



جامعة المستقبل  
AL MUSTAQBAL UNIVERSITY

## كلية العلوم قسم الأمن السيبراني

### Lecture: (3)

#### *Coding techniques*

**Subject:** Coding Techniques

**First Stage**

**Lecturer:** Asst. Lecturer. Suha Alhussieny



### *1- Introduction to coding techniques*

In today's digital world information exchange is being held electronically. So there arises a need for secure transmission of the data. Besides security there are several other factors such as transfer speed, cost, errors transmission etc. that plays a vital role in the transmission process. The need for an efficient technique for compression.

Coding theory, a critical component of information theory, plays an indispensable role in enhancing data transmission accuracy and efficiency across digital communication systems. It delves into the development and analysis of algorithms to correct errors and optimize data compression, ensuring data integrity and security during transmission. Mastering coding theory is pivotal for professionals navigating the realms of telecommunications, computer science, and cybersecurity, making it a foundational subject in the digital age.

- Compress methods are key enabling techniques for multimedia applications.
- Raw media takes much storage and bandwidth
  - A raw video with 30 frame/sec, resolution of 640x480, 24bit color
  - One second of video  $30 * 640 * 480 * 3 = 27.6480$  Mbytes
  - One hour video is about 100Gbytes

**Compression:** the process of coding that will effectively reduce the total number of bits needed to represent certain information.

Information is rarely transmitted directly to the receiver, without



any processing **due to** the followings:

- source alphabet is different from channel one, therefore some adaptation of the source to the channel is needed (*information representation codes*).
- channel must be very efficiently used (close as possible to its full capacity), meaning that the source must be converted into an optimal one. For an efficient use of the channel - in order to minimize transmission time and/or storage space – source compression is needed (*compression codes*).
- it is also necessary to adapt the source to the channel to ensure synchronization between transmitter and receiver.
- information transmitted over a noisy channel is distorted by channel noise; this is why error detecting and correcting codes are used in error control procedures.
- information confidentiality from unauthorized persons must be provided in some applications.

The need for source processing prior to transmission (or storage) is leading to the processing known as coding.

The problem of representing the source alphabet symbols  $S_i$  in term of another system of symbols (usually the binary system consisting of the two symbols 0 and 1) is the main topic of coding.

The **two main problems** of representation are the following:

1. How to represent the source symbols so that their representations are far apart in same suitable sense. As a result, in spite of small changes (noise) in their representation, the altered symbols can be discovered to



be wrong and even possibly corrected (i.e Error – Detecting codes & Error- correcting codes).

2. How to represent the source symbols in a minimal form for purposes of efficiency. The average code length is minimized, where  $i$  is the length of the representation of the  $i$ th symbol  $S_i$  the entropy function provides a lower bound on  $L$  ( $L \geq H(x)$ ).  $N$

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

**Coding techniques** are methods that encode the data bits into symbols that can be modulated and transmitted over the wireless channel. The main objectives of coding techniques are to reduce the error rate, increase the data rate, and optimize the power consumption of the wireless communication systems. There are different types of coding techniques, such as error control coding, source coding, and channel coding. Each type has its own advantages and disadvantages, depending on the characteristics of the wireless channel and the requirements of the application.

## 2- types of coding techniques

### ❖ Error control coding

Error control coding is a coding technique that adds redundancy to the data bits to detect and correct the errors that occur during the transmission over the wireless channel. Error control coding can be divided into two categories: block coding and convolutional coding. Block coding divides the



data bits into blocks of fixed length and adds parity bits to each block. Convolutional coding uses a sliding window to encode the data bits into symbols that depend on the previous and current bits. Error control coding can improve the reliability and accuracy of the wireless communication systems, but it also increases the complexity and overhead of the encoding and decoding processes.

#### ❖ **Source coding**

Source coding is a coding technique that compresses the data bits to reduce the amount of information that needs to be transmitted over the wireless channel. Source coding can be classified into two types: lossless coding and lossy coding. Lossless coding preserves the original data bits without any distortion or loss of information. Lossy coding discards some of the data bits that are less important or redundant, resulting in some distortion or loss of information. Source coding can increase the data rate and reduce the power consumption of the wireless communication systems, but it also decreases the quality and fidelity of the data.

#### ❖ ***Channel coding***

Channel coding is a coding technique that adapts the data bits to the characteristics and conditions of the wireless channel. Channel coding can be categorized into two groups: adaptive coding and cooperative coding. Adaptive coding changes the modulation and coding schemes according to the channel quality and feedback from the receiver. Cooperative coding uses multiple transmitters and receivers to cooperate and share the data bits over the wireless channel. Channel coding can enhance the efficiency and



robustness of the wireless communication systems, but it also requires more coordination and synchronization among the nodes.

### *3- Advantages of coding techniques :*

- **Data Compression:** Encoding can help in compressing data, reducing the amount of storage space required and making data transfer more efficient.
- **Error Detection and Correction:** Some encoding techniques, such as error-correcting codes, can help in detecting and correcting errors that may occur during data transmission.
- **Security:** Encoding can be used to encrypt sensitive information, making it unreadable to unauthorized users and providing a level of security for data transmission and storage.
- **Standardization:** Encoding can help standardize data representation, making it easier for different systems to interpret and process the data consistently.
- **Data Representation:** Encoding allows for the representation of data in different formats, such as text, images, audio, and video, making it possible to store and transmit diverse types of information.

Here are some illustrative **examples of Coding Theory in action.**

- **Mobile Communications:** Error correcting codes ensure that your text messages and calls remain clear and uninterrupted, even in areas of poor signal quality.
- **Data Storage:** Hard drives and SSDs use sophisticated error correcting codes to prevent data corruption, ensuring the integrity of stored information.



- **Satellite Communication:** The transmission of data over vast distances in space is fraught with potential for error; codes developed from Coding Theory principles are crucial for reliable space communication. While Coding Theory deals with error control, its principles are also applied in cryptography for securing data against unauthorized access.

### Real-world applications: Examples of Coding Theory

Coding Theory finds applications in various aspects of modern life, from communication to data storage, each demonstrating the theory's value in enhancing data integrity and efficiency .Here are some prominent examples where Coding Theory plays a critical role:

- **Internet Communications:** Error-correcting codes are essential for ensuring the reliable transmission of data across the Internet. Without them, online data transfers, including streaming and downloading, would be much less efficient and reliable.
- **Wireless Networks:** In wireless communications, codes help mitigate the effects of interference and signal fading, proving critical in environments with variable signal quality.
- **Aerospace Communications:** Spacecraft and satellites rely on advanced coding techniques to communicate with Earth stations, overcoming the immense challenges posed by space conditions.