+ 6\mu sec$$
$$+ (200 \times 8bits / 1500Mbits/sec)$$

$$= 0.55\mu sec + 6\mu sec + 1.06\mu sec$$
$$= 7.61\mu sec$$

Although the bandwidth of the switch is many times that of the shared medium, the latency for unloaded networks is comparable.

Connection Oriented vs. Connection less Communication

Connection Oriented Communication

- In this method, same path is always taken for the transfer of messages.
- It reserves the bandwidth until the transfer is complete. So no other server could use that path until it becomes free.
- Telephone exchange and circuit switching is the example of connection oriented communication.

Connection less Communication

- Here message is divided into packets with each packet having destination address.
- Each packet can take different path and reach the destination from any route by looking at its address.
- Postal system and packet switching are examples of connection less communication.

Network Topologies

Computers in a network can be connected together in different ways. The following three topologies are commonly used:

- Bus topology
- Star topology
- Ring topology

Bus Topology

In this arrangement, computers are connected via a single shared physical medium.

Star topology

Computers are connected through a hub. All messages are broad cast because the hub is not an intelligent device.

Ring Topology

All computers are connected through a ring. Only one computer can transmit data at one time, having a pass called “Token”.

Seven Layer OSI Model

There are seven layers in this model.

1. Physical Layer
2. Data Layer
3. Network Layer
4. Transport Layer
5. Session Layer
6. Presentation Layer
7. Application Layer

OSI Model Characteristics

- An interface is present between any two layers.
- A layer may use the data present in another layer.
- Each layer is abstracted from other layers.
- The service provided by one layer can be used by the other layer.
- Two layers can provide same service e.g. Check Sum calculated at different layers.
- On two machines, six layers are logically connected except the physical layer. The physical layers of two machines are physically connected.

Internet and Packet Switching

Internet works on the concept of packet switching. Application layer passes data to the lower layer and that lower layer passes data to the next lower layer and on so on. In this data passing process through different layers, different headers are attached with the data which shows the source and destination addresses, number of data bytes in packet, type of message etc. At physical layer, this packet is transmitted into the network. At reception, reverse procedure is adopted.

Fragmentation

When a packet is lost in the network, it is re-transmitted. If the size of the packet is large then retransmission of packet is wastage of resources and it also increases the delay in the network. To minimize this delay, a large packet is divided into small fragments. Each fragment contains a separate header having destination address and fragment number. This fragmentation effectively reduces the queuing delay. At destination, these fragments are re-assembled and data is sent to the application layer.

Routing

Routing works on store-and-forward policy. There are three methods used for routing:

- Source-based routing
- Virtual Circuit
- Destination-based routing

TCP/IP

Internet uses TCP/IP protocol. In the TCP/IP model, session and presentation layers are not present, so Store-Forward routing is used.