Distributed Sensing
Lab 9

Distributed Intelligent Systems

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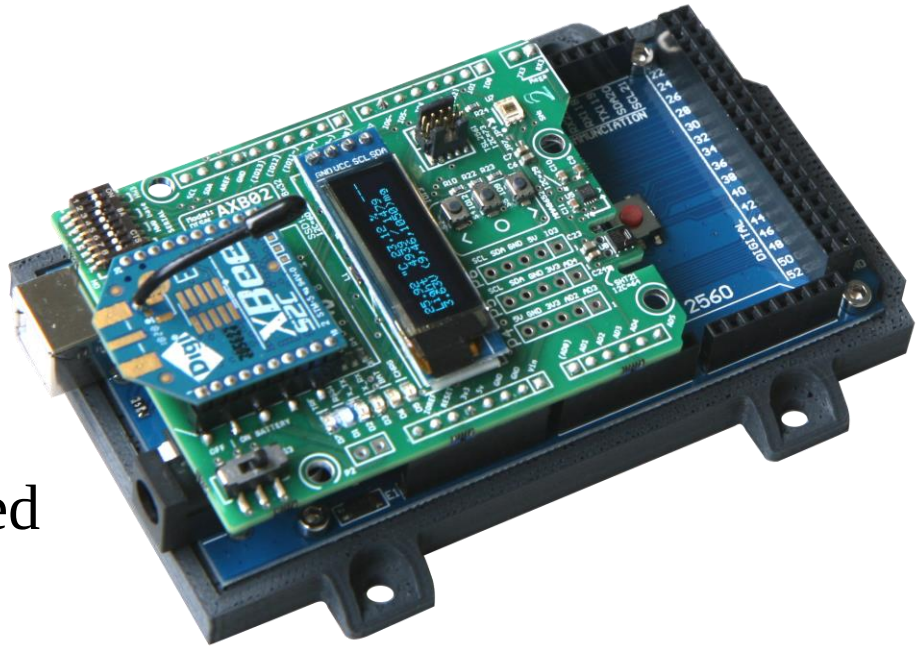
What you will learn today

- Part 1
  - Introduction to the DISAL Arduino Xbee Kit
  - Local sensing, remote sensing, Wireless Sensor Networks (WSNs)
  - Energy efficiency in distributed sensing
- Part 2
  - Multiple basic case studies going through typical topics in distributed sensing in Webots

Hardware

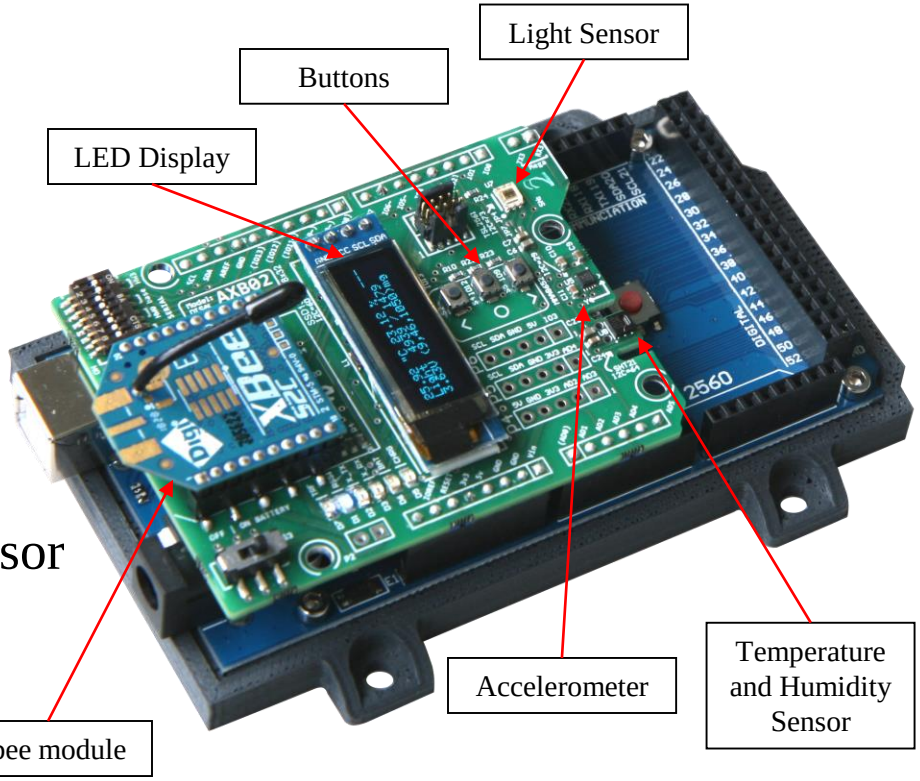
- You will receive:
  - 2 Sensor Nodes
  - 1 Usb Cable



