Exam - EXAMPLE 1

① B)

② $S = \log_2(1 + SNR) = \log_2\left(1 + \frac{P_r}{N_0 \cdot B_c}\right)$

$\Leftrightarrow \uparrow S = \frac{C}{B_c \downarrow}$

R: D)

③
- FER = F
- L times (same frame)

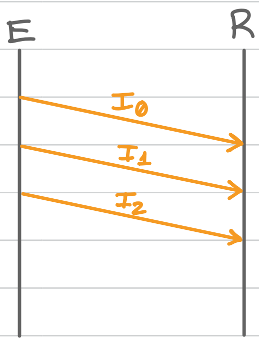
$P(c) = 1 - \underbrace{F^L}$

↳ Todas as frames recebidas com erro

R: D)

④ $W = 2 \text{ bits} = \cancel{2^2} = 4$ $2^2 - 1 = \boxed{3}$

↳ Pode mandar 4 ^{3} frames antes de receber uma mensagem de confirmação



R: ~~D~~) C)

⑤
- M/M/1
- arrival rate = λ packets/s
- capacity = C bit/s
- N packets in queue
- average delay = T

- $\lambda' = 10 \cdot \lambda$ and $C' = 10 \cdot C$ and $L = L'$:

$L = L'$

$\Leftrightarrow \frac{C}{\mu} = \frac{C'}{\mu'}$

$\Leftrightarrow \frac{\cancel{C}}{\mu} = \frac{10 \cdot \cancel{C}}{\mu'}$

$\Leftrightarrow \mu' = 10 \cdot \mu$

$T = \frac{1}{\mu - \lambda}$

$\Leftrightarrow T = \frac{1}{\frac{\mu'}{10} - \frac{\lambda'}{10}}$

$\Leftrightarrow T = \frac{10}{\mu' - \lambda'}$

$\Leftrightarrow T = 10 \cdot T'$

$\Leftrightarrow \boxed{T' = T/10}$

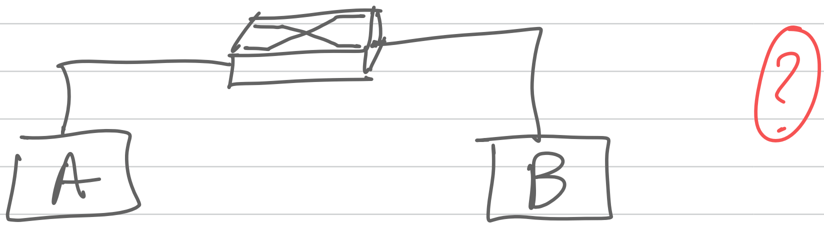
$N = \frac{\lambda}{\mu - \lambda}$

$\Leftrightarrow N = \frac{\lambda'/\cancel{10}}{\mu'/\cancel{10} - \lambda'/\cancel{10}}$

$\Leftrightarrow \boxed{N = \frac{\lambda'}{\mu' - \lambda'} = N'}$

R: C)

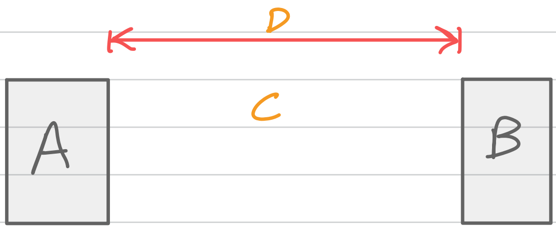
6



R: E)

7 D)

8



w = W

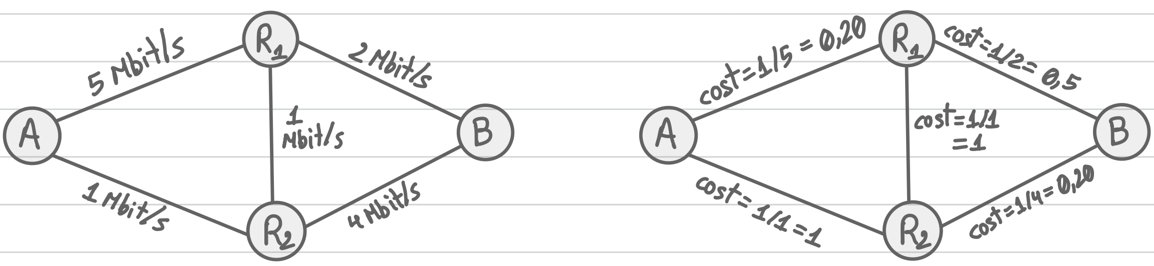
RTT = R

Bitrate = Congestion Window / RTT

$= \boxed{W / R \text{ (bytes/s)}}$ ← throughput

R: D)

9



∘ minimum cost path = $A \rightarrow R_1 \rightarrow B$ (maximum throughput is 2 Mbit/s)

