On Structuring Energy-aware Sequence-control Software

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OUTLINE

On Structuring Energy-aware Sequence-control Software

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2. Framework
3. Use case
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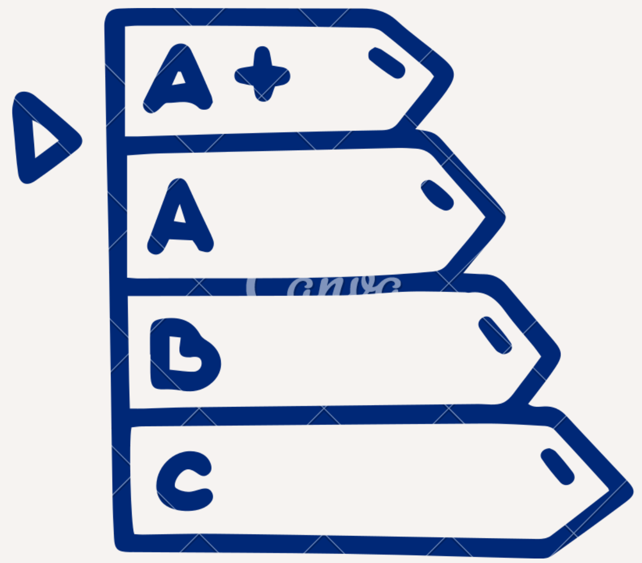
1. Introduction

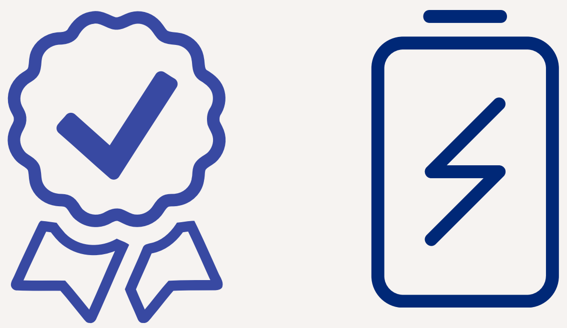
On Structuring Energy-aware Sequence-control software

