SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution
Coimbatore-35

DEPARTMENT OF INFORMATION TECHNOLOGY

23ITT304 Information Coding Technique

Unit I

Information Theory

Variable Length Codes

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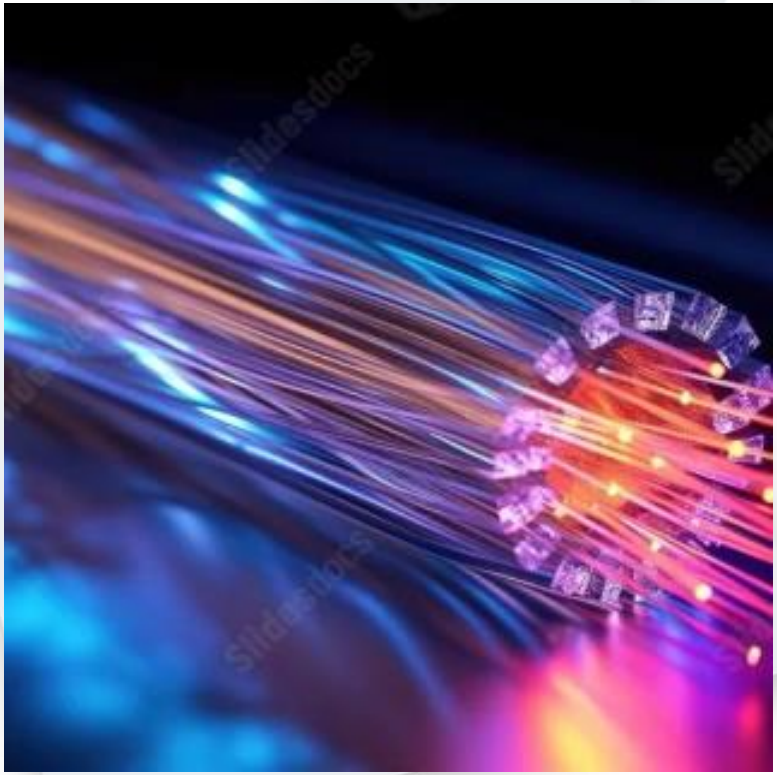


Shannon’s Theorem

Understanding the Limits of Data Transmission

What Is Information?

Beyond Words

Information isn't just text—it's anything that reduces uncertainty, like a yes/no answer or a digital signal.

From Analog to Digital

In electronics, information is converted into binary—sequences of 0s and 1s—so machines can process it.

A Simple Analogy

Think of Morse code: short and long pulses carry meaning. Similarly, bits transmit data across channels.

The Problem of Noise

Real-World Challenge

All communication channels—Wi-Fi, phone lines, radio—have noise: electrical interference or signal loss.

