Al-Mustaqbal University
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Digital Communication

Lecture 8
Source Coding Techniques
DPCM, DM, ADM, and ISI

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Aims of this Lecture

- By the end of this lecture, students will be able to:

  ✔ Understand the different source coding techniques.

  ✔ Explain the principles of DPCM, DM, and ADM.

  ✔ Identify advantages, limitations, and modifications of each technique.

  ✔ Discuss Inter-Symbol Interference (ISI) and its effects.

Differential Pulse Code Modulation (DPCM)

- **What is DPCM?**

- **Definition:** DPCM predicts the next sample value based on past values, transmitting only the difference.
  Why? Reduces redundancy and overall bit rate.
  How? Uses a predictor and encoder to transmit the difference between actual and predicted values.

How DPCM Works?

1 The predictor estimates the current sample based on past samples.

2 The difference (error) between predicted and actual values is transmitted.

3 A decoder reconstructs the signal by adding the error back to the predicted value.

Equation:

$$e(nT_s) = x(nT_s) - \hat{x}(nT_s)$$

where:

- $e(nT_s)$ is the quantized error.

- $x(nT_s)$ is the actual sample value.

- $\hat{x}(nT_s)$ is the predicted sample value.

Delta Modulation (DM)

- **Definition:** DM transmits only 1 bit per sample by comparing the current and previous sample.
  Why? Reduces data rate and system complexity.
  How? Uses a 1-bit quantizer with a fixed step size δ.

How DM Works?

1. If the current sample is higher than the previous, transmit '1'.
2. If lower, transmit '0'.
3. The decoder reconstructs the signal using a staircase approximation.

✅ **Advantages:**

✔ Requires low bandwidth.

✔ Simple implementation.

❌ **Disadvantages:**

✖ Slope overload distortion (step size too small).

✖ Granular noise (step size too large).

Adaptive Delta Modulation (ADM)

- **Definition:** ADM adjusts step size dynamically to improve performance.
  Why? Reduces both slope overload distortion and granular noise.
  How? Increases step size for step changes, decreases for small variations.

How ADM Works?

1️⃣ If consecutive '1's or '0's occur, increase step size.

2️⃣ If alternating '1's and '0's occur, decrease step size.

3️⃣ Uses an adaptive algorithm to dynamically change step size.

✅ **Advantages:**

✔️ Overcomes slope overload and granular noise.

✔️ Suitable for speech and audio transmission.

❌ **Disadvantages:**

✖️ More complex than DM.

✖️ Requires additional logic for step size control.

Inter-Symbol Interference (ISI)

- **Definition:** ISI occurs when one symbol interferes with another due to channel dispersion.
  Why? Causes errors in digital communication, reducing signal clarity.
  How? Arises due to overlapping of successive pulses in the transmission channel.

How to Reduce ISI?

- ◆ **Equalization:** Adjusts received signal to compensate for distortion.
  ◆ **Pulse Shaping:** Uses filtering to limit bandwidth and avoid overlapping.
  ◆ **Increasing Symbol Rate:** Reduces time overlap between pulses.

- ✅ **Applications of ISI Reduction:**
  ✔ Mobile communication.
  ✔ High-speed data transmission.
  ✔ Optical fiber communication.

Summary

📌 **DPCM**: Transmits only the difference between predicted and actual samples.

📌 **DM**: Uses 1-bit quantization with a fixed step size.

📌 **ADM**: Adjusts step size dynamically for better performance.

📌 **ISI**: Interference between symbols, reduced using equalization and filtering.

Thank you