INTRODUCTION



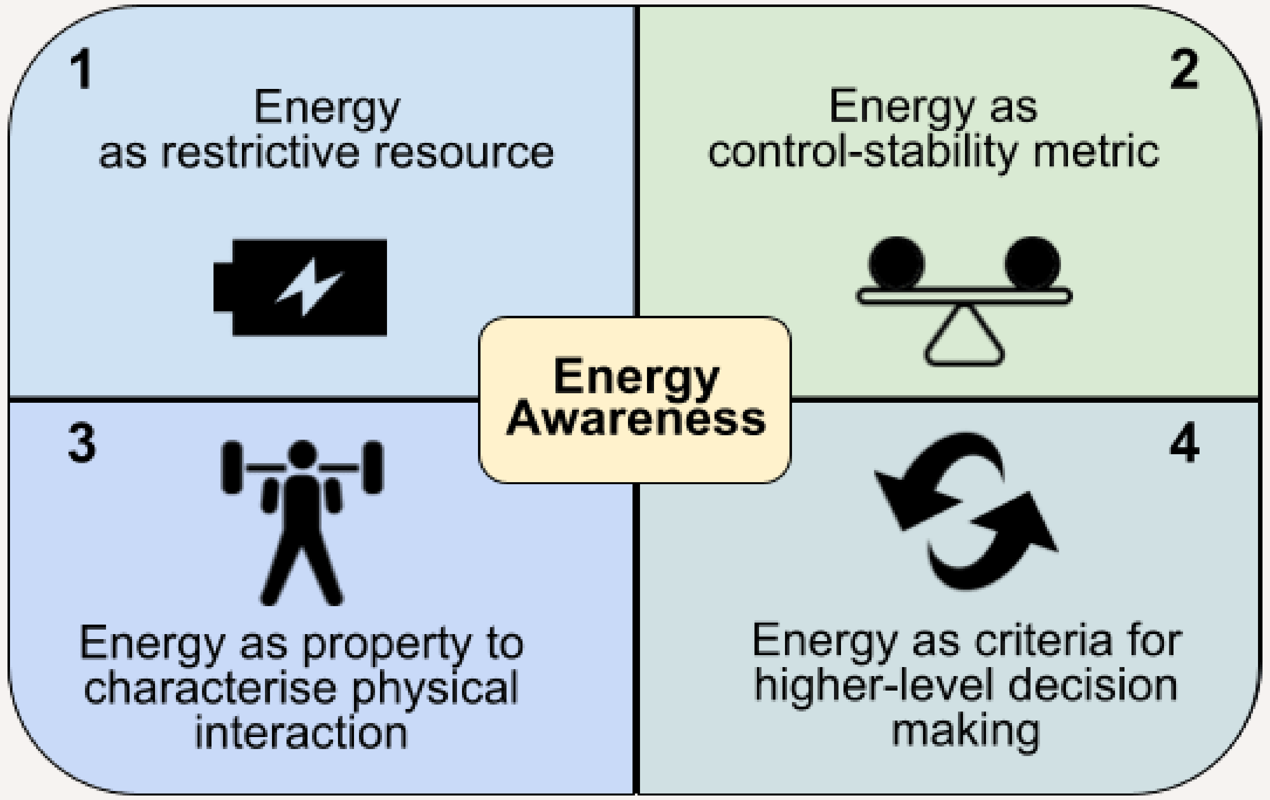
Energy Awareness

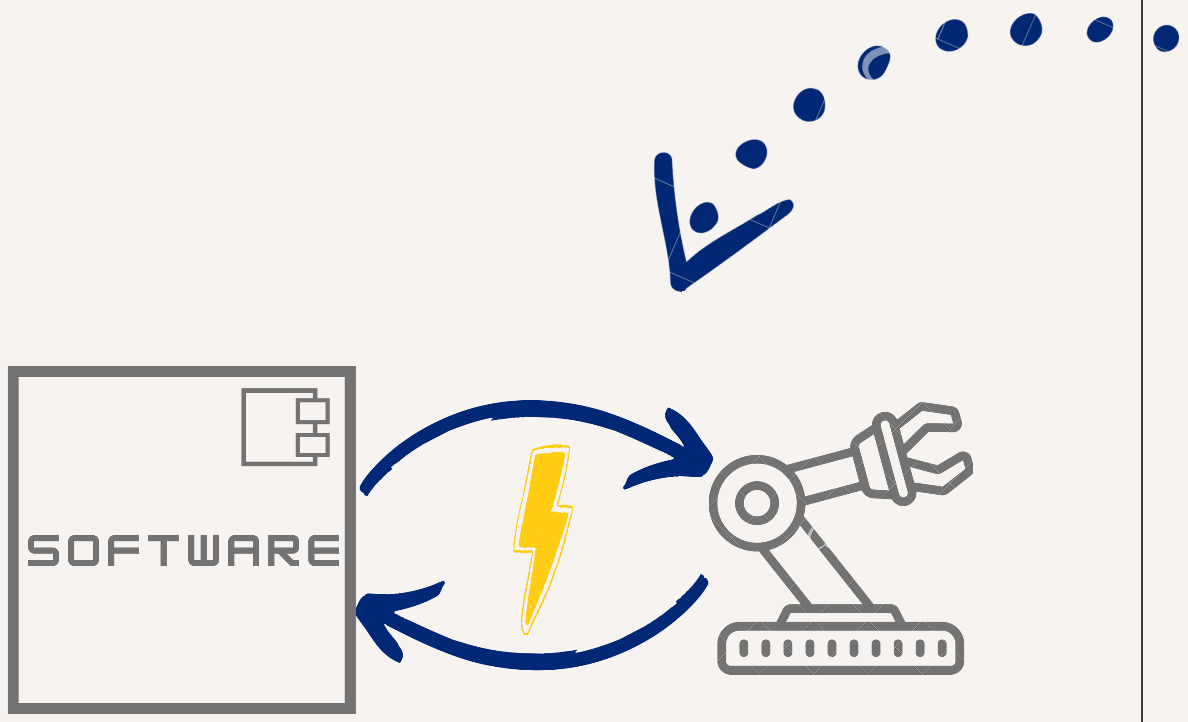
- is associated to energy efficiency
- using energy information, e.g.,
  - as constraint for QoS
  - as metric for battery autonomy



Using energy information

- is convenient in control design, e.g.,
  - for control stability
  - for fault tolerance
  - for robot safety



