وزارة التعليم العالي والبحث العلمي

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Subject

Principles of Information theory

Class: First

Lecturer: 1

Teaching the subject

RAED ALSHMARY

Introduction

In modern digital systems, we need to **store and transmit data efficiently**.

However, digital data often contains **redundancy**, and during transmission it may be affected by **noise**, which causes errors.

Therefore, several important concepts were developed, such as:

- **Data Compression**
- **Coding Theory**
- **Information Theory**

The main objectives are:

- Reduce data size
- Transmit data efficiently
- Minimize transmission errors

Data Compression

Data compression means reducing the number of bits required to represent data **without losing important information**..

Simple Example
Instead of writing:
AAAAAA
We can represent it as:
6A
This reduces the data size

Goals of Data Compression

- Reduce storage space
- Increase transmission speed
- Reduce network bandwidth usage

Information Theory

studies the amount of information contained in an event.

Basic Rule

The rarer the event, the more information it carries.

- Example

When tossing a coin:

•Probability of Head = 0.5

•Probability of Tail = 0.5

Both outcomes carry equal information.

But if an event has: Probability = 0.01

It carries **more information** because it is rare.

Relationship Between Coding and Information Theory

Coding methods are often based on **symbol probabilities**.

Basic Idea

•Frequently occurring symbols → **short codes**

•Rare symbols → **longer codes**

Symbol	Probability	Code Length
A	High	1 bit
B	Medium	2 bits
C	Low	3 bits

This reduces the **overall data size**.

Communication System Model

A typical **communication system** consists of several components:

1.Information Source

Generates the data (text, image, audio).

2.Encoder

Converts the information into binary code.

3.Communication Channel

The medium used to transmit data, such as:

1. Internet
2. Cable
3. Wireless signals

4.Noise

Any disturbance that may cause errors.

1.Decoder

Converts the coded data back to its original form.

2.Destination

The final user or system receiving the data.

Communication Model

Source → Encoder → Channel → Decoder → Destination

↑

Noise

Basic Concepts in Information Theory

Information theory is based on three main concepts:

1. Information Measure

A way to quantify the **amount of information** in a message.

2. Channel Capacity

The **maximum amount of information** that can be transmitted through a communication channel reliably.

3. Coding

Using efficient techniques to represent data in order to:

- Reduce errors
- Improve transmission efficiency

Fundamental Idea of Information Transmission

The fundamental principle states that:
Information can be transmitted over a communication channel **with very low error rates**, even in the presence of noise, **if the transmission rate is less than the channel capacity** and proper coding techniques are used.

Symbol	Frequency
A	50
B	30
C	20

Example Coding

In efficient coding:

- **A** receives a short code
- **B** receives a medium code
- **C** receives a longer code

A = 0

B = 10

C = 11

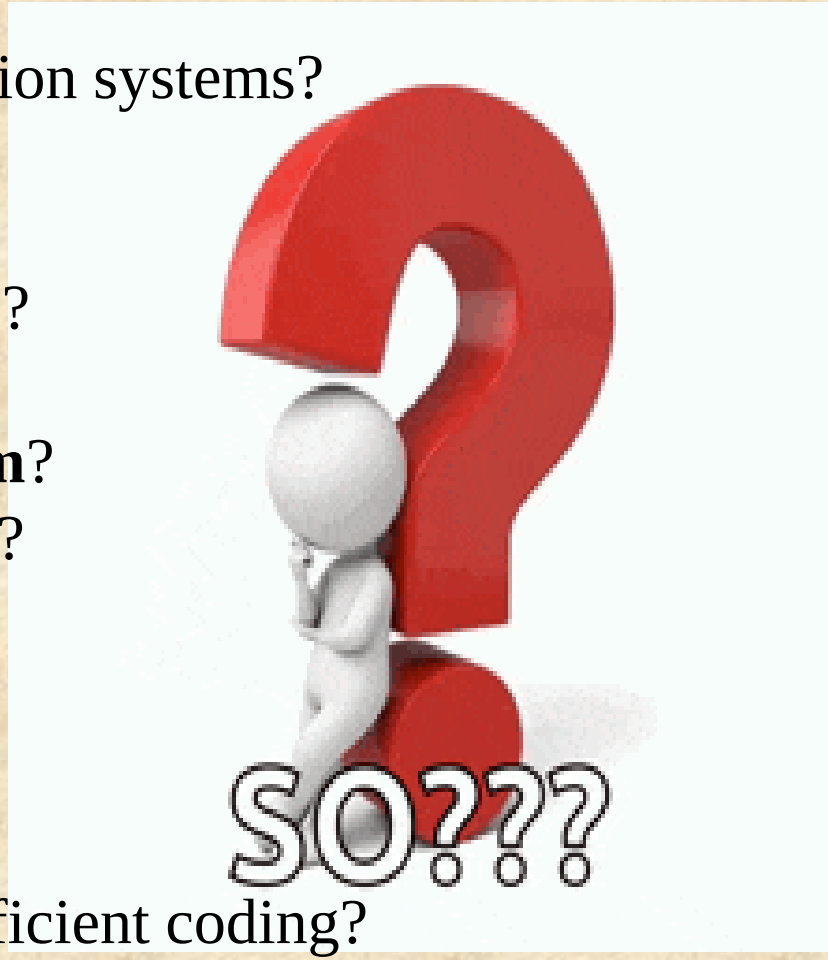
Importance of Coding in Cyber Security and Computing

Coding techniques are widely used in:

- Data compression
- Error detection and correction
- Digital communications
- Computer networks
- Cryptographic systems

Lecture questions

1. What is meant by **data compression**?
2. Why is data compression important in modern communication systems?
3. What is **Information Theory**?
4. Who developed the concept of **Information Theory**?
5. What is the main goal of **coding** in communication systems?
6. What is meant by **redundancy** in data?
7. What are the main components of a **communication system**?
8. What is the role of the **encoder** in a communication system?
9. What is the role of the **decoder** in data transmission?
10. What is meant by **noise** in a communication channel?
11. How can noise affect transmitted data?
12. What is meant by **channel capacity**?
13. Why do frequent symbols usually have **shorter codes** in efficient coding?
14. What is the relationship between **coding and information theory**?
15. In your opinion, how is coding used in **cyber security and computer networks**?



Conclusion

- Coding is used to represent information efficiently.
- Information theory measures the amount of information in messages.
    - Data compression reduces data size.
- Communication systems include source, encoder, channel, noise, decoder, and destination.
- The goal is to transmit information efficiently with minimal errors

Thank you