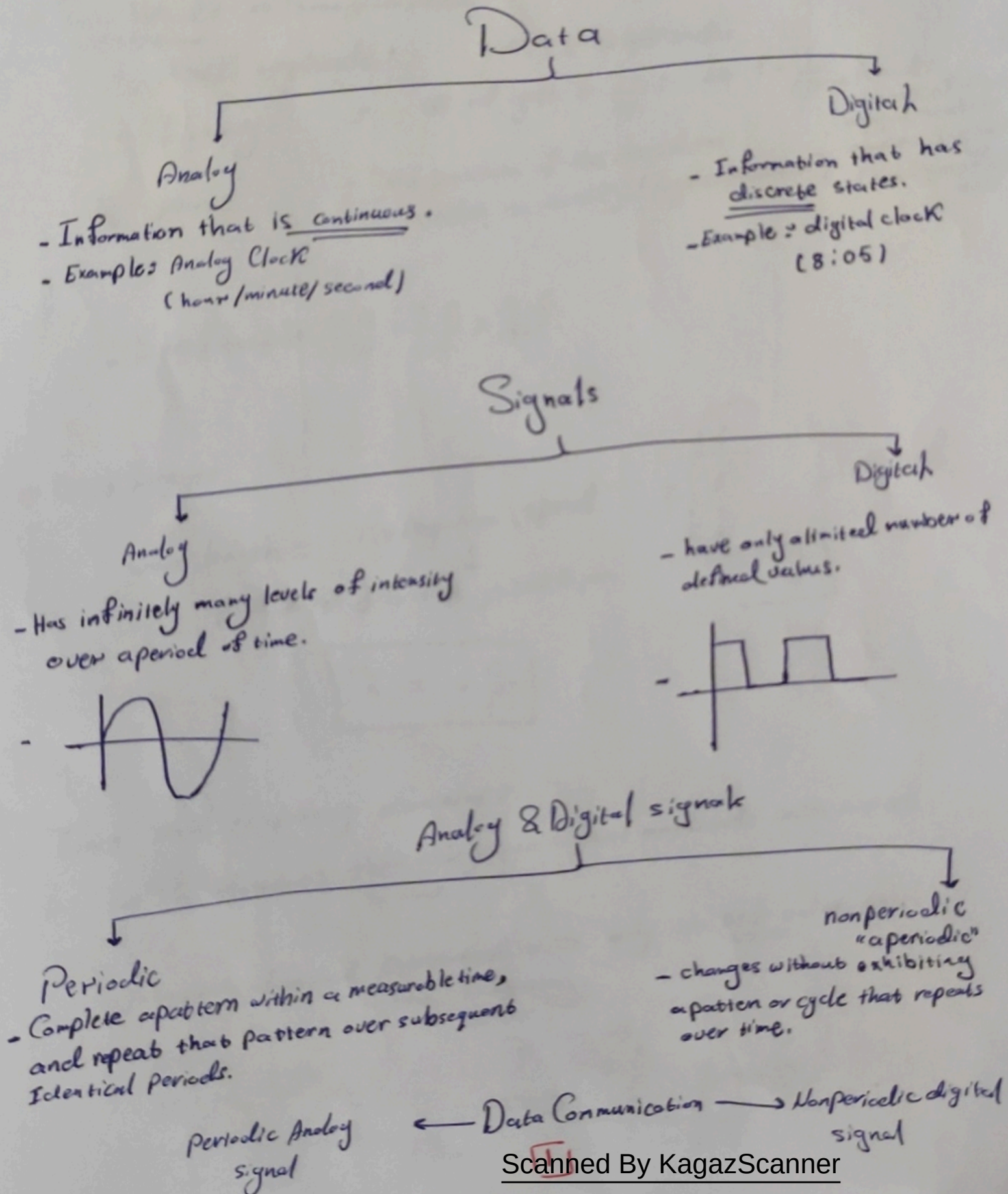


Chapter 3: Introduction to Physical Layer

Ahmed R. Ayhaal/Kundi

3.1: Data And Signals



2. Periodic Analog Signals

Simple $\rightarrow$ Sine wave $\rightarrow$ موجة جيبية
 Composite $\rightarrow$ Composed of multiple sine waves.

