資工三 109590004 呂育瑋

1

(a)

$\min(R_1, R_2, R_3) = R_1 = 500\ \text{kbps}$

(b)

$\min(R_1, R_2, R_3) = R_3 = 200\ \text{kbps}$

2

(a)

$\frac{2M}{100k} = \frac{2000}{100} = 20$ users

(b)

20%

(c)

$C^{40}_{n} \cdot (0.2)^{n} \cdot (0.8)^{40-n}$

(d)

$1 - \sum_{n=0}^{20} C^{40}_{n} \cdot (0.2)^{n} \cdot (0.8)^{40-n}$

3

$$\left(0 + \frac{L}{R} + 2\frac{L}{R} + \cdots\cdots + (N-2)\frac{L}{R} + (N-1)\frac{L}{R}\right) \cdot \frac{1}{N}$$

$$= \sum_{i=0}^{N-1} i \frac{L}{NR}$$

$$= \frac{(N-1)\cdot N}{2} \cdot \frac{L}{NR}$$

$$= \frac{(N-1)L}{2R}$$

4

$d_1 = 4000\ \text{km}$ $\quad S_1 = S_2 = 2 \cdot 10^8\ \text{m/s}$

$d_2 = 1000\ \text{km}$ $\quad R_1 = R_2 = 2\text{M bps}$

$L = 1000\ \text{bytes} = 8000\ \text{bits}$

end-to-end delay (ms) $= d_{proc} + d_{queue} + d_{trans} + d_{prop}$

$$= 1 + \frac{L}{R_1} + \frac{L}{R_2} + \frac{d_1}{S_1} + \frac{d_2}{S_2}\ (\text{msec})$$

end-to-end delay (ms) $= 1 + 1000 \times \left(\frac{8000}{2M} + \frac{8000}{2M} + \frac{4000k}{2\cdot 10^8} + \frac{1000k}{2\cdot 10^8}\right)$

$$= 1 + 1000 \times (0.004 + 0.004 + 0.02 + 0.005)$$

$$= 1 + 33$$

$$= 34\ \text{msec}$$

5

$d = 10000\text{km}$, $R = 1\text{Mbps}$, $S = 2.5 \times 10^8\ \text{m/sec}$

(a)

$d_{prop} = \frac{d}{S} = \frac{10000k}{2.5\times 10^8} = \frac{1}{2.5\times 10} = \frac{1}{25} \approx 0.04\,s$ $\qquad R \cdot d_{prop} = 1M \cdot 0.04 = 40\ \text{kbits}$

(b)

400 kbits > bandwidth-delay product, maximum bits = 40 kbits

(c)

Bandwidth-delay product is the maximum number of bits that can be filled in a network link.

(d)

width of a bit $= \frac{d}{R \cdot d_{prop}} = \frac{10000k}{40k} = \frac{1000}{4} = 250\ m$

(e)

width of a bit $= \frac{d}{R \cdot d_{prop}} = \frac{d}{R \cdot \frac{d}{S}} = \frac{S}{R}$