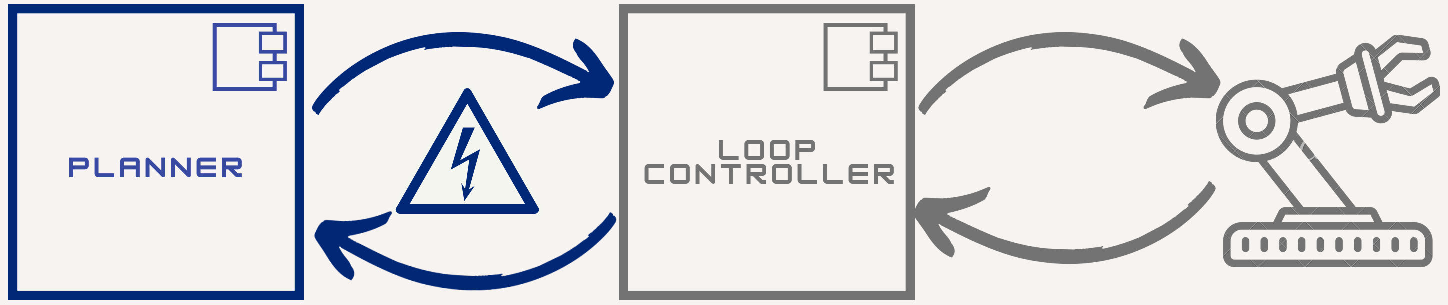


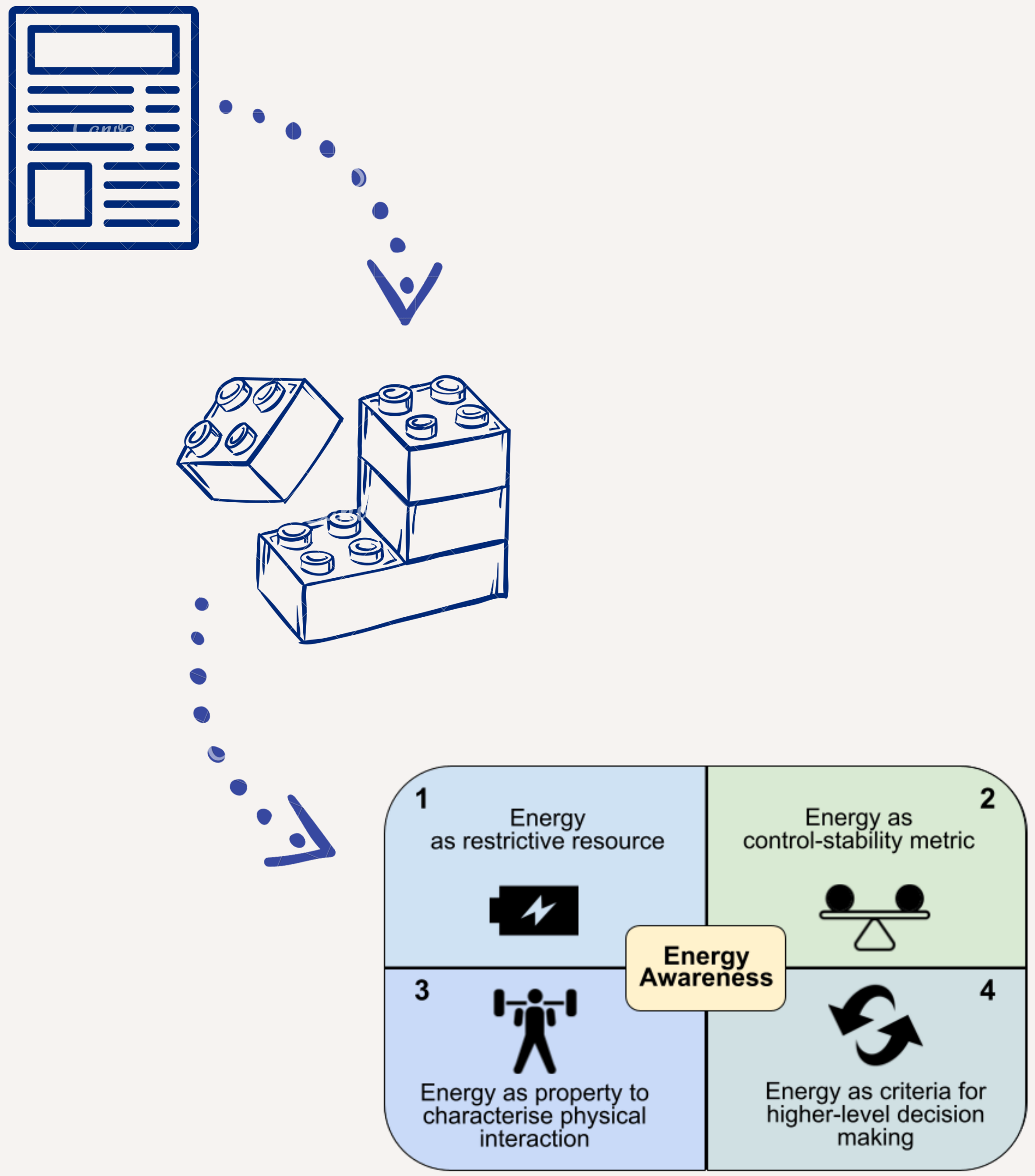
The communication between the software and the mechanics

- can be interpreted as energy exchange
  - iff the control signals contain information on:
    - forces and velocities
- this is already in use for loop control of robots.