Sine Wave $\Rightarrow$ Three Parameters

- [1] Peak amplitude
- [2] Frequency $\rightarrow$ # of cycle in 1 sec $\Rightarrow f = \frac{1}{T}$ التردد
 Period $\rightarrow$ amount of time a signal needs to complete 1 cycle. [See figure 3.5]
- [3] phase $\rightarrow$ the position of the waveform relative to time 0. (degrees/radians)

- See Example 3.4, 3.5, 3.6

* Wave Length

Wave length = Propagation speed
سرعة انتشار الموجة، الطول الموجي

$$\lambda = \frac{1}{f} \rightarrow \text{period}$$

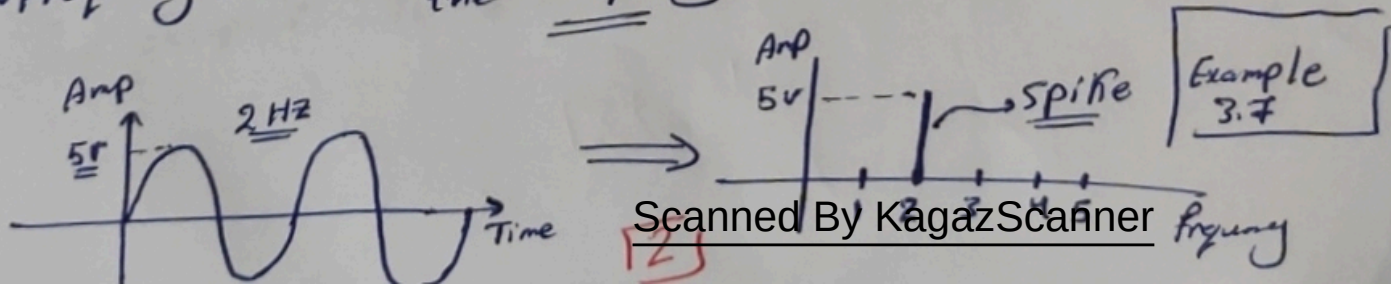
f frequency

$$\lambda = \frac{c}{f}$$

* Time and Frequency domains

$\rightarrow$ Time domain $\rightarrow$ show changes in signal amplitude with respect to time.

$\rightarrow$ Frequency domain $\rightarrow$ concerned with only the peak value and the frequency.



* Composite Signals: a signal made of many simple sine waves.

phase / Amp / Freq of each simple sine wave = info.

* Bandwidth: Range of freq contained in composite signal.

$$B = f_h - f_L$$

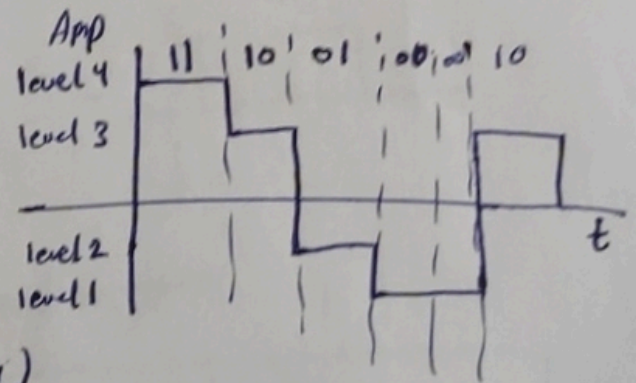
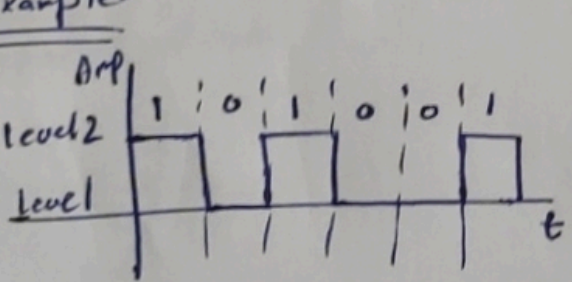
$\downarrow$ $\downarrow$
 highest lowest
 freq freq

- See Examples 3.10, 3.11, 3.12

3.3: Digital Signals

↳ digital signal can have more than two levels.
 → Each level needs $\lceil \log_2 L \rceil$ bits

Examples



* Bit Rate: (instead of frequency)
 → number of bits sent in 1s. (bps)

