1SC4310 – Principles of information theory and communication networks for IoT

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Department: DÉPARTEMENT SIGNAL, INFORMATION, COMMUNICATION
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 34,50

Description

This course will first present the theoretical foundations and fundamental limits in information theory and then study concrete cases of network standards and protocols for the Internet of Things.

Information theory, fruit of the work of scientists such as Hartley, Shannon, Wiener and Kolmogorov, is a major tool to solve fundamental problems of the digital world such as: implementation of large-scale broadband communication networks, storage and processing of massive data or cryptography. The first part of the course introduces the fundamental concepts and results of this theory, as well as the algorithms that can be used to solve problems. This course will also serve as introduction for more advanced courses in communications and statistics.

The various wireless communication systems for IoT, short or long range (Zigbee, SigFox, LoRA, LTE-M, NB-IoT, etc.) will then be presented. We will be interested in their design at the radio level for efficient data collection but also for storage and centralized or distributed data processing architectures, adapted to application requirements (execution time, security, etc.).

Quarter number

ST4

Prerequisites (in terms of CS courses)

CIP EDP

Syllabus

I. Information Theory

1) Introduction: motivations (communication networks, processing and storage of massive data), probabilistic tools.

2) Information measures: entropy, relative entropy and mutual information for discrete alphabets. Properties of information measures: string rule, informational inequalities (Fano, Log-sum, Data Processing etc.).

3) Data Compression: source encodings, prefix codes, unencrypted codes, and Kraft inequality. Coding of Huffman, Fano-Shannon and Lempel-Ziv. Fundamental limits. Optimality and complexity of Huffman coding. Typical sequences.

4) Data Transmission, Discrete Channels: channel coding, coding and decoding. Examples of discrete channels. Shannon's theorem, channel capacity. Return on typicity, attached typicity. Complexity and coding.

5) Data Transmission, Continuous Channels: information measurements for continuous alphabets, source and capacity coding theorems. Gaussian channels and models for communications, modulations. Fundamental limits, Shannon-Hartley's theorem. Extensions: parallel channels, colored noise. Coding for Gaussian channels. Multi-user communication.

6) Quantization: quantization of continuous valued signals, rate distortion theory, optimal quantization schemes.

II. Wireless telecommunications networks for IoT

7) Presentation of different wireless communication standards for IoT, low or long range

8) Radio mechanisms for IoT (modulation, coding, retransmissions, access to the canal)

9) Data Collect and Storage Architecture

10) Impact of application requirements for security, resilience and geolocation on the design of the collect and processing system.

Class components (lecture, labs, etc.)

Lectures, Tutorials, Homework

course : 25h30, tutorials : 7h30, a written exam : 1h30

Grading

Written exam : 1h30

Course support, bibliography

Detailed PDF slides available on edunao.

Learning outcomes covered on the course

Understand the algorithms and fundamental limitations for data transmission, storage and data processing.

Understand the physical meaning of information measures

Implement algorithms to apply the concepts of information theory to real problems,

Evaluate the performance of these algorithms.

Understand communication mechanisms and protocols that allow low-cost sensors with high energy consumption constraints to transmit their information.

Calculate the dimension a wireless network for IoT applications with special coverage and capacity requirements.

Design a secure storage and data processing system for IoT tailored to application requirements.

Description of the skills acquired at the end of the course

Understand the algorithms and fundamental limitations for data transmission, storage and data processing.

Understand the physical meaning of information measures

Implement algorithms to apply the concepts of information theory to real problems,

Evaluate the performance of these algorithms.

Understand communication mechanisms and protocols that allow low-cost sensors with high energy consumption constraints to transmit their information.

Dimension a wireless network for IoT applications with special coverage and capacity requirements.

Design a secure storage and data processing system for IoT tailored to application requirements.