A sequence controller

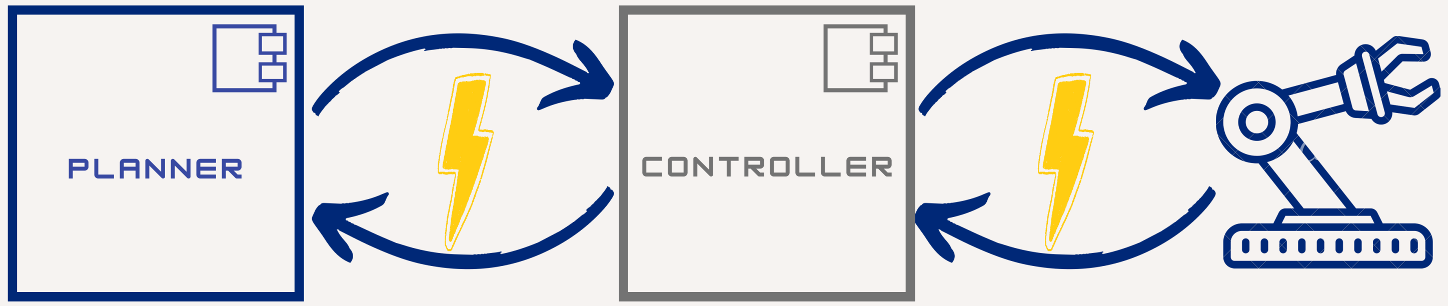
- produces a stream of setpoints for the loop controller
  - e.g., trajectories computed by a planner
- this can be interpreted as an energy supply
  - iff setpoints and feedback contain information on
    - forces and velocities
- this energy supply is implicit and can be unrestricted



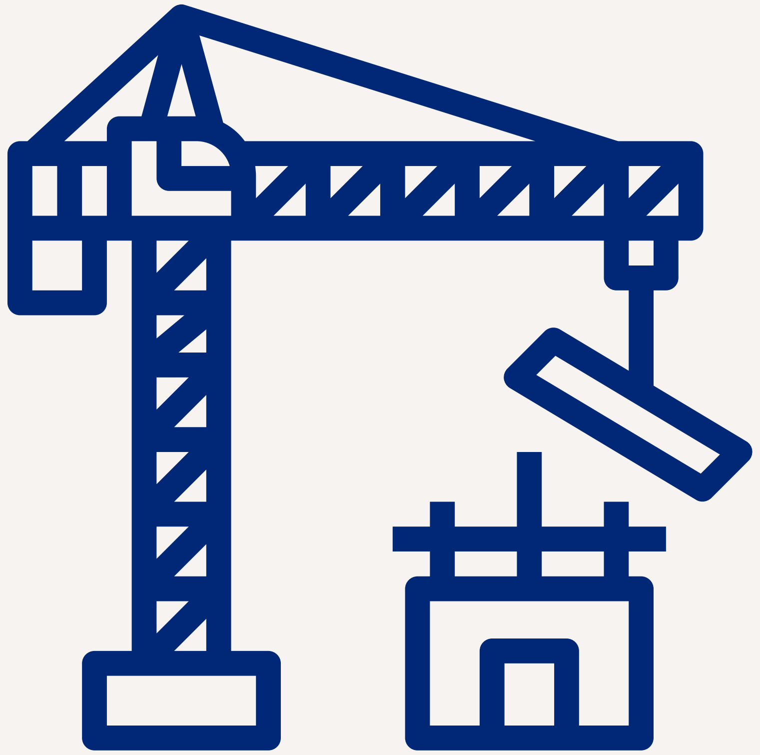


An architecture

- accounting for the energy information
- making the energetic relations explicit and available



2. Framework



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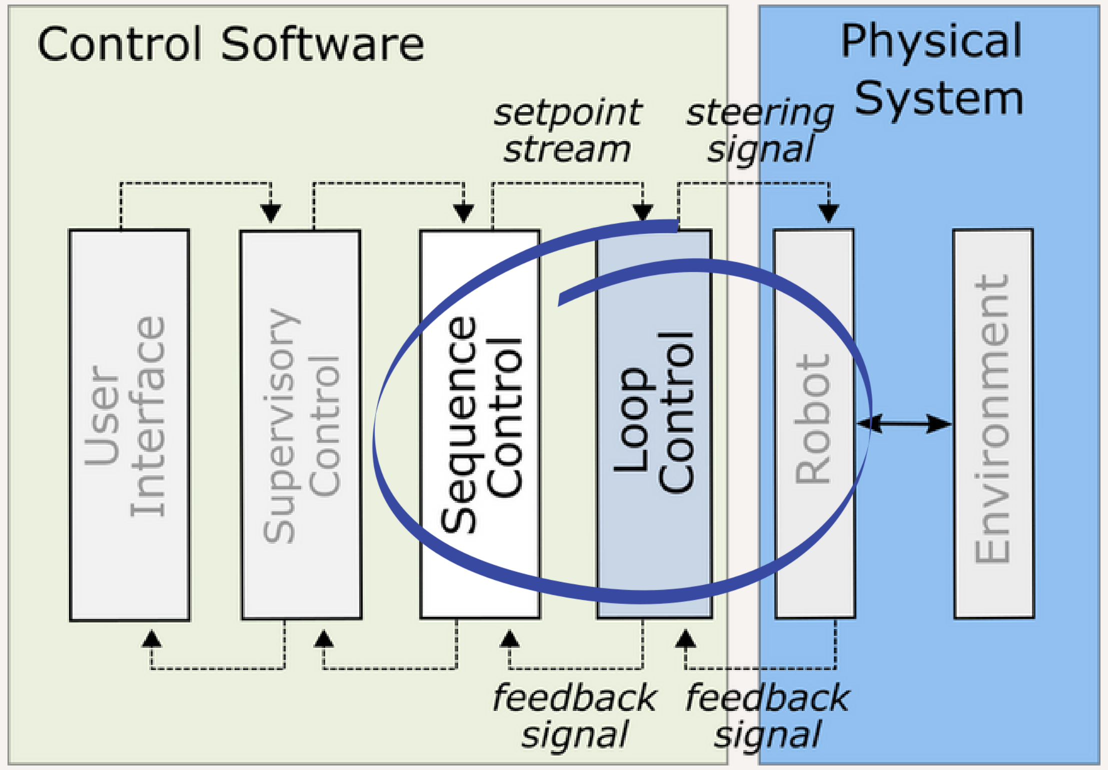