See Examples 3.18, 3.19

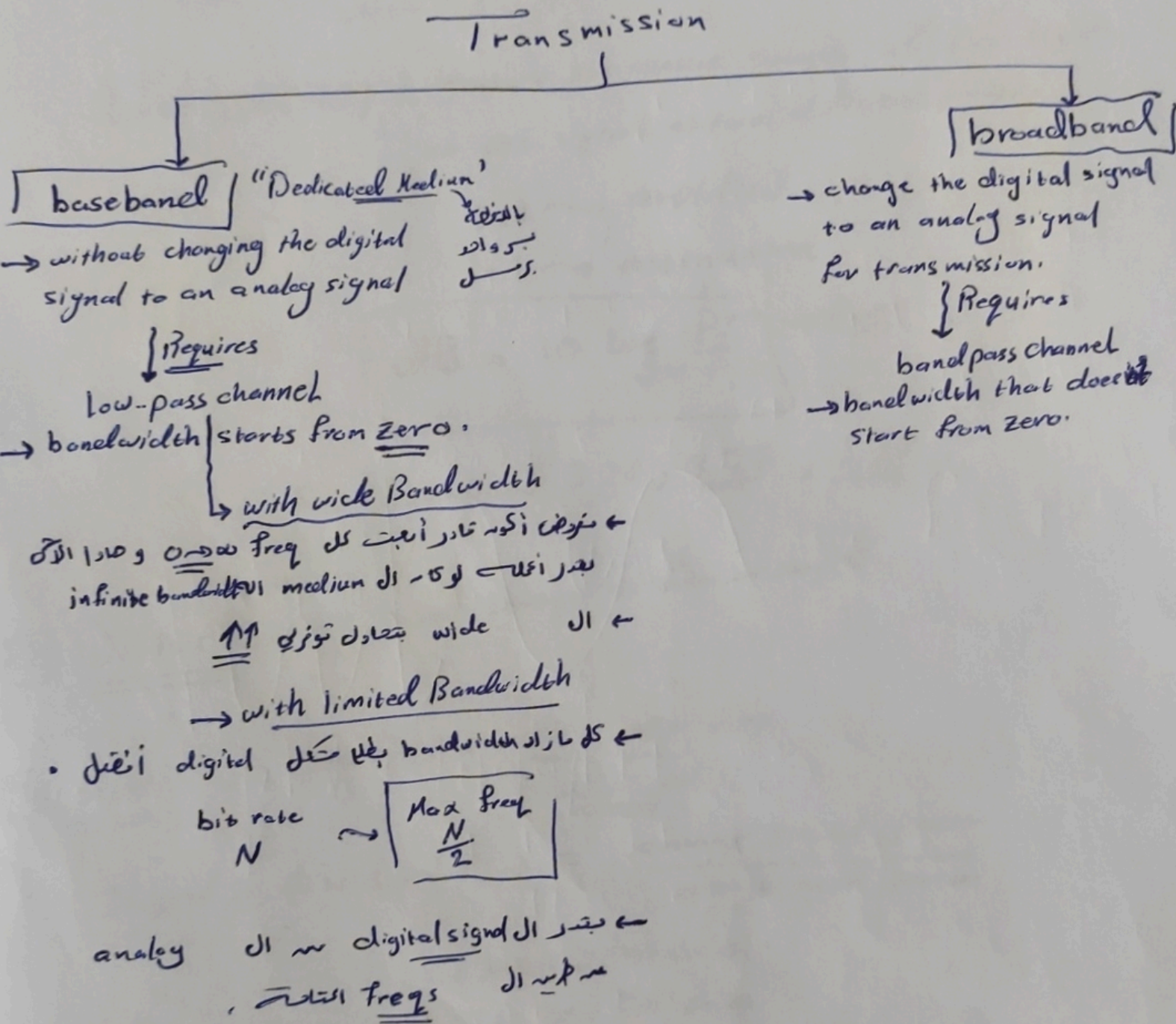
[3]

Chapter 3: Introduction to physical layer

(Part 2)

Ahmed R. Agha Kundi

Transmission of digital signals:
 ↓
 composite analog signal with frequencies between $0 \sim \infty$



See Examples 3.22, 3.23

3.4: Transmission Impairment

Impairment Causes:

1) Attenuation : loss of energy

→ Amplifier جهاز يضخم الإشارة

Decibel (dB) : Measure the relative strengths of two signals or one signal at two different points.

(+) → amplified

(-) → attenuated

$$\boxed{dB = 10 \log_{10} \frac{P_2}{P_1}} \rightarrow \text{Power}$$

See Examples 3.26, 3.27, 3.28

2) Distortion : signal changes its form or shape.

3) Noise : دخول موجات أخرى على الإشارة الأصلية

Noise Signal

$$\text{Signal to Noise (SNR)} = \frac{\text{average signal power}}{\text{average noise power}}$$

high → Noise أقل
low → Noise أكثر

$$\boxed{SNR_{dB} = 10 \log_{10} SNR}$$

See Examples 3.31, 3.32

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3.5 Data Rate Limits

ما هي سرعة إرسال البيانات عبر الوسط الناقل

→ Data Rate depends on:

[1] Bandwidth

[2] level of signal we use.

[3] quality of the channel.