R: E)

10 B)

(11)

- Selective - Repeat ARQ
- $C_{channel} = 2\ Mbit/s = (2\times10^6)\ bit/s$
- $T_p = 250\ ms$
- $E[L] = 250\ bytes = 250\times8 = 2000\ bits$
- $BER = 10^{-4} \longrightarrow FER = 1-(1-10^{-4})^{2000} \approx 0{,}1813$
- $M = 64$

$\rightarrow R_{máx.} = ?\ \left(S\cdot(R\ [ou\ C])\right)$

$$W_{max} = \frac{M}{2} = \frac{64}{2} = 32$$

$$\boxed{R_{máx} = S\cdot C}$$

$$a = \frac{T_p}{T_f} = \frac{250\ ms}{L/C} = \frac{0{,}250\ \cancel{s}}{2000\ \cancel{bit}/(2\times10^6)\ \cancel{bit/s}} = 250$$

$$S = \frac{W\cdot(1-P_e)}{1+2\cdot a} = \frac{32\times(1-0{,}2)}{1+2\cdot250} = 0{,}0511$$

$$P_e = FER = 1-(1-BER)^L = 1-(1-10^{-4})^{2000} \approx 0{,}2$$

$$R_{MAX} = S\cdot C = 0{,}0511\times(2\times10^6) = 102\ 195{,}6\ bit/s \approx \boxed{102\ Kbit/s}$$

(12)

- $S = 1$
- $BER = 10^{-4} \longrightarrow FER = 0{,}8$

$\rightarrow W = ?$

$$1+2\cdot a = 1+2\cdot\frac{T_p}{T_f} = 1+2\cdot\frac{0{,}250}{2000/(2\times10^6)} = 1+2\times250 = 501$$

$$\begin{cases} S = 1 & ,\ W \geq 1+2\cdot a \\ S = \dfrac{W}{1+2\cdot a} & ,\ W < 1+2\cdot a \end{cases}$$

$$W_{MAX} = \frac{64}{2} = 32$$

Como queremos $S=1$, então usamos a fórmula para $W \geq 1+2a$:

$$W \geq 1+2\cdot a \Leftrightarrow 2^{K-1} \geq 501$$
$$\Rightarrow K-1 \geq \log_2(501)$$
$$\Leftrightarrow K \geq 9{,}97$$
$$\Rightarrow K \geq 10,\ \text{pois}\ K \in \mathbb{Z}_0^+$$
$$\hookrightarrow W = 2^{K-1} = 2^{10-1} = 2^9 = \boxed{512}$$

(13)

- $L = 1{,}30 \times E[L] = 1{,}30 \times 2000 = 2600$ bits
- $FER = P_e = 0{,}05$
- $T_p = 250$ ms
- $C_{channel} = R_{channel} = (2 \times 10^6)$ bit/s

$\rightarrow R_{MAX} = ?$

$$\boxed{R_{MAX} = S \cdot R}$$

$$W = \frac{64}{2} = 32$$

$$W = 1 + 2 \cdot a$$

$$\Rightarrow 2^{K-1} = 501$$

$$\Leftrightarrow K - 1 = \log_2(501)$$

$$\Rightarrow K = 9{,}97 \approx 10$$

$$1 + 2 \cdot a = \underbrace{501}_{\text{ex. anterior}}$$

$$W_{MAX} = 2^{K-1} = 2^{10-1} = 2^9 = 512$$

$$S = \frac{W \cdot (1 - P_e)}{1 + 2 \cdot a} = \frac{32 \times 0{,}95}{501} = 0{,}061$$

$$R_{MAX} = S \cdot C = 0{,}061 \times (2 \times 10^6) \approx \boxed{121 \text{ Kbit/s}}$$

(14)

- M/M/1
- $\lambda = 600$ pac/s
- $E[L] = 1500$ Bytes $= 1500 \times 8 = 12000$ bits
- $\rho = 1 - 0{,}40 = 0{,}60$

$\rightarrow T = ?$

$$T = \frac{1}{\mu - \lambda} = \frac{1}{\mu - 600}$$

?

$$\rho = \frac{\lambda}{\mu} \Rightarrow \mu = \frac{\lambda}{\rho} = \frac{600 \text{ pac/s}}{0{,}60} = 1000 \text{ pac/s}$$

$$= \frac{1}{1000 - 600} = \frac{1}{400} = 0{,}0025 \text{ s} = \boxed{2{,}5 \text{ ms}}$$

(15)

- M/M/1/B
- $B = 1$

$\rightarrow P[\text{NumberOfPackets} > 0] = ?$

Como $\rho = 0{,}60 \ (< 1)$, então $P(0) = \dfrac{(1-\rho) \cdot \cancel{\rho^0}^{(1)}}{1 - \rho^2} = \dfrac{0{,}40}{1 - (0{,}60)^2} = 0{,}625$

