Coding Theory: Introduction

What is Coding Theory?

Goal: read the data from the corrupted data.

What is Coding Theory?

Communication channels

Transmitter | Channel | Receiver

What is Coding Theory?

Erasure channels

Transmitter | Channel | Receiver

$(x_1, x_2, x_3, x_4, x_5) \longrightarrow$ Erasures $\longrightarrow (x_1, *, x_3, *, *)$

What is Coding Theory?

Channels with Errors

Transmitter | Channel | Receiver

$(x_1, x_2, x_3, x_4, x_5) \longrightarrow$ Errors $\longrightarrow (y_1, y_2, y_3, y_4, y_5)$

We usually do not know where/when errors happened.

What is Coding Theory?

Discrete channels with Errors

Transmitter | Channel | Receiver

$$\underbrace{(x_1, x_2, x_3, x_4, x_5)}_{\in A, |A| < \infty} \longrightarrow \text{Errors} \longrightarrow \underbrace{(y_1, y_2, y_3, y_4, y_5)}_{\in A, |A| < \infty}$$

What is Coding Theory?

Continuous channels with Errors

Transmitter | Channel | Receiver

$$\underbrace{(x_1, x_2, x_3, x_4, x_5)}_{\in \mathbb{R}^5 \text{ or } \mathbb{C}^5} \longrightarrow \text{Errors} \longrightarrow \underbrace{(y_1, y_2, y_3, y_4, y_5)}_{\in \mathbb{R}^5 \text{ or } \mathbb{C}^5}$$

What is Coding Theory?

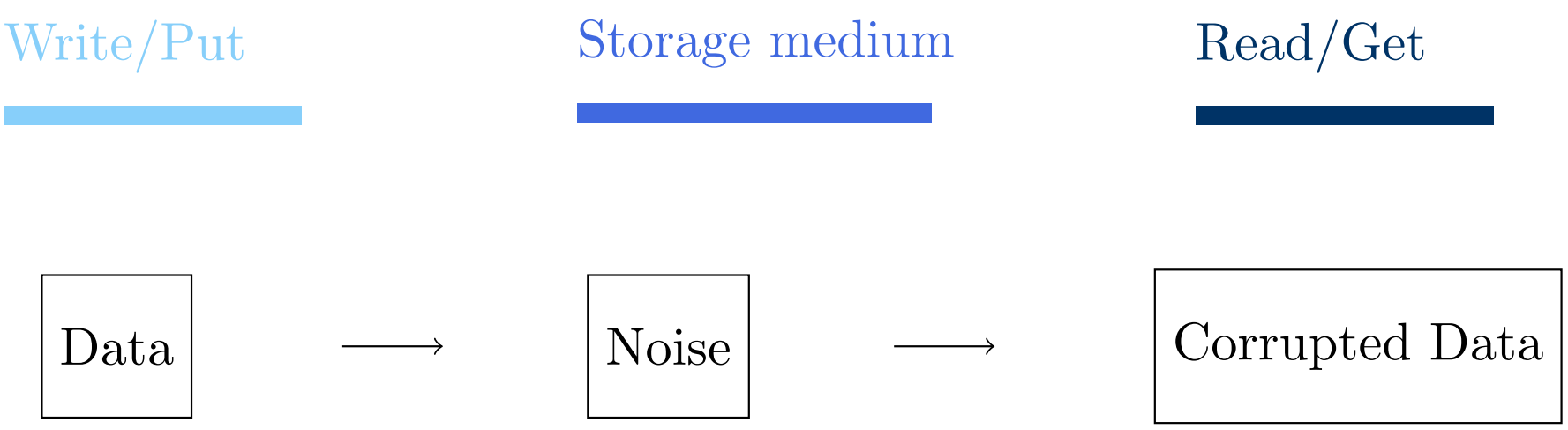
- Multi-input multi-output channels

Transmitter | Channel | Receiver

$$\underbrace{\begin{bmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{bmatrix}}_{\in \mathbb{C}^{2\times 2}} \longrightarrow \text{Errors} \longrightarrow \underbrace{\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}}_{\in \mathbb{C}^{2\times 2}}$$

What is Coding Theory?

- Storage systems



What is Coding Theory?

Erasure channels

Write/Put | Storage medium | Read/Get

$$(x_1, x_2, x_3, x_4, x_5) \longrightarrow \text{Erasures} \longrightarrow (x_1, *, x_3, *, *)$$