→ To calculate data Rate

- ↳ Nyquist (noiseless channel)
- ↳ Shannon (noisy channel)

[1] Nyquist

$$\text{Bit Rate} = 2 \times \text{bandwidth} \times \log_2 L$$

See Examples 3.34, 3.35, 3.36

[2] Shannon

$$\text{Capacity} = \text{bandwidth} \times \log_2 (1 + \text{SNR})$$

See Examples 3.39

$$C = B \times \frac{\text{SNR}_{\text{dB}}}{3}$$

[3]

P3-7

a- 1 bit lasts 0.001s

$$\text{bit rate} = \frac{1}{\text{bit duration}} = \frac{1}{0.001s} = \underline{\underline{1000 \text{ bps}}}$$

c- 10 bits last 20 μs

1 bit $\rightarrow$ 20 μs

$$= \frac{1}{20 \times 10^{-6}} = 50000 \text{ bps}$$

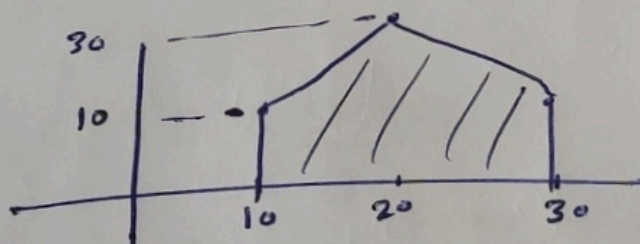
P3-9

8 bits $\rightarrow$ (16 ns) $\rightarrow$ 16×10^{-9}

?? $\rightarrow$ 1s

$$= \frac{8}{16 \times 10^{-9}} \text{ bps}$$

P-13



P-14 $B = 6 \text{ MHz}$ $f = \frac{N}{2}$

$$\text{data rate} = 2 \times 6 = 12 \text{ Mbps}$$

$$\text{three harmonic} = \frac{2 \times 6}{3} = \underline{\underline{4 \text{ Mbps}}}$$

P-16

$$+10 \text{ dB} = 10 \log_{10} \frac{P_2}{5}$$

$$-1 \text{ dB} = 10 \log_{10} \frac{P_2}{5} \rightarrow 10^{-1} = \frac{P_2}{5} \rightarrow P_2 = \underline{\underline{5 \times 10^{-1} \text{ W}}}$$

P3-21:

$$SNR = 1000$$

$$B = 4000 \text{ KHz}$$

$$\begin{aligned} \text{Capacity} &= B \times \log_2(1+SNR) \\ &= 4000 \times 10^3 \times (\log_2(1+1000)) = \boxed{} \text{ bps} \end{aligned}$$

P3-22: $B = 4 \text{ KHz}$

$$SNR = \frac{10}{0.005} = \underline{\underline{2000}}$$

$$\text{Capacity} = 4000 \times \log_2(1+2000) = \boxed{} \text{ bps}$$

P3-25:

$$SNR = \frac{200 \times 10^{-3}}{10 \times 2 \times 10^{-6}} = 10,000$$

$$SNR_{dB} = \underline{\underline{10 \log_{10} 10000}}$$

P3-27:

$$\begin{aligned} C &= B \times \frac{SNR_{dB}}{3} \\ &= 20 \times 1000 \times \frac{40}{3} = \underline{\underline{267 \text{ Kbps}}} \end{aligned}$$

[a]

P3-30:

$$\begin{aligned} \text{transmission time} &= \text{packet length} / \text{bandwidth} \\ &= \frac{8000000}{200000} = \boxed{40 \text{ s}} \end{aligned}$$

[5]

P-33 :

→ Frame size = 5×10^6 bits

→ 10 routers / Queuing time 2ms
Processing time 1ms

→ distance = 2000 km

→ Propagation speed = 2×10^8 m/s

→ B = 5×10^6 bps

Latency = Processing time + Queuing time + Transmission Time
+ Propagation time

$$\text{Processing time} = 10 \times 1 \text{ ms} = \underline{\underline{10 \times 10^{-6} \text{ s}}}$$

$$\text{Queuing time} = 10 \times 2 \text{ ms} = \underline{\underline{20 \times 10^{-6} \text{ s}}}$$

$$\text{Transmission time} = \frac{5 \times 10^6}{5 \times 10^6} = \underline{\underline{1 \text{ s}}}$$

$$\text{Propagation Time} = \frac{2000 \times 10^3}{2 \times 10^8} = \underline{\underline{0,01 \text{ s}}}$$

$$= 10 \times 10^{-6} + 20 \times 10^{-6} + 1 + 0,01$$

$$= \boxed{\quad} \quad \#$$

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