COMPUTER NETWORKING Study Notes

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Study Notes
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Contents

Chapter 1

Computer Networks and the Internet

1.1 The Internet

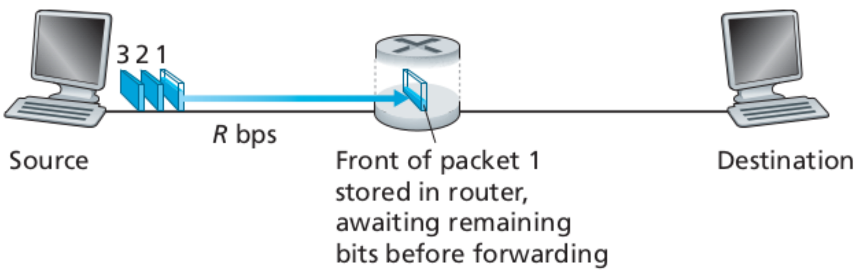
1.1.1 Terminology

1. ISP: Internet Service Provider
2. Host: End System
3. DSL: Digital Subscriber Line
4. FTTH: Fiber To The Home
5. LAN: Local Area Network
6. WAN: Wide Area Network

1.2 Packet Switching

packets :smaller chunks of data known as .

1.2.1 Store and Forward Transmission



1. The packet switch must receive the entire packet before it can transmit it.
2. Store: the switch buffer the packet's bits.
3. Forward: transmit the packet onto the outbound link.

1.2.2 Queuing Delays and Packet Loss

1. Each node has an output buffer/queue.
2. Each packet on the buffer wait for its turn to be transmitted.
3. Queuing Delay: The time that packet waits in the buffer.
4. Packet Loss: when buffer is completey full, the arriving packets will be dropped.

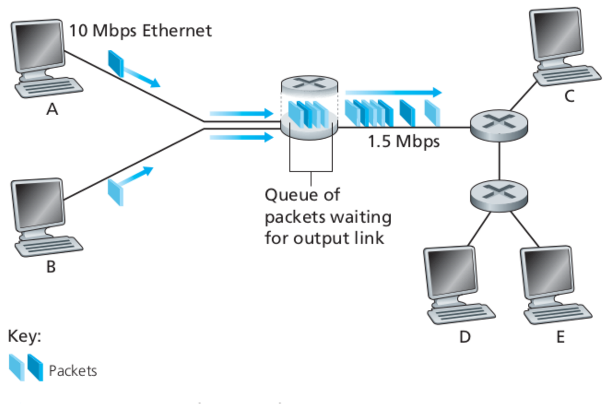


Figure 1.1: Packet Switching

1.2.3 Forwarding Tables and Routing Protocols

1. Each router has an IP address.
2. Each router has a **forwarding table**: Maps the destination addresses to outbound links.
3. End-to-end routing <=> taxi driver who doesn't use map but instead prefers to ask the directions.

1.3 Circuit Switching

Usage: traditional telephone networks.

1. Circuit Switching reverse resources.

1.3.1 Multiplexing in Circuit-Switched networks

1. FDM: frequency-division multiplexing
2. TDM: time-division multiplexing

FDM:frequency-division multiplexing

Frequency spectrum of a link is divided up among the connections established across the link.
For example, FM radio stations use FDM to share frequency spectrum between 88MHZ nd 108MHZ.

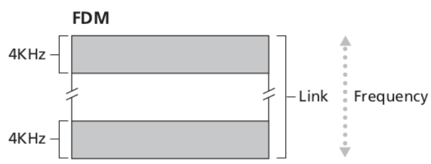


Figure 1.2: FDM

TDM: time-division multiplexing

Time is divided into frames of fixed duration, each frame is divided into fixed number of time slots. Each frame is like a round. At each frame, the use has guaranteed time slots to use.

