جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

كلية العلوم
قسم الأمن السيبراني

Lecture: (5)

Code efficiency and redundancy

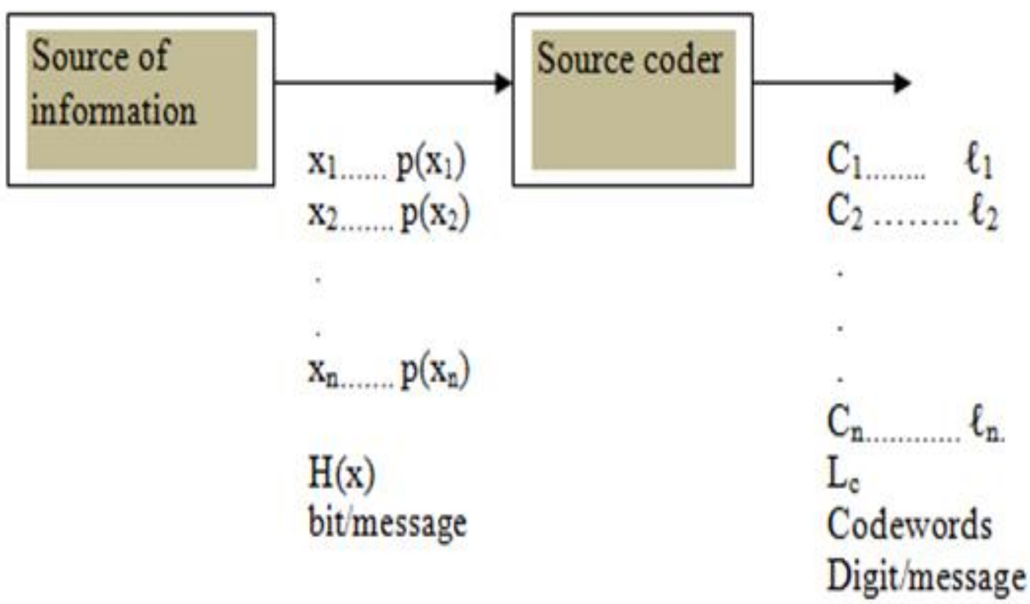
Subject: Coding Techniques
First Stage
Lecturer: Asst. Lecturer. Suha Alhussieny

Source codes:

The source coder will transform the messages into a finite sequence of digits, called the codeword of the message. If binary digits (bits) are used in this codeword, then we obtain what is called " Binary Source Coding"**.**

The aim of source coding is to produce a code which, on average, requires the transmission of the maximum amount of information for the fewest binary digits. This can be quantified by calculating the **efficiency** η of the code.

A code is a mapping from the discrete set of symbols $\{0, \cdots, M - 1\}$ to finite binary sequences.



However before calculating efficiency we need to establish the length of the code. The length of a code is the average length of its code words and is obtained by:

$$L = \sum_{i=1}^{n} P_i l_i$$

For the purposes of efficiency. The average code length is minimized, where li is the number of digits in the i^{th} symbol and n is the number of symbols the code contains.

For fixed length code

$\boldsymbol{L} = \boldsymbol{l_i} = \lceil log2\ M \rceil$ where M is the number of symbols.

OR

1- $L_c = \log_2 n$ bit/message if $n = 2^r$ ($n = 2,4,8,16,\ldots$ and r is an integer) which gives $\eta = 100\%$

2- $L_c = Int[\log_2 n] + 1$ bits/message if $n \neq 2^r$ which gives less efficiency

Source Code Efficiency:

L = average length of the code

L = $\sum_{i=1}^{n} Pi\ \ li$ bits/symbol.

$$\xi_{code} = \frac{H(x)}{L} * 100\% \quad where\ \xi_{code} = \text{code Efficiency}$$

Redundancy of the Code:

$$R_{code} = \frac{L - H(x)}{L} * 100\% = \left(1 - \frac{H(x)}{L}\right) * \ 100\%$$

$$= \left(1 - \xi_{code}\right) * \ 100\% \qquad where\ R_{code} = Code\ Redundancy$$

Example 1:

Let x = { x1,x2,⋯⋯,x16 } where Pi = 1/16 for all i, fined $\xi\ source\ code$

Sol:

H(x) = log2 M = log2 16 = 4 bits/symbol (because P1 = P2= ..=P16 = 1/M)

$L = [log2\ M]$

$L = [log2\ 16]$ = 4 bits/symbol.

Code Redundancy = L – H.

R = 4 - 4 = 0.

$$\therefore \ \xi_{source\ code} = \frac{H(x)}{L} * 100\% = \frac{4}{4} * 100\% = 100\%$$

Example 2:

Let x = { x1,x2,⋯,x12 } where Pi = 1/12 for all i, fined ξ *source code*

Sol:

H(x) = $\log_2$ M = $\log_2$ 12 = 3.585 bit/symbol (because P1 = P2= ...=P12 = 1/M)

$$L_C = Int[\log_2 n] + 1 \quad \text{bits/message}$$

L= Int [$\log_2$ 12]+1 = 4 bits/symble

Code Redundancy = L – H.

R = 4 – 3.585 = 0.415.

$$\therefore \ \xi_{source\ code} = \frac{H(x)}{L} * 100\% = \frac{3.585}{4} * 100\% = 89\ \%$$

Example 3:

For ten equi-probable messages coded in a fixed length code, find the efficiency.

Sol:

$$p(x_i) = \frac{1}{10} \text{ and } L_C = Int[\log_2 10] + 1 = 4 \text{ bits}$$

$$\eta = \frac{H(X)}{L_C} \times 100\% = \frac{\log_2 10}{4} \times 100\% = 83.048\%$$

Example 4:

For eight equi-probable messages coded in a fixed length code, find the efficiency

Sol:

$$p(x_i) = \frac{1}{8} \text{ and } L_C = \log_2 8 = 3 \text{ bits and } \eta = \frac{3}{3} \times 100\% = 100\%$$