Thinking in layers

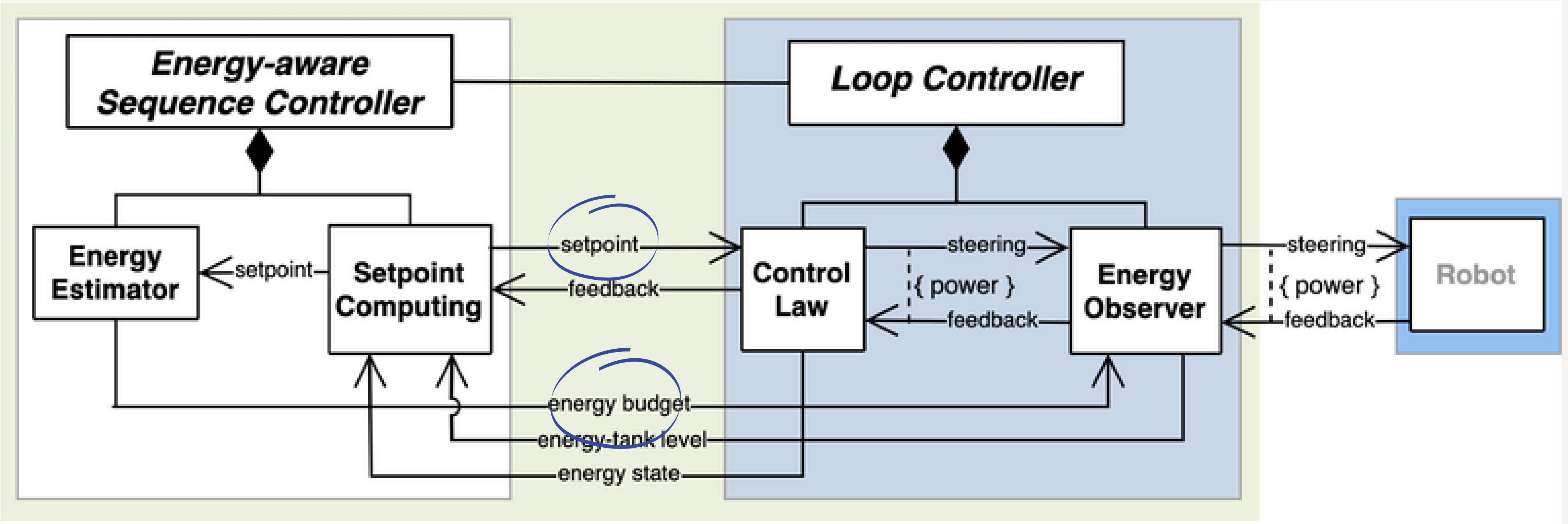
- the sequence-control layer:
  - computes the sequence of robot movements
    - it may contain a trajectory planner
- the loop-control layer:
  - computes steering values
    - it contains the control-law algorithm