1.3.2 Packet Switching Versus Circuit Switching

Advantage of Packet Switching

1. It offers better sharing of transmission capacity
2. Simpler, more efficient, and less costly to implement.

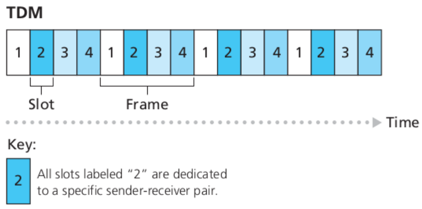


Figure 1.3: TDM

1.3.3 Why Packet Switching is more efficient?

Assumption: 90/10 rule: 90 percent of the time the user is idling.

Suppose users share a 1 Mbps link. Also suppose that each user alternates between peri- ods of activity, when a user generates data at a constant rate of 100 kbps, and periods of inactivity, when a user generates no data. Suppose further that a user is active only 10 percent of the time.

With Circuit Switching, 100 kbps must be reversed even the user is drinking coffee. Therefore only 1Mbps/100Kps = 10 users can share the link at the same time.

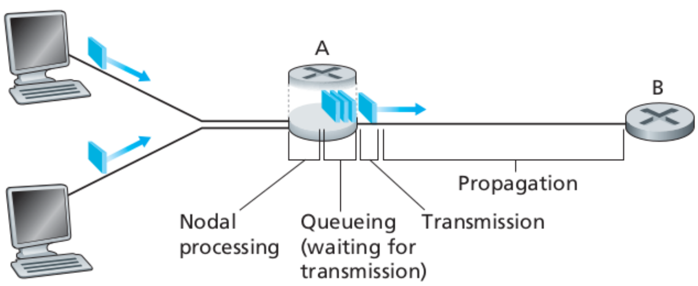
With Packet Switching, if there are 35 users, the probability that there are 11 or more users using the link simultaneously is less than 0.0004. Statistically, the packet switching is more efficient.

1.3.4 Advantage of Circuit Switching

1. Rate is guaranteed, suitable for real time services.

1.3.5 Delay, Loss, and Throughput in Packet-Switched Networks

Nodal delay = Processing Delay + Queuing Delay + Transmission Delay + Propagation Delay



1. Throughput: The amount of data per unit time that can be transferred between end hosts.
2. Processing Delay: The time required to examine the packet's header and determine where to direct packet is part of processing delay.
3. Queuing Delay: The time that the packet waits in the buffer.
4. Transmission Delay: The amount of time to put the complete packet onto the link.
5. Propagation Delay: The time required to propagate from the beginning of the link to the next node.

Processing Delay

Several parts of the processing delay:

1. The time required to examine the packet's header
2. The time required to check bit-level errors

Queuing Delay

The length of queuing delay is depended on the number of packets waiting in the buffer/queue. If the queue is empty and no other packet is currently being transmitted, the queuing delay will be zero. Queuing can vary in a large scope. Queuing delays can be on the order of microseconds to milliseconds in practice.

Transmission Delay

Transmission delay depends on the physical medium of the link.
Transmission delay = the time the first bit is put on the link - the time the last bit is put on the link.
Denote the packet size L, and the transmission rate R.
The transmission delay will be $\frac{L}{R}$.

Propagation Delay

Propagation Delay depends on the physical medium of the link.
Denote the distanct between nodes d, and the speed of propagation (the speed of the link, usually a little less than the speed of light).
The propagation delay is d/s.
The progation delay can be negligible using fiber, but can be dominant if using satellite link.

1.3.6 Queuing Delay and Packet Loss

Unlike other delays, queuing delay can vary from packet to packet. For example 10 packets arrive at the same empty queue at the same time, the first packet will have zero queuing delay and the last packet will have relatively large queuing delay.
When is the queuing delay large and when is it insignificant? => Depends on the rate of the arrving traffic(packets), the transmission rate of the link, and hether the traffic arrives periodically or arrives in bursts.

Let a denote the average rate at which packets arrive at the queue (a is in units of packets/sec). Recall that R is the transmission rate; that is, it is the rate (in bits/sec) at which bits are pushed out of the queue. Also suppose, for simplicity, that all packets consist of L bits.

$$\text{Traffic instensity: } \frac{La}{R}$$

If $\frac{La}{R}$ >1, the link is very busy and the queuing delay will continously increse and into infinite. If $\frac{La}{R}$ < 1, is a necessary for reduce the queuing delay.

