HW1

P9. Consider the discussion in Section 1.3 of packet switching versus circuit switching in which an example is provided with a 1 Mbps link. Users are generating data at a rate of 100 kbps when busy, but are busy generating data only with probability p = 0.1. Suppose that the 1 Mbps link is replaced by a 1 Gbps link.

(a) What is N, the maximum number of users that can be supported simultaneously under circuit switching?

(b) Now consider packet switching and a user population of M users. Give a formula (in terms of p, M, N) for the probability that more than N users are sending data.

(a) N = 1G / 100k = 10,000

(b) $\sum_{n=N+1}^{M}\binom{M}{n}p^n(1-p)^{M-n}$

P13.

(a) Suppose N packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length L and the link has transmission rate R. What is the average queuing delay for the N packets?

(b) Now suppose that N such packets arrive to the link every LN/R seconds. What is the average queuing delay of a packet?

(a) 平均排队延迟 = (N-1)L/(2R)

(b) 平均排队延迟 = (N-1)L/(2R)

P21. Consider Figure 1.19(b). Now suppose that there are M paths between the server and the client. No two paths share any link. Path k (k = 1,2, ⋯, M) consists of N links with transmission rates $R^k_1, R^k_2, \cdots, R^k_N$. If the server can only use one path to send data to the client, what is the maximum throughput that the server can achieve? If the server can use all M paths to send data, what is the maximum throughput that the server can achieve?

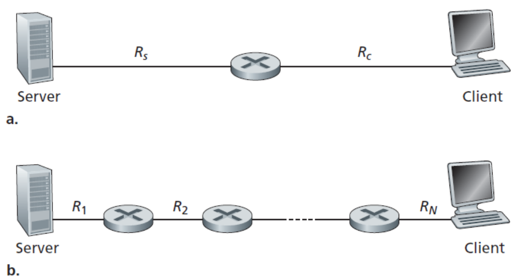

Figure 1.19 ♦ Throughput for a file transfer from server to client

(a) $\max\{\min\{R^1_1, R^1_2, \cdots, R^1_N\}, \min\{R^2_1, R^2_2, \cdots, R^2_N\}, \cdots, \min\{R^M_1, R^M_2, \cdots, R^M_N\}\}$

(b) $\sum_{k=1}^{M} min\{R_1^k, R_2^k, \dots, R_N^k\}$

P23. Consider Figure 1.19(a). Assume that we know the bottleneck link along the path from the server to the client is the first link with rate R_s bits/sec. Suppose we send a pair of packets back to back from the server to the client, and there is no other traffic on this path. Assume each packet of size L bits, and both links have the same propagation delay d_{prop}.

(a) What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives?

(b) Now assume that the second link is the bottleneck link (i.e., $R_c < R_s$). Is it possible that the second packet queues at the input queue of the second link? Explain. Now suppose that the server sends the second packet T seconds after sending the first packet. How large must T be to ensure no queuing before the second link? Explain.

(a) 到最终目的地的到达间隔时间为 L/R_s

(b) 需要排队。$T \geq \frac{L}{R_c} - \frac{L}{R_s}$

P25. Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of R = 2 Mbps. Suppose the propagation speed over the link is 2.5×10^8 meters/sec.

(a) Calculate the bandwidth-delay product, $R \times d_{prop}$

(b) Consider sending a file of 800,000 bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time?

(c) Provide an interpretation of the bandwidth-delay product.

(d) What is the width (in meters) of a bit in the link? Is it longer than a football field?

(e) Derive a general expression for the width of a bit in terms of the propagation speed s, the transmission rate R, and the length of the link m.

(a) $R \times d_{prop} = 2Mbps \times \frac{2}{25}s = 160000\ bits$

(b) 最多有$160000\ bits$在链路上传输且尚未到达目的地

(c) bandwidth-delay product 表示在链路上的最大比特数

(d) 宽度=S/R = 125m，标准足球场长度 105 米（90-120 米），比足球场长

(e) 宽度=S/R

P33. Consider sending a large file of F bits from Host A to Host B. There are three links (and two switches) between A and B, and the links are uncongested (that is, no queuing delays). Host A segments the file into segments of S bits each and adds 80 bits of header to each segment, forming packets of L = 80 + S bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from Host A to Host B. Disregard propagation delay.

end-end delay= $(\frac{F}{S} + 2)\frac{S+80}{R}$

$S = \sqrt{40F}$时，延迟最小