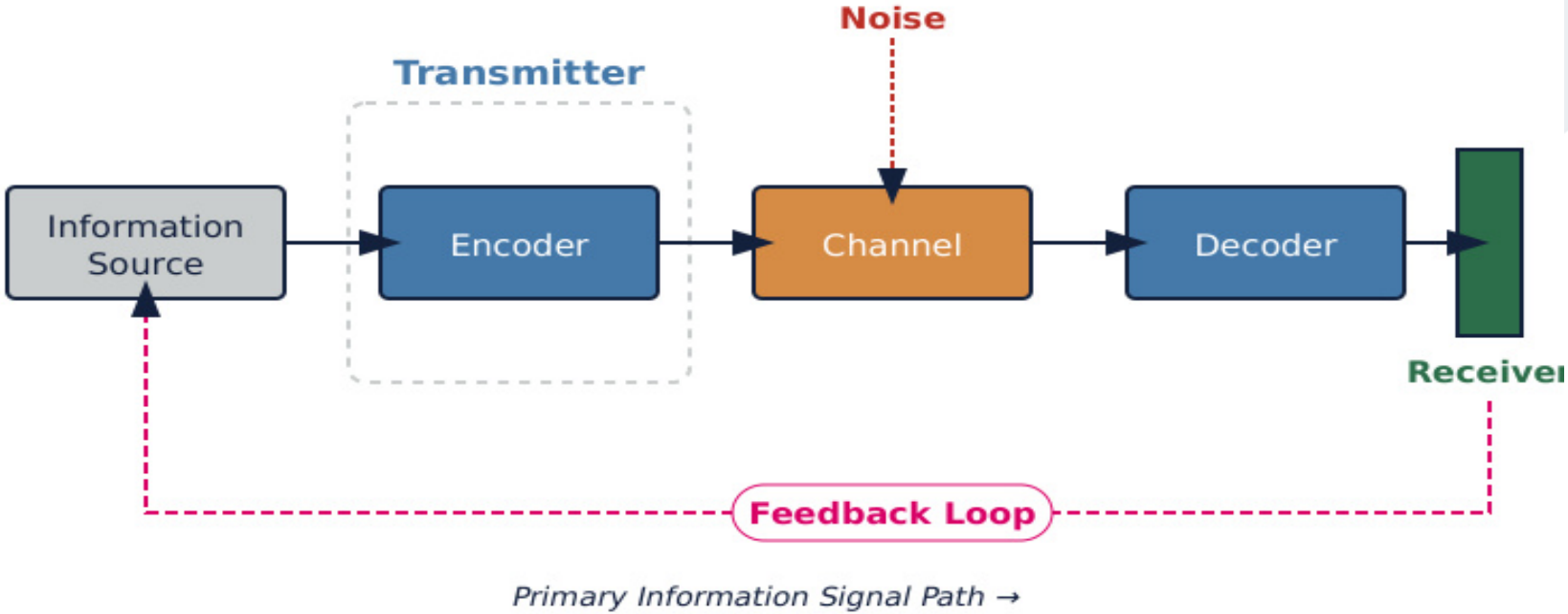
Why It Matters

Noise corrupts data. A '1' might be received as a '0', causing errors in messages or downloads.

Shannon's Insight

He asked: *How much data can we send reliably, even with noise?*

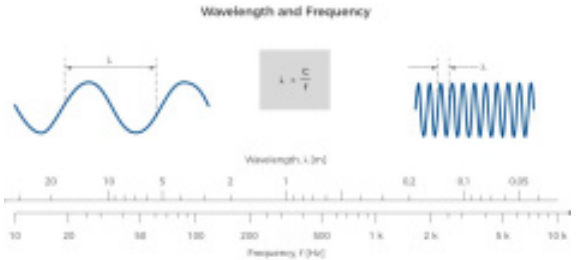
The Communication System



Key Concepts Behind the Theorem

Bandwidth

The maximum frequency range a channel can carry, like how wide a highway is for data.



Signal Power

Strength of the transmitted data signal compared to background noise.

Noise Power

Unwanted energy in the channel that interferes with the signal.

Shannon's Formula Revealed

The Famous Equation

$C = B \times \log_2(1 + S/N)$

Where:

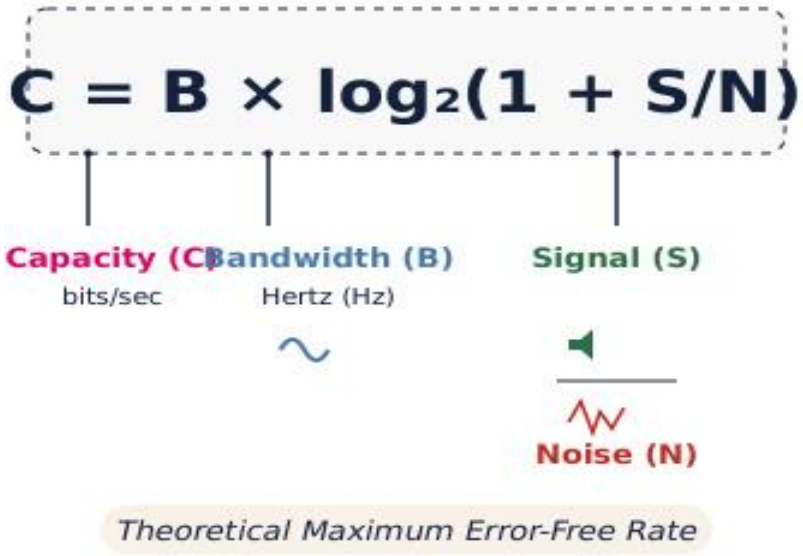
- **C** = Channel capacity (bits/sec)
- **B** = Bandwidth (Hz)
- **S/N** = Signal-to-Noise Ratio

What It Means

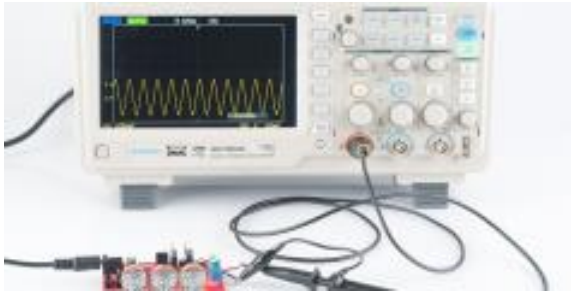
This formula gives the maximum error-free data rate on a noisy channel.

Real Insight

Increase capacity by boosting signal or widening bandwidth, but only to a limit.



Applying Shannon's Theorem



Formulas:

1. **SNR Calculation:**

$$\text{SNR} = \frac{\text{Transmit Power} \times \text{Channel Gain}}{\text{Noise Power}}$$

2. **Noise Power Calculation:**

$$\text{Noise Power (dBm)} = -174 + 10\log_{10}(B)$$

Note: B is the bandwidth and its unit is in Mbit/s.

3. **Channel Gain Calculation:**

$$\text{Channel Gain (dB)} = 10\log_{10}\left(\frac{\lambda^2}{(4\pi d)^2}\right)$$

Measure Bandwidth

Determine the frequency range of the communication channel.

Calculate S/N

Find the ratio of signal power to noise power in decibels.