Então $P[\text{NumberofPackets} > 0] = 1 - P(0) = 1 - 0{,}625$

$$= 0{,}375$$

$$\approx \boxed{0{,}38}$$

(16) ∘ $L = 1500$ Bytes $= 1500 \times 8 = 12000$ bits

$\rightarrow N_W = ?$

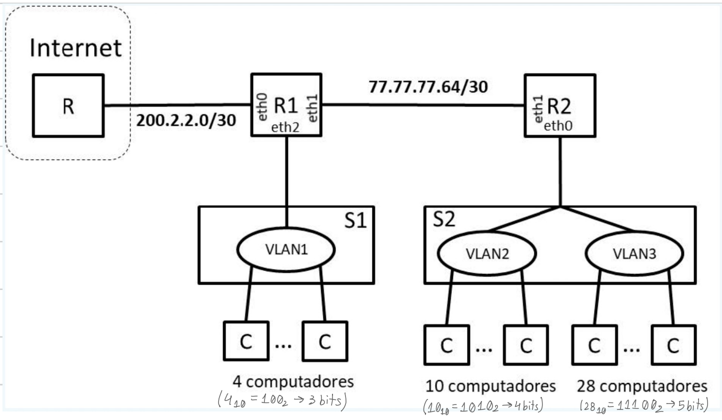
$\boxed{N_W = \lambda \cdot T_W = \rho N} \rightarrow$ Teorema Little

Como o tamanho L é fixed lenght, entaõ estamos perante um M/D/1.

$$T_W = \frac{\rho}{2 \cdot \mu \cdot (1-\rho)} = \frac{0,6}{2 \times 1000 \times 0,4} = 0,00075 \text{ s}$$

$$N_W = \lambda \cdot T_W = 600 \cdot 0,00075 = \boxed{0,45}$$

(17)



/30	–	2 bit $\rightarrow 2^2 - 2 = 4 - 2 = 2$ endereços
/29	–	3 bit $\rightarrow 2^3 - 2 = 8 - 2 = 6$ endereços
/28	–	4 bit $\rightarrow 2^4 - 2 = 16 - 2 = 14$ endereços
/27	–	5 bit $\rightarrow 2^5 - 2 = 32 - 2 = 30$ endereços
/26	–	6 bit $\rightarrow 2^6 - 2 = 64 - 2 = 62$ endereços
/25	–	7 bit $\rightarrow 2^7 - 2 = 128 - 2 = 126$ endereços
/24	–	8 bit $\rightarrow 2^8 - 2 = 256 - 2 = 254$ endereços

∘ Começar pela VLAN com mais hosts:

VLAN3 : 5 bits $\rightarrow N_{hosts} = 2^5 - 2 = 32 - 3 = 30$ hosts (77.77.77.96 /27) → 64 + 32 → 30 endereços + +2 reservados

VLAN2 : 4 bits $\rightarrow N_{hosts} = 2^4 - 2 = 14$ hosts (77.77.77.112/28) → 92 + 16, → 14 endereços + 2 reservados

VLAN1 : 3 bits $\rightarrow N_{hosts} = 2^3 - 2 = 6$ hosts (77.77.77.120/29) → 112 + 8, → 6 endereços/hosts + 2 reservados

R: 77.77.77.96/27

18

01 | 000000
.64/26

0 → 010 | 00000 .64/27
1 → 011 | 00000 $\boxed{.96/27}$ ← VLAN3, escolhemos este porque tem o bit 27, contrário ao endereço do enunciado $64 = 01000000_2$, então desenvolvemos o outro ramo porque esse já foi usado.

010 | 00000 .64/27:
0 → 0100 | 0000 .64/28
1 → 0101 | 0000 $\boxed{.80/28}$ → VLAN2, porque tem o bit 28 ao contrário do dado no enunciado 0100 0000.

0100 | 0000 .64/28:
0 → 01000 | 000 .64/29
1 → 01001 | 000 $\boxed{.72/29}$ → VLAN1

Broadcast: $\boxed{77.77.77.95}$

80	0
40	0
20	0
10	0
5	1
2	0
1	1
0	

Trocar para 1 os bits 32 − mask = 4

$1011111_2 = 95_{10}$

19

- Broadcast VLAN1: 77.77.77.79
- Highest address of R1.eth2 (Brodcast − 1): 77.77.77.78

72	0
36	0
18	0
9	1
4	0
2	0
1	1
0	

$1001111_2 = 79_{10}$

20

- R2 default gateway: Tem a ligação direta ao outro router.
- Endereço dado no enunciado: 77.77.77.64/30 passa a ser R2 eth0: 77.77.77.65.