

① $H(S) = 2.06$ Shannon coding $\Rightarrow \bar{\ell}$

a) $\eta = ?$ $\eta = \frac{H(S)}{\bar{\ell}}$ $\eta \in \left(\frac{2.0}{2.1}, \frac{2.0}{2.0} \right] \Rightarrow \eta > \frac{2.0}{2.1}$

b) $\rho = ?$ $\rho = 1 - \eta$ $\rho = \left[0, 1 - \frac{2.0}{2.1} \right)$

c). 2 messages $\Rightarrow H_{\max} = 1 \text{ b}$

10 messages $\Rightarrow H_{\max} = \log_2(10)$ $\left(\frac{1}{10}, \frac{1}{10}, \dots, \frac{1}{10} \right) \Rightarrow$

n messages $\Rightarrow H_{\max} = \log_2(n)$ $\left(\frac{1}{n}, \frac{1}{n}, \dots, \frac{1}{n} \right)$

1000 messages $\Rightarrow H_{\max} = \log_2(1000) \approx 10$

X messages $\Rightarrow H_{\max} = \log_2(X) \geq 2.06$

$\Rightarrow X \geq 2^{2.06} = 4.12 \text{ messages}$

20 bit/s

② $S: \begin{pmatrix} \Lambda_1 & \Lambda_2 & \Lambda_3 & \Lambda_4 & \Lambda_5 \\ 0.05 & 0.4 & 0.1 & 0.25 & 0.2 \end{pmatrix}$

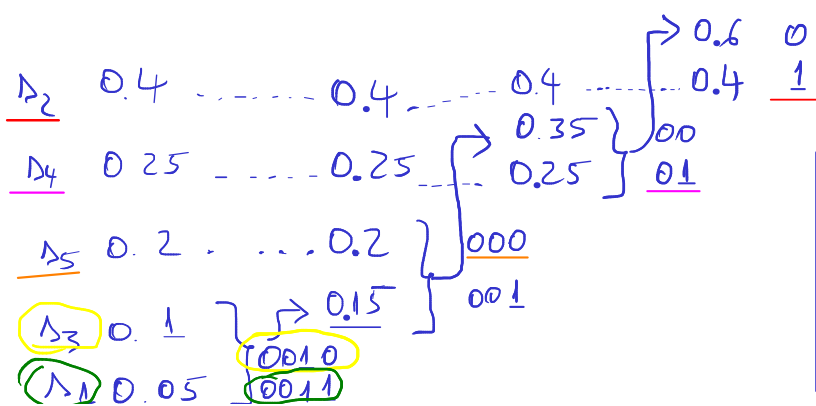
Shannon

		$\ell_i = \lceil \log_2(p_i) \rceil$	
Λ_2	0.4	2	00
Λ_4	0.25	2	01
Λ_5	0.2	3	100
Λ_3	0.1	4	1010
Λ_1	0.05	5	10111

Shannon - Fano

Λ_2	0.4	0			
Λ_4	0.25	1	0		
Λ_5	0.2	1	1	0	
Λ_3	0.1	1	1	1	0
Λ_1	0.05	1	1	1	1

Huffman



Λ_1	0011
Λ_2	1
Λ_3	0010
Λ_4	01
Λ_5	000

$$b). \quad \bar{l} = \sum p(\Delta_i) \cdot l_i = 0.05 \cdot \underline{4} + 0.4 \cdot \underline{1} + 0.1 \cdot \underline{4} + \\ + 0.25 \cdot \underline{2} + 0.2 \cdot \underline{3} = \underline{2.16}$$

$$H(s) = 2.046$$

$$\eta = \frac{2.04}{2.1}$$

$$\xi = 1 - \eta$$

c).

$$\bar{l}_0 = 0.05 \cdot 2 + 0.4 \cdot 0 + 0.1 \cdot 3 + 0.25 \cdot 1 + 0.2 \cdot 3 = \underline{1.256}$$

$$\bar{l}_1 = 0.05 \cdot 2 + 0.4 \cdot 1 + 0.1 \cdot 1 + 0.25 \cdot 1 + 0.2 \cdot 0 = \underline{0.85}$$

$$p_0 = \frac{1.25}{2.1} = 0.59$$

$$p_1 = \frac{0.85}{2.1} = 0.41$$