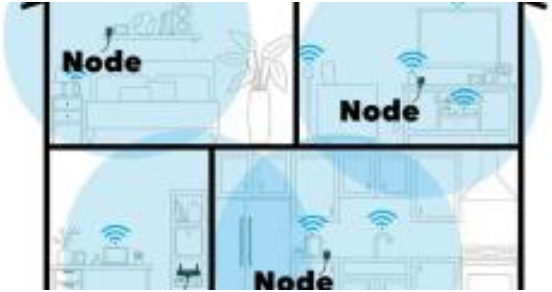
Compute C

Plug values into Shannon's formula to get maximum data rate.

Real-World Applications

5G Networks

Engineers use Shannon's limit to design faster, reliable mobile data systems.



Wi-Fi Design

Optimizing router placement and frequency bands for minimal noise.

Satellite Comms

Ensuring clear signals across vast distances with low power.

Understanding Shannon's Theorem: From Basics to Application

Question 1:

What does channel capacity mean in the context of Shannon's Theorem?

Question 2:

Why must the signal-to-noise ratio be greater than zero for effective data transmission according to Shannon's Theorem?

Question 3:

Calculate the maximum channel capacity for a system with 4000 Hz bandwidth and a signal-to-noise ratio of 15 using Shannon's formula.

Answers on the next slide...

Understanding Shannon's Theorem: From Basics to Application

Answer 1:

Channel capacity is the maximum rate at which data can be transmitted over a communication channel with negligible errors, as defined by Shannon's Theorem.

Answer 2:

The signal-to-noise ratio (S/N) must be greater than zero because a zero or negative ratio implies the signal is lost in noise, making reliable communication impossible.

Answer 3:

If a channel has a bandwidth of 4000 Hz and a signal-to-noise ratio of 15, the maximum channel capacity is 16,000 bits/sec, calculated using $C = B \times \log_2(1 + S/N) = 4000 \times \log_2(16) = 4000 \times 4$.

The Legacy of Shannon

A Foundational Breakthrough

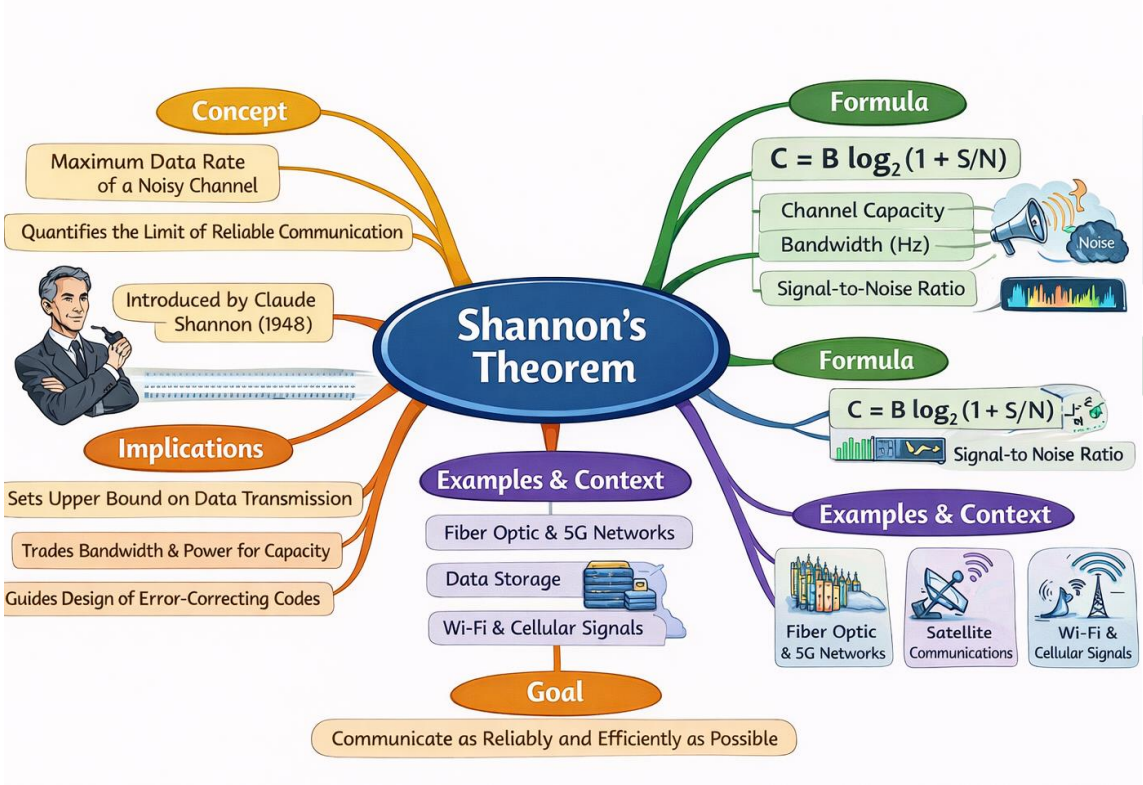
Shannon's Theorem set the theoretical foundation for the digital age.

More Than Just Theory

It guides every device that sends data—from smartphones to Mars rovers.

Think About It

Next time your video call is smooth, remember: Shannon made it possible.



Thank you