Computer Networks and the Internet

Group 9 - FOBE

Delay, Loss, and Throughput in Packet-Switched Networks

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I. Review Questions

R18

Propagation delay:

$$d_{prop} = \frac{d}{s} = \frac{2,500}{2.5 \cdot 10^5} = 10\ ms$$

This delay doesn't depend on packet length and transmission rate !

So, It will take a packet of length 1000 bytes **10 ms** to propagate over a link of distance 2500 km.

R19

A.

$$\text{The throughput for the file transfer} = min(R1, R2, R3) = 500\ kbps$$

B.

How long will it take to transfer the file to Host B:

$$t_{A->B} = \frac{\text{file size}}{\text{throughput for the file transfer}} = \frac{32000000}{500000} = 64\ s$$

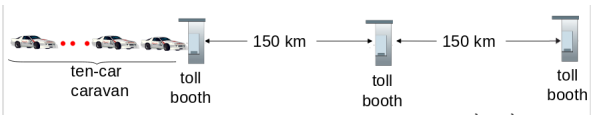
C.

$$\text{The throughput for the file transfer} = min(R1, R2, R3) = 100\ kbps$$

$$t_{A->B} = \frac{\text{file size}}{\text{throughput for the file transfer}} = \frac{32000000}{100000} = 320\ s$$

II. Problems

P5



A.

The time taken by a car to travel 150 km:

$$d_{prop} = \frac{\text{distance travelled}}{\text{propagation speed}} = \frac{150}{100} = 1.5\ h = 90\ m$$

The overall tollbooths service time for 10 cars:

$$d_{trans} = 12 \cdot 3 \cdot 10 = 360\ s = 6\ m$$

End to end delay:

$$d_{\text{end to end}} = d_{prop} + d_{trans} = 90 + 6 = 96\ m$$

B.

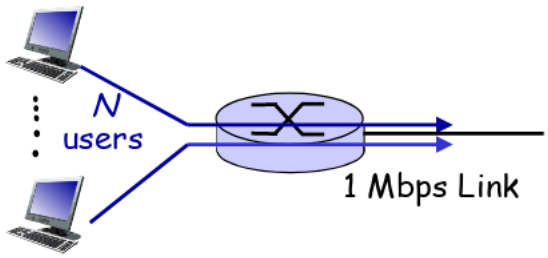
The overall tollbooths service time for 8 cars:

$$d_{trans} = 12 \cdot 3 \cdot 8 = 288\ s = 4.8\ m$$

End to end delay:

$$d_{\text{end to end}} = d_{prop} + d_{trans} = 90 + 4.8 = 94.8\ m$$

P9



A.

The maximum number of users that can be supported simultaneously under circuit switching:

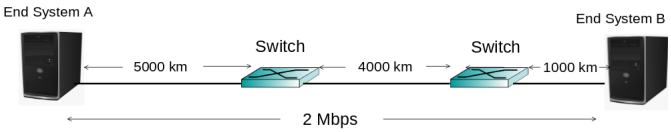
$$N = \frac{\text{total transmission rate}}{\text{data generation rate of each user}} = \frac{1\ Gbps}{1,000\ kbps} = 10,000\ users$$

B.

Formula (in terms of p, M,N) for the probability that more than N users are sending data:

$$P(\text{more than 20 users}) = 1 - \sum_{i=0}^{N} \binom{M}{i} p^i \, (1-p)^{M-i}$$

P10



The packet switch processing delay:

$$d_{proc} = 3 \; msec$$

Each link Transmit packet:

$$T_t = \frac{1,500 \cdot 8}{2 \cdot 10^6} = 0.006 \; s$$

First propagates link:

$$d_{prop(1)} = \frac{d_1}{s_1} = \frac{5,000 \cdot 10^3}{2.5 \cdot 10^8} = 0.02 \; s$$

Second propagates link:

$$d_{prop(2)} = \frac{d_2}{s_2} = \frac{4,000 \cdot 10^3}{2.5 \cdot 10^8} = 0.016 \; s$$

Third propagates link:

$$d_{prop(3)} = \frac{d_3}{s_3} = \frac{1,000 \cdot 10^3}{2.5 \cdot 10^8} = 0.004 \; s$$

End to end Delay:

$$\begin{aligned} d &= d_{prop(1)} + d_{prop(2)} + d_{prop(3)} + 2 \, d_{proc} + 3 \, T_t \\ &= 0.02 + 0.016 + 0.004 + 2 \cdot 0.003 + 3 \cdot 0.004 \\ &= 0.064 \; s \end{aligned}$$

P12

$$\begin{aligned} \text{Queuing Delay} &= \frac{nL + (L - x)}{R} \\ &= \frac{8(4 \cdot 1,500 + (1,500 - 750))}{2 \cdot 10^6} \\ &= \frac{6570 \cdot 8}{2 \cdot 10^6} \\ &= 0.026 \; s \end{aligned}$$