Coding Theory

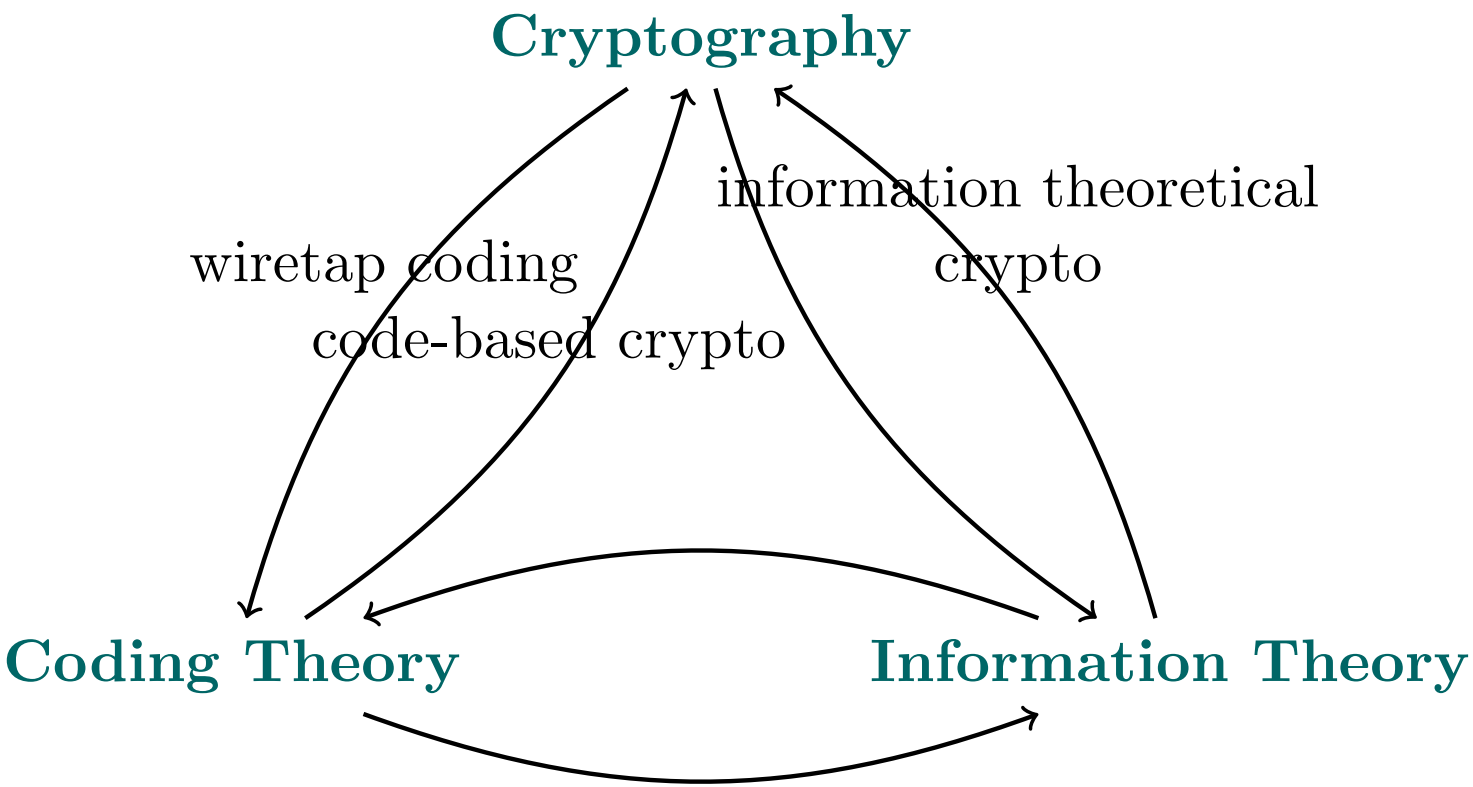
Study of the design of mechanisms to ensure reliability of data transmission in the presence of perturbance.

For storage systems, transmission/reception corresponds to put/get operations.

This course mostly concentrates on transmission systems, for discrete channels.

Coding Theory

Related Areas



{ Coding for communications (wired, wireless)
Coding for storage (CD, RAID systems, cloud storage) }

Network coding

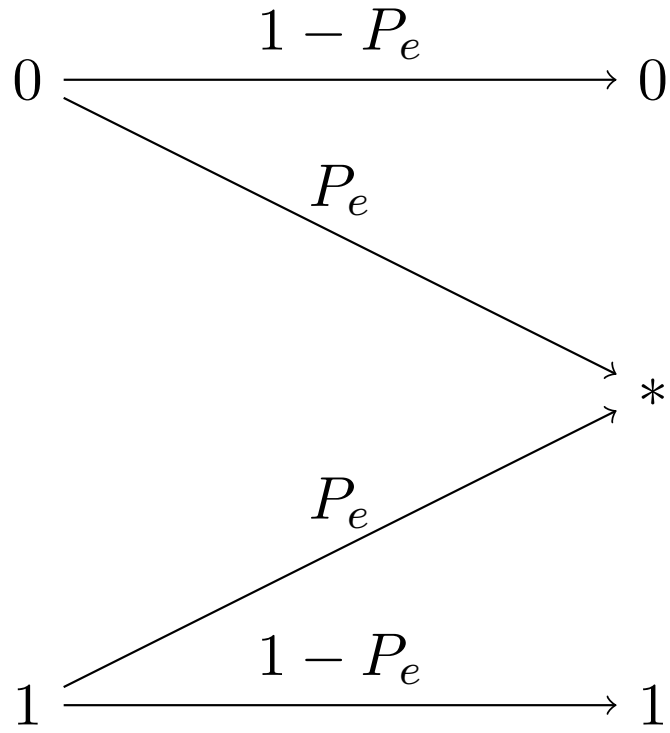
Coding for memories

Quantum coding

(Source coding and compression)

Binary Erasure Channel

Channel with erasure probability P_e, binary input 0 and 1, and ternary output 0, 1 or $*$.



Discrete Erasure Channels

Binary Erasure Channel

Transmitter | Channel | Receiver

$$\underbrace{(0,1,0,0,1)}_{\in\{0,1\}} \longrightarrow P_e \longrightarrow (0,1,0,*,1)$$