Goal:

Create specific mechanisms for the coordination and control based on aggregate measures of Internet of Things Systems

Important terms to understand:

- Coordination: The idea of planning together to reach solutions
- Control:
  - R. Scattolini, "Architectures for distributed and hierarchical model predictive control — a review", in Journal of process control, 19(5), 723-731, 2009. [PDF]
  - **Model Predictive Control:** Different type of algorithms implemented to manage systems. (Idea: run a prediction of the program, to see in the "future" what the system will look like and try then make decisions on how to continue running the system)
  - Types of Hierarchy in systems:
- Aggregate measures:
  - J. Beal, D. Pianini and M. Viroli, "Aggregate Programming for the Internet of Things," in Computer, vol. 48, no. 9, pp. 22-30, Sept. 2015, DOI: 10.1109/MC.2015.261. [PDF]
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- Internet of Things:
  - https://www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/
  - Physical devices connected amongst each other through the bias of the internet (ex: smart homes). They enable us to control them from afar.

Objective:

Write a report explaining the different specifications that can be implemented to help with the control and coordination of IoT systems. Explain the thought process, how we reached these ideas and show how they work. (Use the example of the mini system to then move forward)

Research Plan:

The idea is to find specific mechanisms to help with the control and coordination of Internet of Things systems.

First, we build a smaller model, to understand what we are looking for and understand how systems work.

Then take all these ideas and transfer them to bigger applications (IoT).

Miniature (Test) Model: (Light and Sound Emitting blocks)

Base Question: "if less than 75% of system blocks have enough charge to emit light for 5 minutes, then 20% of these blocks shall switch off their speakers"

Implementations:

- Naïve: All the blocks run independently, we check the battery percentage of each and if a certain amount does not have the correct right percentage, we shut off the speakers.
    - Benefit: It works the speakers turn off, and battery is saved
    - Limitations: Each block has no intel on what the other blocks are up to, we want to find a way to link these blocks together

- System: The idea now is to have all the blocks running on one system; hence all the blocks are connected amongst each other, and we can run global functions that will give us information about the global system and not just the individual blocks
    - Benefit: We now have minimal working **coordination**
    - Limitations: We are missing the control aspect of the system. The system has no real use, it just runs without having any understanding of what to do it just follows basic rules of implementation
    - Additional Question: Do we want to shut off the completely the speaker or do we just want to reduce? Does the system evolve based on the environment it is in (if its dark outside or day...)? What happens if a block is out of service and completely shuts down?

- Current SYSTEM:
    - **What we have tried to implement:**
        - Blocks:
            - Associate the battery percentage to how much light/sound is actually emitted (each "x lux" consumes "y battery %")
            - Node system (have each block associated to it's neighbor)
        - System:
            - Additional functions are added to have a better global understanding of the system (battery percentage of the rows...)
            - Add additional parameters to each function (this will help with the control of the model)
    - **What we want to implement:**

        - Potentially have a way to visualize the functioning of the system (python packages, matplotlib...)
        - Have an attempt at aggregate programming, hence that would mean more communication amongst the blocks.

    - **NECESSARY:**
        - Correctly define the model. Make sure we understand what we are looking for, what the goal is, how do we reach said goal...

CURRENT MODEL DEFINITION:

- Regulator: The addition of the regulator would then enable us to start working with the idea of MPC
    - ***LATER IMPLEMENTATION***
    - Try to run the regulator using a "Digital Twins" ALGORITHM:
        - ***https://dl.acm.org/doi/abs/10.1145/2968456.2974007***

IMPORTANT TO UNDERSTAND:

- The concept of "battery" of the blocks, or "speakers" or "light" is just a concept that is not the important aspect of the project (it helps for understanding but not the main point)
- Questions we have to ask ourselves:
    - What is the result that is expected from the system?
    - How do we reach said goal?
        - Modify whole system?
        - Change some elements of system?

Overall Summary:

Following the overview of the two research papers on aggregate programming and hierarchical models, we started working on our own implementation of a miniature system to better

understand how systems work and then be able to convert our miniature test into a more generalized version. We understand that the important part is not the individual elements of the system but more generally understanding the system as a whole, and then going into the details of how the smaller elements of the system can be taken care of. WE must go from the bigger picture to then focus on the smaller details.