Sri SAI RAM ENGINEERING COLLEGE
INSTITUTE OF TECHNOLOGY
West Tambaram, Chennai - 44

Sairam INSTITUTIONS

SAIRAM DIGITAL RESOURCES

YEAR II

SEM III

EC8394

ANALOG AND DIGITAL COMMUNICATION

UNIT NO 4

SOURCE AND ERROR CONTROL CODING

- Measure of information
- Entropy
- Source coding theorem

ELECTRONICS & COMMUNICATION ENGINEERING

4 QUALITY EDUCATION

NBA NATIONAL BOARD OF ACCREDITATION

NAAC NATIONAL ASSESSMENT AND ACCREDITATION COUNCIL A+

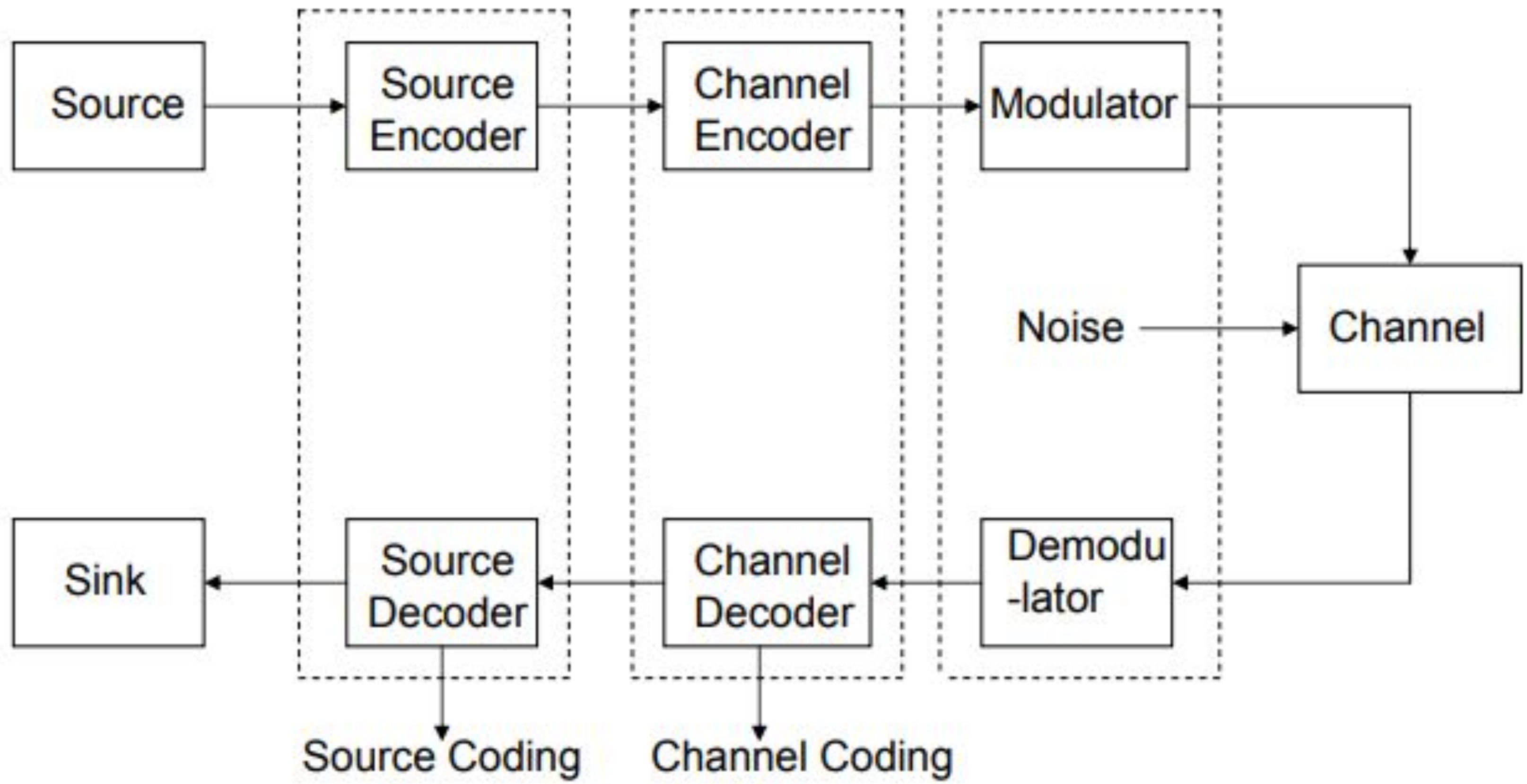
nirf NATIONAL INSTITUTIONAL RANKING FRAMEWORK

BUREAU VERITAS Certification

Information Theory

- Information theory is concerned with the fundamental limits of communication.
- Source coding converts source output to bits. Source output can be voice, video, text, sensor output, etc.,
- Channel coding adds extra bits t o data transmitted over the channel. This redundancy helps combat the errors introduced in transmitted bits due to channel noise.
- Sources can generate "information" in several formats like sequence of symbols such as letters from the English alphabet or binary symbols from a computer file or analog waveforms such as voice and video signals.

Communication System



Discrete Memoryless Source

- A source from which the data is being emitted at successive intervals, which is independent of previous values, can be termed as discrete memoryless source.

- This source is discrete as it is not considered for a continuous time interval, but at discrete time intervals.

- This source is memoryless as it is fresh at each instant of time, without considering the previous values.

Entropy

- Entropy is the measure of the average information content per symbol.
- Consider a Discrete Memoryless Source.
- The symbols emitted by the source is defined by the set

$$S = \{s_0, s_1, s_2, \ldots s_{K-1}\}$$

- Probability of the source emitting a symbol s_k is defined by p_k and hence the information contained by symbol s_k can be expressed as

$$I(s_k) = \log\left(\frac{1}{p_k}\right)$$

- Certain & Uncertain events – Example?

Properties of Entropy

- *Property 1:*

  $H(S) = 0$ if and only if $p_k = 1$

  for any value of k and all other symbols have zero probability i.e., *no uncertainity*

- *Property 2:*

  $H(S) = \log_2 K$ if and only if $p_k = 1/K$

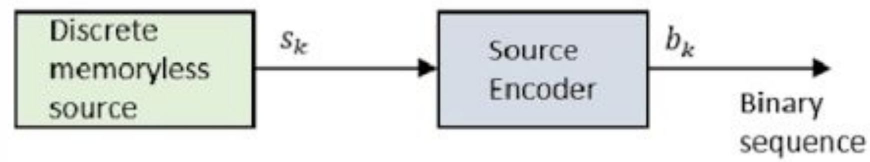
  for all the symbols (equiprobable) in the set i.e., *maximum uncertainity*

Source Coding Theorem

Requirements:

- Binary codeword
- Uniquely decodable
- If l_k is the length of codeword corresponding to symbol s_k, then average codeword length is given by

$$\bar{L} = \sum_{k=0}^{K-1} p_k l_k$$



Theorem:

Given a discrete memoryless source of entropy H(S), the average codeword length Ĺ for any distortionless source coding is bounded as

$$\bar{L} \geq H(S)$$

Coding Efficiency = H(S) / Ĺ

Conditional Entropy

The amount of uncertainty remaining about the channel input after observing the channel output, is called as Conditional Entropy. It is denoted by $H(x|y)$.

This parameter is essential to understand Mutual Information.

For $Y = y_k$, the conditional entropy is given by

$$H(x \mid y_k) = \sum_{j=0}^{j-1} p(x_j \mid y_k) \log_2 \left[\frac{1}{p(x_j \mid y_k)} \right]$$