FRAMEWORK

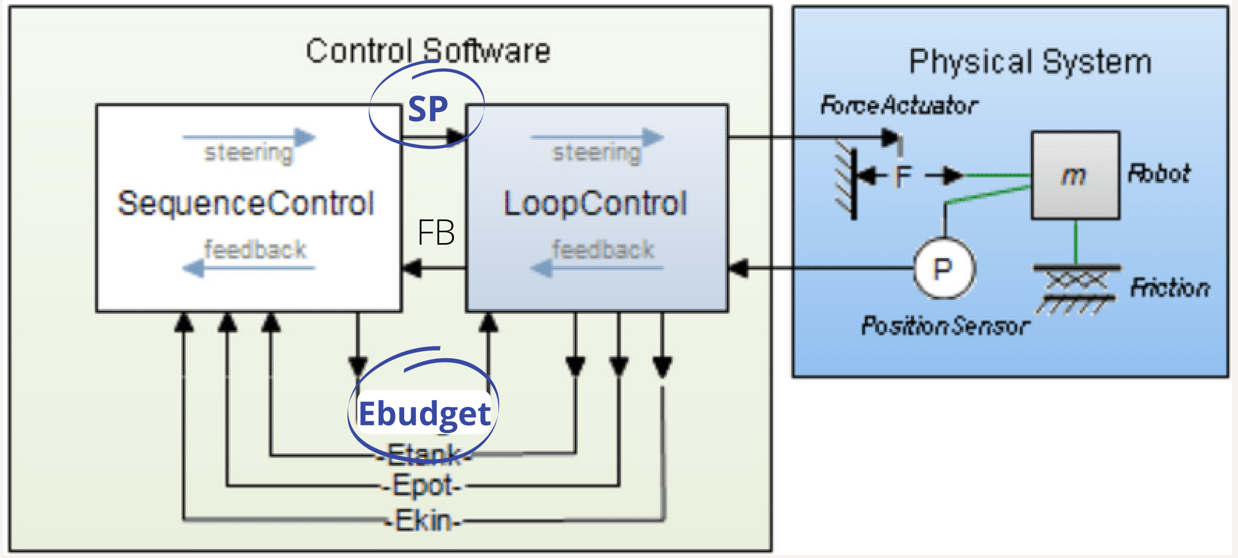
Energy-aware Sequence Controller (EaSC)

- communicates setpoints and energy budget
- the energy budget (Ebudget) represents:
  - the energy required to track the setpoint (SP)
  - the limited energy "supplied" by the planner