- Each sensor node is composed by:
  - 1 Arduino board
  - 1 Sensor shield
  - 1 Xbee module for communication

Hardware

- You will work with:
  - LED display
  - Buttons
  - Light sensor
  - Accelerometer
  - Temperature and Humidity Sensor
  - Xbee communication module



Software

- Use the Arduino IDE installed on the computers.
  - NOTE: if you are working in the EPFL computer rooms, open the IDE first and then open the files inside it
- Download and extract the .tar file with the code from Moodle

Programming an Arduino

- Connect the Arduino to your computer
- Select the correct *Board* and *Port* in the *Tools* menu
- Add the libraries you need the first time you use them (*Sketch/Include Library/ Manage Libraries)*
- Verify your code 
- Correct mistakes (if any), they will be shown in the console
- Upload code to the board 

Arduino code structure

- setup() → called once at startup or reset, used for initialization and configuration
- loop() → main body of the program. Keeps looping

Arduino communication

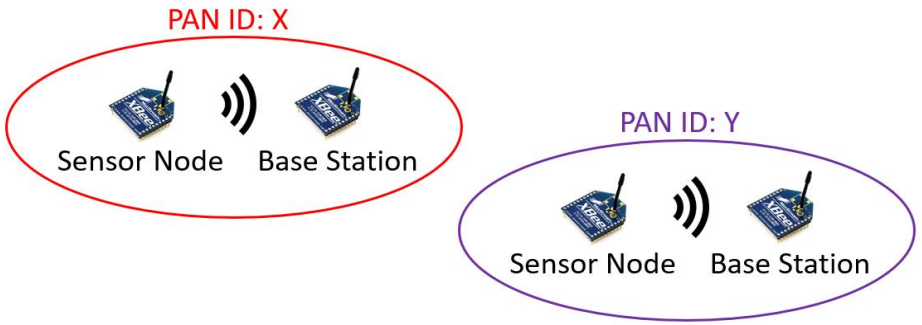
- Serial line communication via USB cable between the board and the computer (*Serial.print("Hello world/n");*)
- Baud rate (set to 9600 for this lab)
- Serial monitor and Serial plotter tools
- I2C communication between microcontroller and sensors (already implemented)

Xbee basics

- Low cost and easy-to-use modules for short-range communication
- Zigbee and 802.15.4 compliant
- Two nodes:
  - One used as transmitter (power it with the battery)
  - One used as a base station (connect it to the computer)
- Transmitter node: reads data from sensors and sends it to base station
- Base station: receives data from transmitter and sends it to the computer

