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CS 438: Communication Networks

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CS 438: Homework 1

Question 1

1. Data rate is a function of the transmitted signal's **(c) bandwidth**.
2. (a) BW >= CF, (b) BW = CF, (c) BW <= CF
3. (b) The received signal would contain the frequencies of the transmitted signal, plus some other frequencies from the reflections.
4. (a) 1, (f) true
5. (d) FALSE, because the propagation delay of the first bit is in parallel to the transmit time of the subsequent bits.
6. (d) Average waiting time increases super linearly (faster than linearly) as La/r increases and approaches 1
7. (a) no less than, (d) might not

Question 2

1. Statistical Multiplexing

X ~ Binom(n = 22, p = 1 - 0.3 = 0.7)

P(X=21) = 22C21 * 0.7^21 * 0.3^1 = 0.003686

P(X=22) = 22C22 * 0.7^22 * 0.3^0 = 0.000391

P(X=21 OR X=22) = 0.003686 + 0.000391 = 0.004077

2. User Satisfaction 1 / 2

Avg(P) = 4 + (20 - 4) / 2 = 12

S = k * P = 5 * 12 = 60

3. User Satisfaction 2 / 2

E[S] = E[log10(P) + k] = (1/16) * Integral(4, 20)[log10(p) + 5]dp = (1/16) * (4, 20)[5p] + Integral(4,20)[log10(p)] = (1/16) * ((100 - 20) + Integral(4,20)[log10(p)]) = 6.041.

Question 3

1. 0-1 seconds: 1 packet processed. 1-2 seconds: 1 packet processed. 2-3 seconds: 1 packet processed. 3-4 seconds: 1 packet processed. 4-5 seconds: 1 packet processed. 5-6 seconds: 1 packet processed. 6-7 seconds: 1 packet processed. 7-8 seconds: 0 packets processed. 8-9 seconds: 1 packet processed; 1 packet queued. 9-10 seconds: 1 packet processed; 1 packet queued.

   Average packet throughput: 0.9 packets/sec.

   Average queuing delay: 0.2 seconds.

2. 0-1 seconds: 1 packet processed; 4 packets queued. 1-2 seconds: 1 packet processed; 3 packets queued. 2-3 seconds: 1 packet processed; 2 packets queued. 3-4 seconds: 1 packet processed; 1 packet queued. 4-5 seconds: 1 packet processed. 5-6 seconds: 1 packet processed; 4 packets queued. 6-7 seconds: 1 packet processed; 3 packets queued. 7-8 seconds: 1 packet processed; 2 packets queued. 7-8 seconds: 1 packet processed; 2 packets queued. 8-9 seconds: 1 packet processed; 1 packet queued. 9-10 seconds: 1 packet processed.

   Average packet throughput: 1 packet/sec.

Average queuing delay: 2 seconds.

3. 0-1 seconds: 0 packets processed. 1-2 seconds: 0 packets processed. 2-3 seconds: 0 packets processed. 3-4 seconds: 0 packets processed. 4-5 seconds: 0 packets processed. 5-6 seconds: 0 packets processed. 6-7 seconds: 0 packets processed. 7-8 seconds: 1 packet processed; 9 packets queued. 8-9 seconds: 1 packet processed; 8 packets queued. 9-10 seconds: 1 packet processed; 7 packets queued.

   Average packet throughput: 0.3 packets/sec.

   Average queuing delay: 2.4 seconds.

4. 0-1 seconds: 0 packets processed. 1-2 seconds: 0 packets processed. 2-3 seconds: 1 packet processed; 1 packet queued. 3-4 seconds: 1 packet processed. 4-5 seconds: 1 packet processed. 5-6 seconds: 0 packets processed. 6-7 seconds: 1 packet processed; 2 packets queued. 7-8 seconds: 1 packet processed; 1 packet queued. 8-9 seconds: 1 packet processed; 2 packets queued. 9-10 seconds: 1 packet processed; 3 packets queued.

   Average packet throughput: 0.7 packets/sec.

   Average queuing delay: 0.9 seconds.

5. If packets arrive faster than the router can process them, they have to wait longer in the queue, which increases the average queuing delay.

Question 4

1. SNR = Signal / Noise = (12milliWatt / m^2 / 64 m^2) / 0.02milliWait / m^2 = 9.375 milliWatt / m^2. C = 20MHz * log2(1 + 9.375) = 67.50 Mbps.
2. 135 = 20MHz * log2(1 + 12/R^2) = 0.335M.
3. 202.5 = B * log2(10.375) = 59.9993 MHz.

Question 5

1. $T = T\_transmit + T\_propogation = (R / C) + (D / c)$

   $C = Bmin * log\_2(1 + SNR) = Bmin * log\_2(1 + P)$

   $T - (D / c) = R / (Bmin * log\_2(1 + P)$

   $Bmin * log\_2(1 + P) = R / (T - (D / c))$

   $Bmin = R / (log\_2(1+P) * (T - (D / c)))$

2. Leonard Kleinrock – Developed the Packet Switching theory (efficiently sharing computer resources by breaking data into smaller packets).

   Radia Perlman – Developed the Spanning Tree Protocol (STP) and IS-IS, which help make routing more robust, scalable, and manageable.

   Bob Metcalfe – Invention, standardization, and commercialization of Ethernet.

   Martin Cooper – Created the essential wireless platform that enabled mobile internet access.

   Vint Cerf – Co-designed the fundamental TCP/IP protocol suite with Robert Khan.

   Tim Berners Lee – Invented worldwide web (WWW) in 1989.

Question 6

1. (a) – Outage.

   (b) – Fading.

   (c) – Fading.

   (d) – Interference.

   (e) – Interference.

(f) – Congestion.

(g) – Congestion.

2. (a), (c), (g), (h)