Metamodel



Model

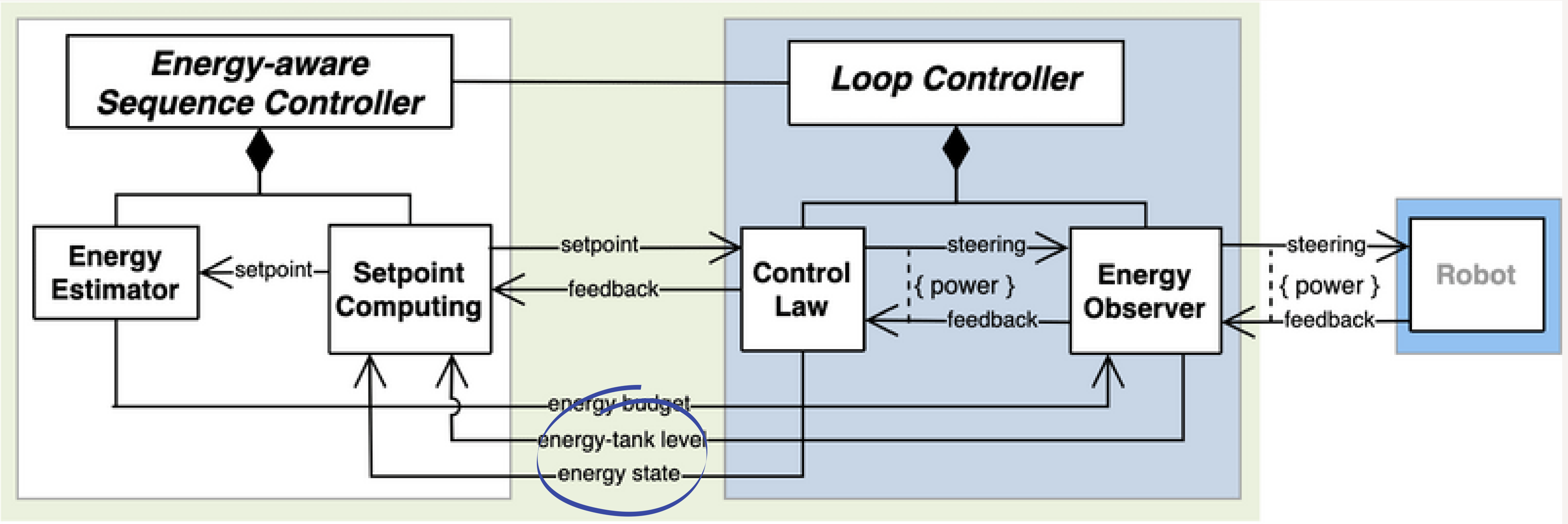


FRAMEWORK

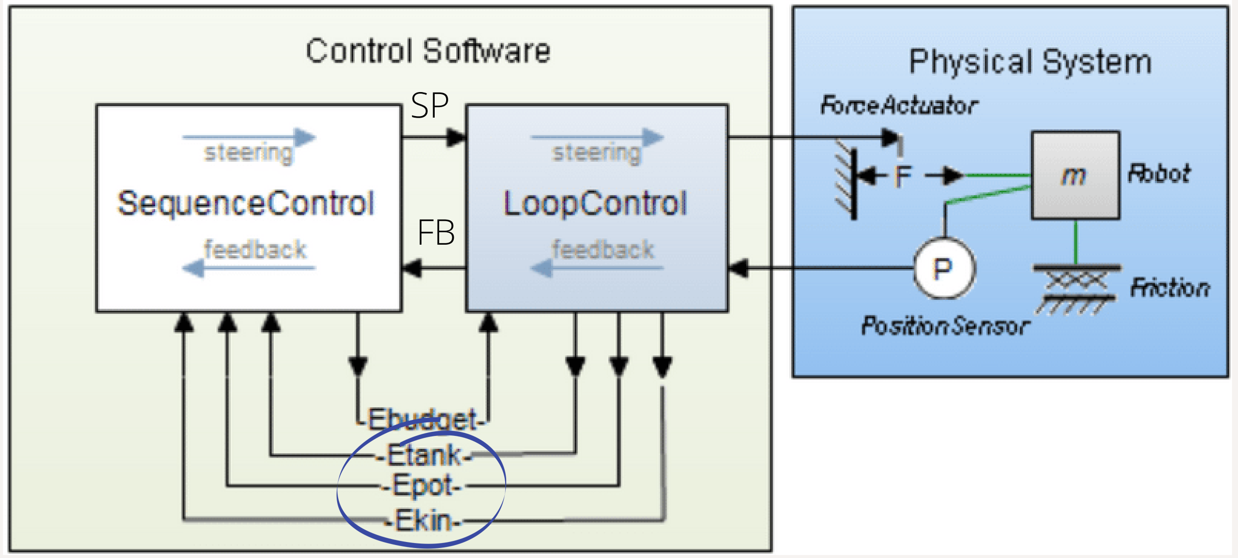
The EaSC also receives energy information

- gives insight on the physical interaction
- e.g., energy-budget consumption
    - i.e., energy-tank level (Etank)