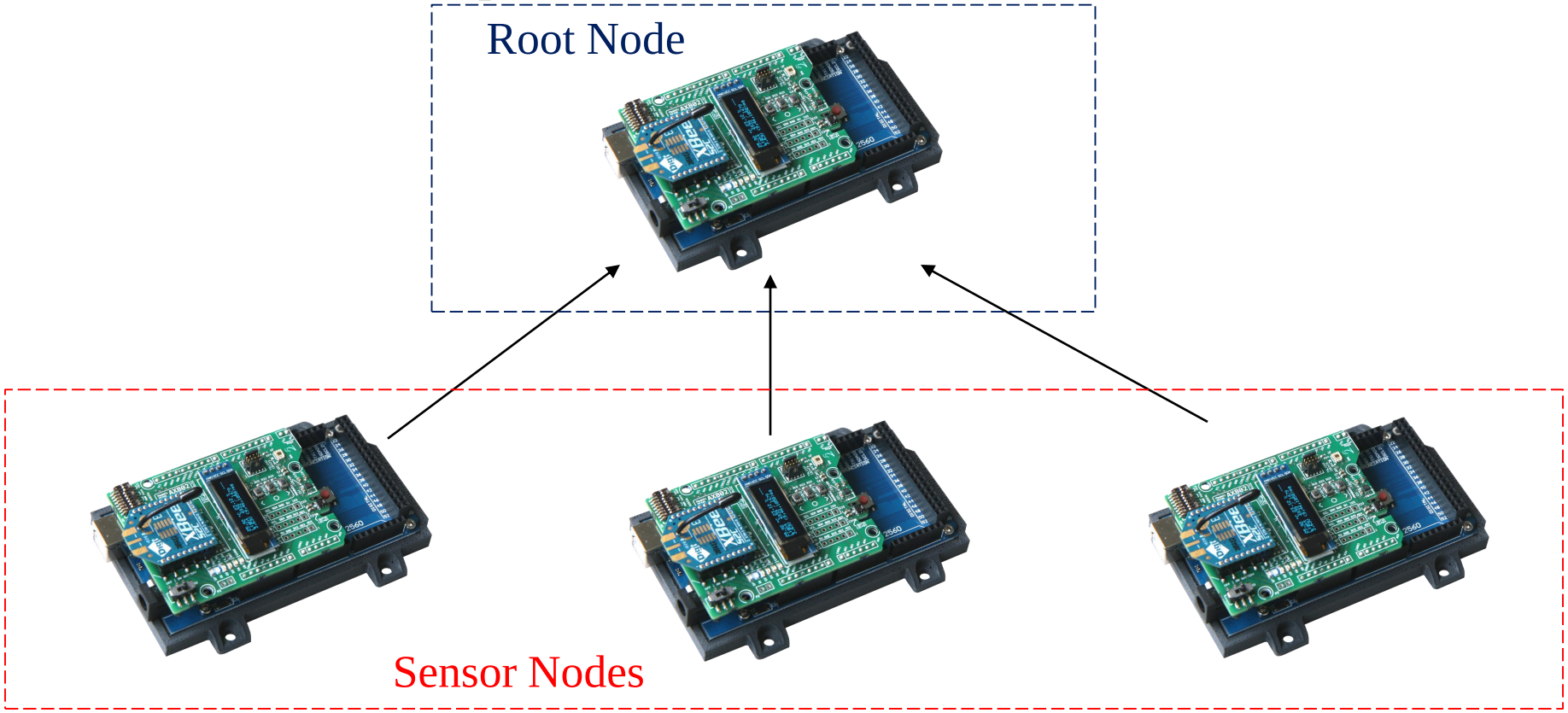
Xbee programming

- In this lab, the Serial3 line is used to communicate from the board to the Xbee.
- In part 3 and 4, set the same PAN ID in the transmitter and in the receiver to create a network (**use the number of your computer as PAN ID**)



Spatial Suppression with Arduino

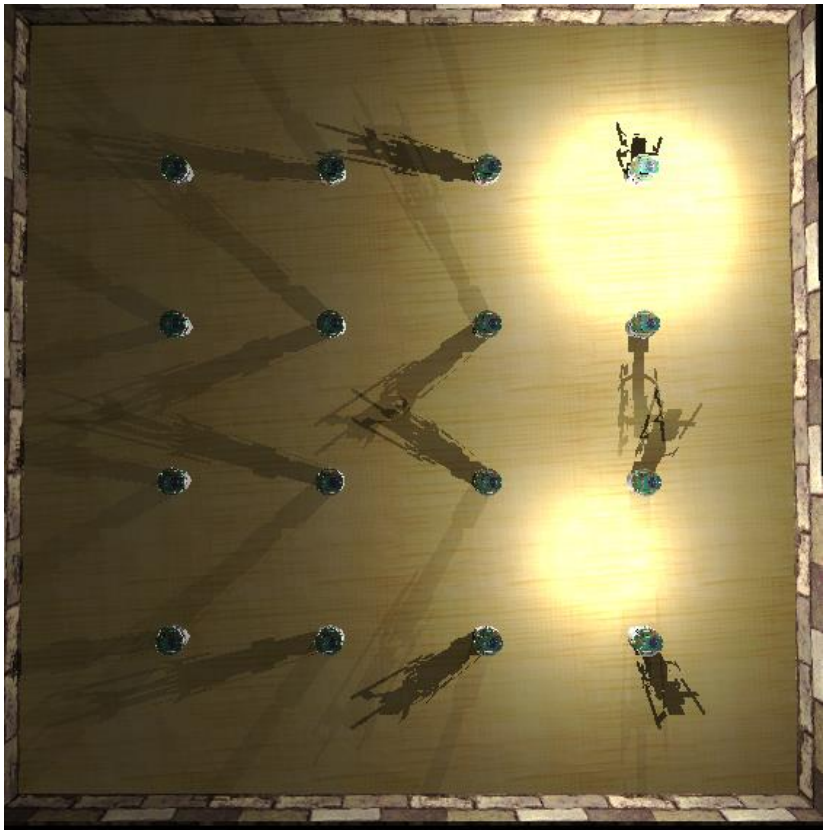
For this part of the lab, **pair up with a colleague**. You will need 4 Arduinos to accomplish the task