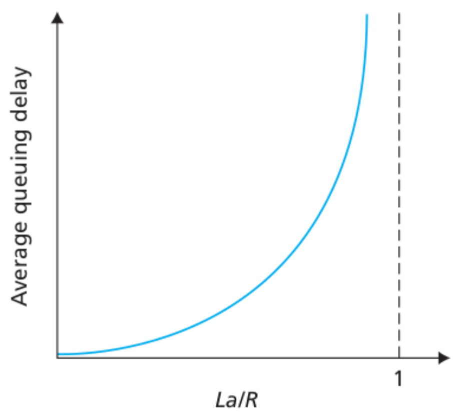


Figure 1.4: Dependence of average queuing delay on traffic intensity

1.3.7 End-to-End Delay

Suppose there are $N-1$ routers between the source host and the destination host. The transmission rate is fixed R, and the the distanct between each router is L. The end-to-end delay is:

$$d_end - end = \sum_{i=1}^{N} d_{proc} + d_{trans} + d_{prop} + d_{queu_i}$$

1.4 Protocol layering

Five-layer Internet Protocol Stack: Each layer provides services to the layer aboves it by 1)performing certain actions within that layer and by 2)using the services of the layer directly below it.

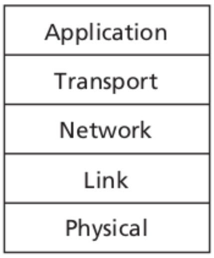


Figure 1.5: Five-layer Protocol Stack

1.4.1 Packet at different layers

1. Message : Application Layer
2. Segment : Transport Layer
3. Datagram : Network Layer
4. Frame : Link Layer

1.4.2 Application Layer

The Internet's application layer includes many protocols:

1. HTTP
2. SMTP
3. FTP
4. DNS
5. ...

1.4.3 Transport Layer

1. TCP
2. UDP

1.4.4 Networking Layer

Only one procotol is available at this layer => **IP** (*Internet Protocol*).

1.4.5 Link Layer

Examples of linklayer protocols include:

1. Ethernet
2. WiFi
3. DOCIS

1.4.6 Physical Layer

The protocols in this layer are again link dependent and further depend on the actual transmission medium of the link For example, Ethernet has many physical-layer protocols:

1. twisted-pair copper wire
2. coaxial cable
3. fiber

need to be

In each case, a bit is moved across the link in a different way.

1.5 Encapsulation

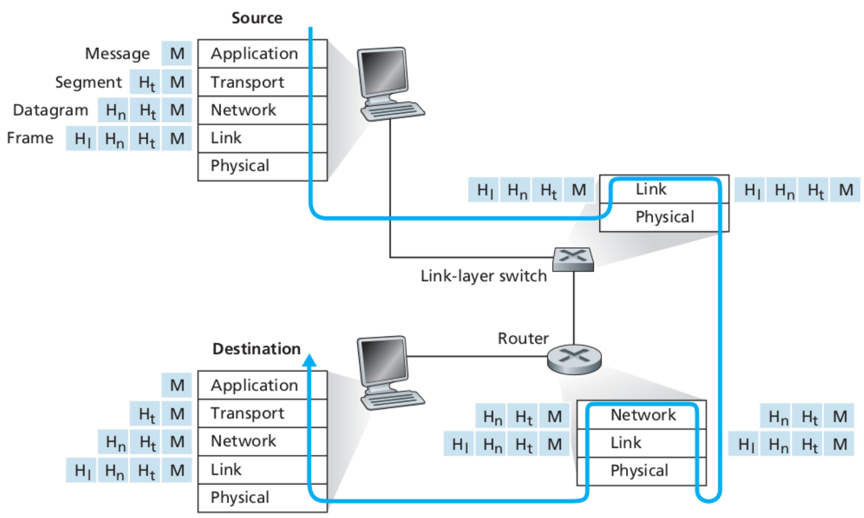


Figure 1.6: Encapsulation

Chapter 2

Application Layer