At the end of the Arduino part

- Upload the code in the folder *maintenance* on both boards
- Ensure that the battery switch is off

Webots Simulation



- Multiple basic case studies going through typical topics in distributed sensing:
  - performance evaluation
  - space-division scheduling
  - time-division scheduling

- network of 16 robots
- sensing light field

General Performance Metric

$$M_C(\alpha,\beta,\gamma,\delta) = \alpha \cdot \left(1 - \frac{1}{\varphi_{max} - \varphi_{min}} \cdot \sqrt{\frac{\sum_{n=1}^{N} \left(\hat{\varphi}_n(x,y,t) - \varphi_n(x,y,t)\right)^2}{N}} \right) + \beta \cdot \left(1 - \frac{\sum_{k=1}^{K} S_k}{K \cdot T \cdot F_s / L_s} \right) + \gamma \cdot \left(1 - \frac{\sum_{k=1}^{K} P_k}{K \cdot T \cdot F_m} \right) + \delta \cdot \left(1 - \frac{\sum_{k=1}^{K} V_k}{K \cdot T \cdot v_{max}} \right)$$

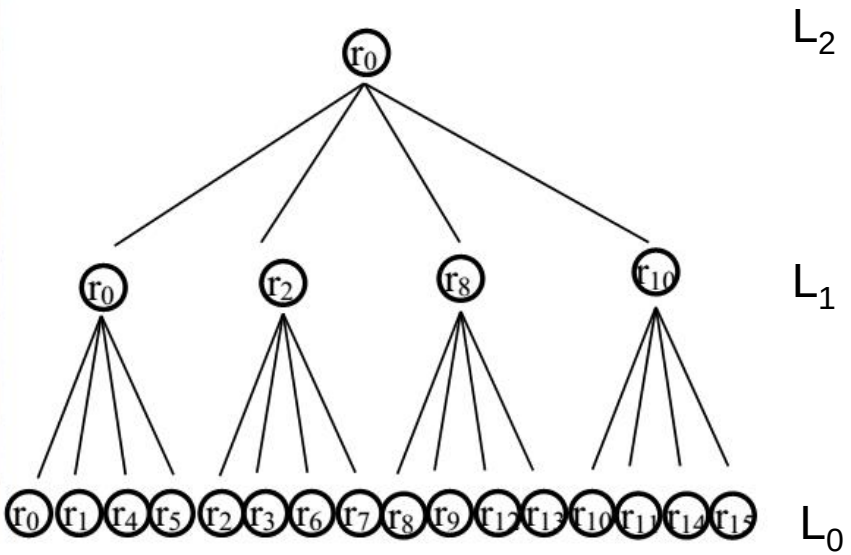
Estimation error

Measurement cost

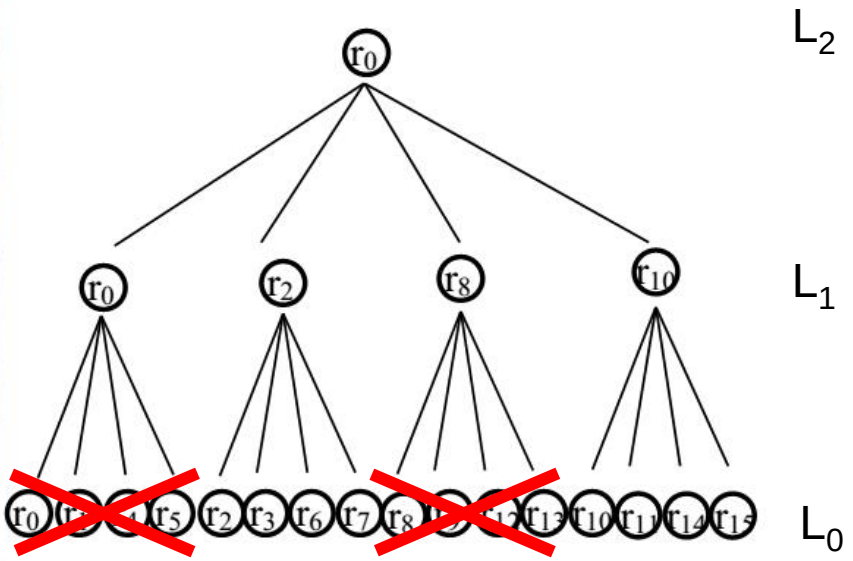
Communication cost

Mobility cost

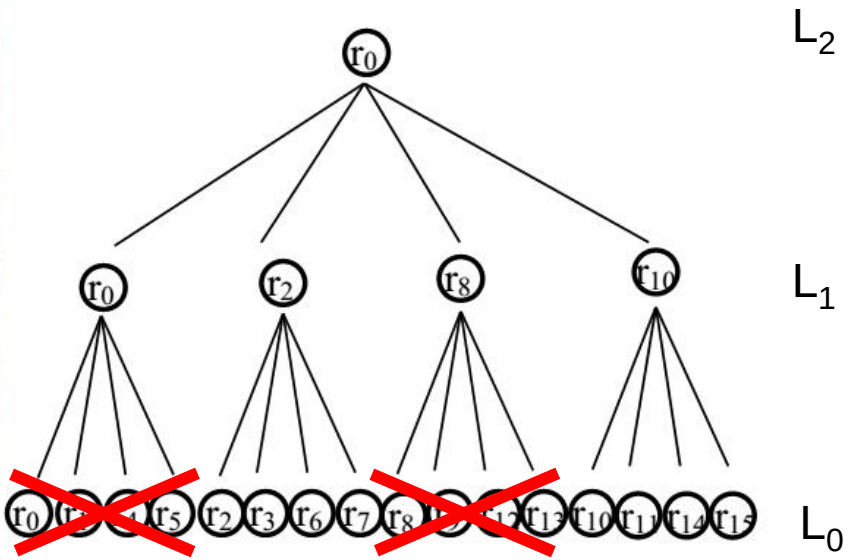
Backcasting

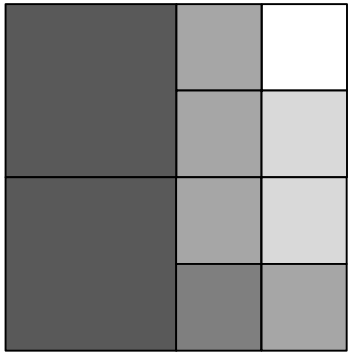


Backcasting

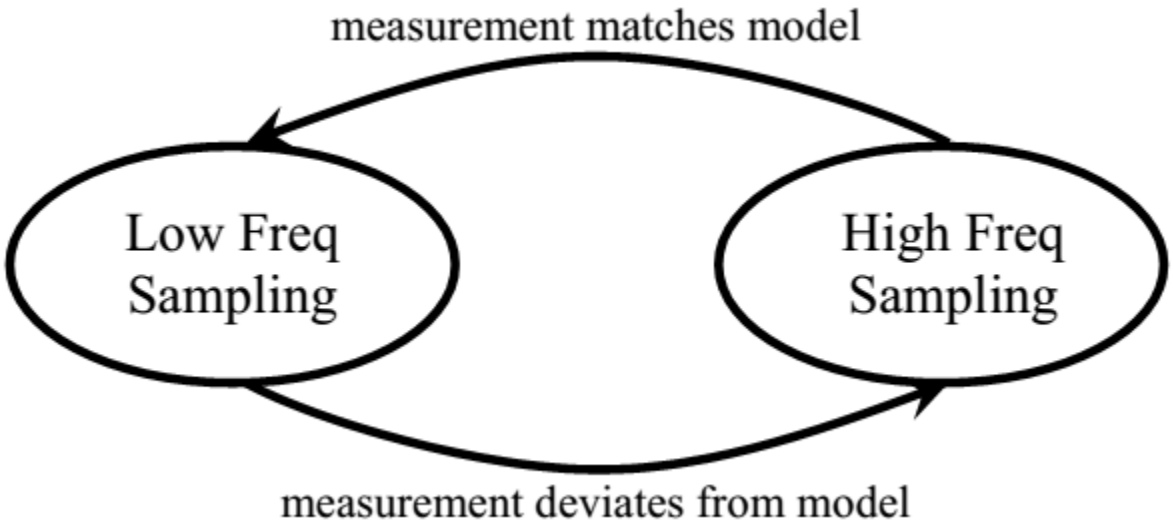


Backcasting





Time Adaptive Sampling



Assumption: linear model of sensed process $\hat{x}_t = \alpha \cdot x_{t-1} + \beta$

Please fill in the feedback form for Lab 9!

Thank you!