Metamodel



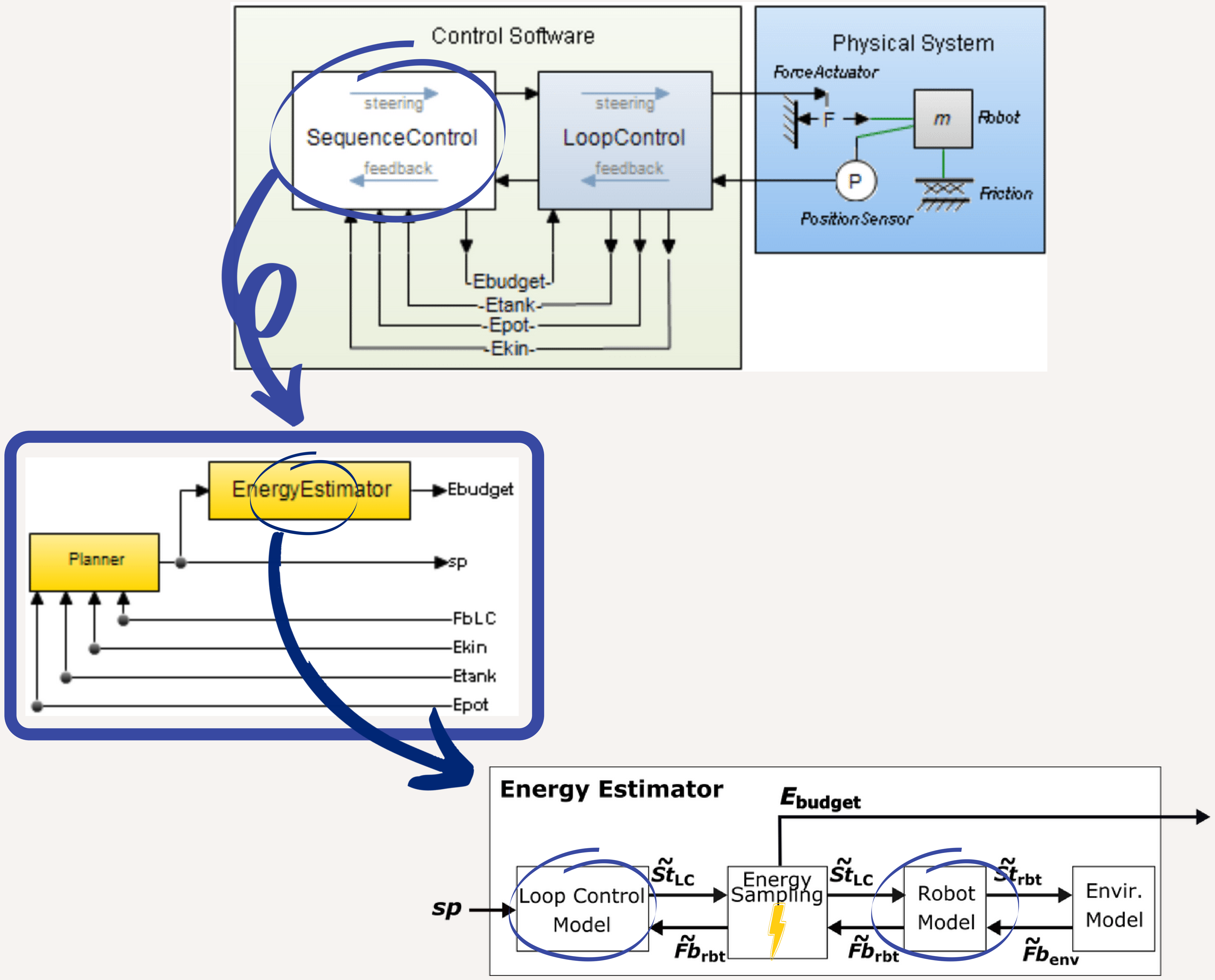
Model



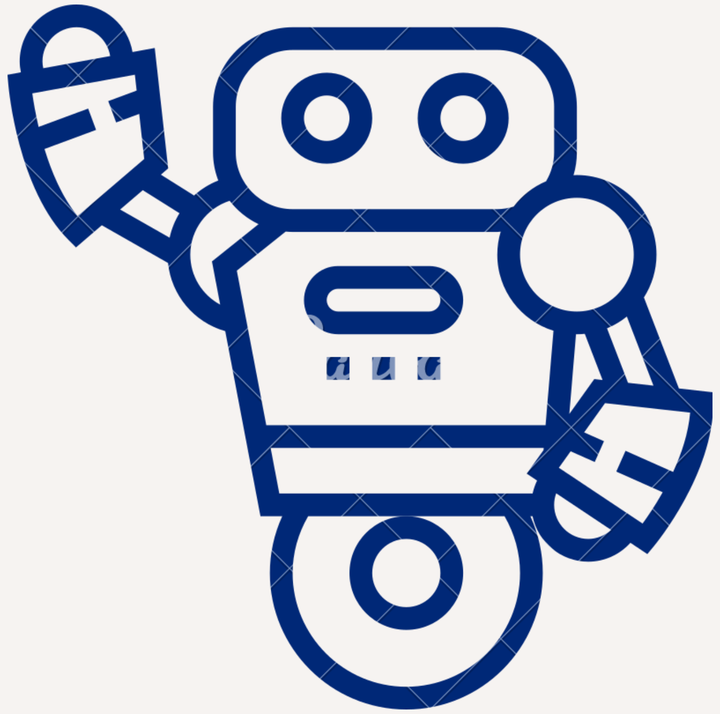
FRAMEWORK

Inside the EaSC

- a planner
  - computing the setpoint values
- an energy estimator (EE)
  - using models to generate the energy budget
  - this represents how much energy is needed



3. Use case



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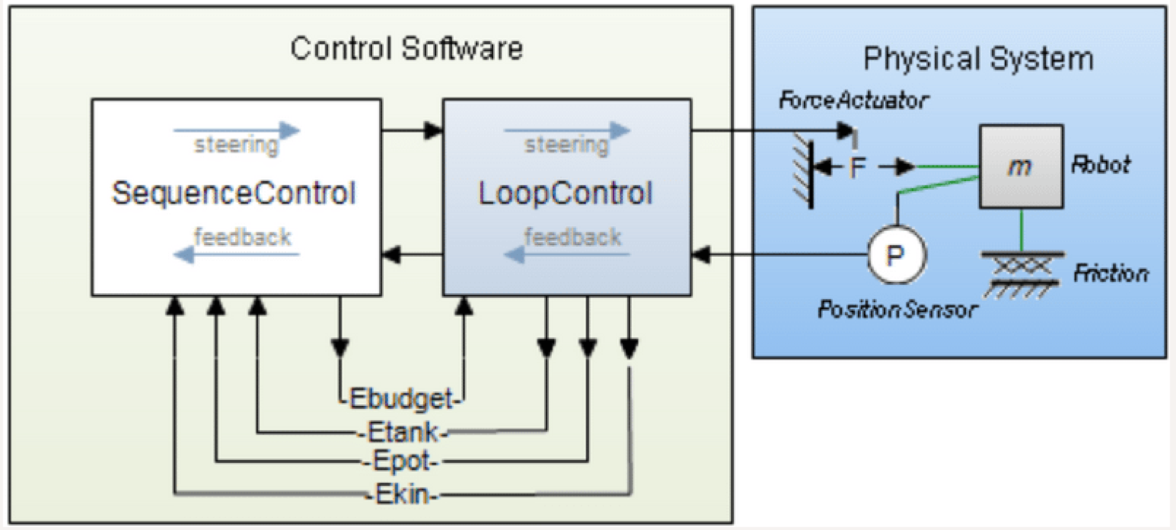
USE CASE



Simulation of mobile robotic platform

- Scenario 1
  - ground truth – i.e., ideal situation
  - EE parameters matching the physical system

- Scenario 2
  - higher friction than expected
  - EE parameters not matching the physical system

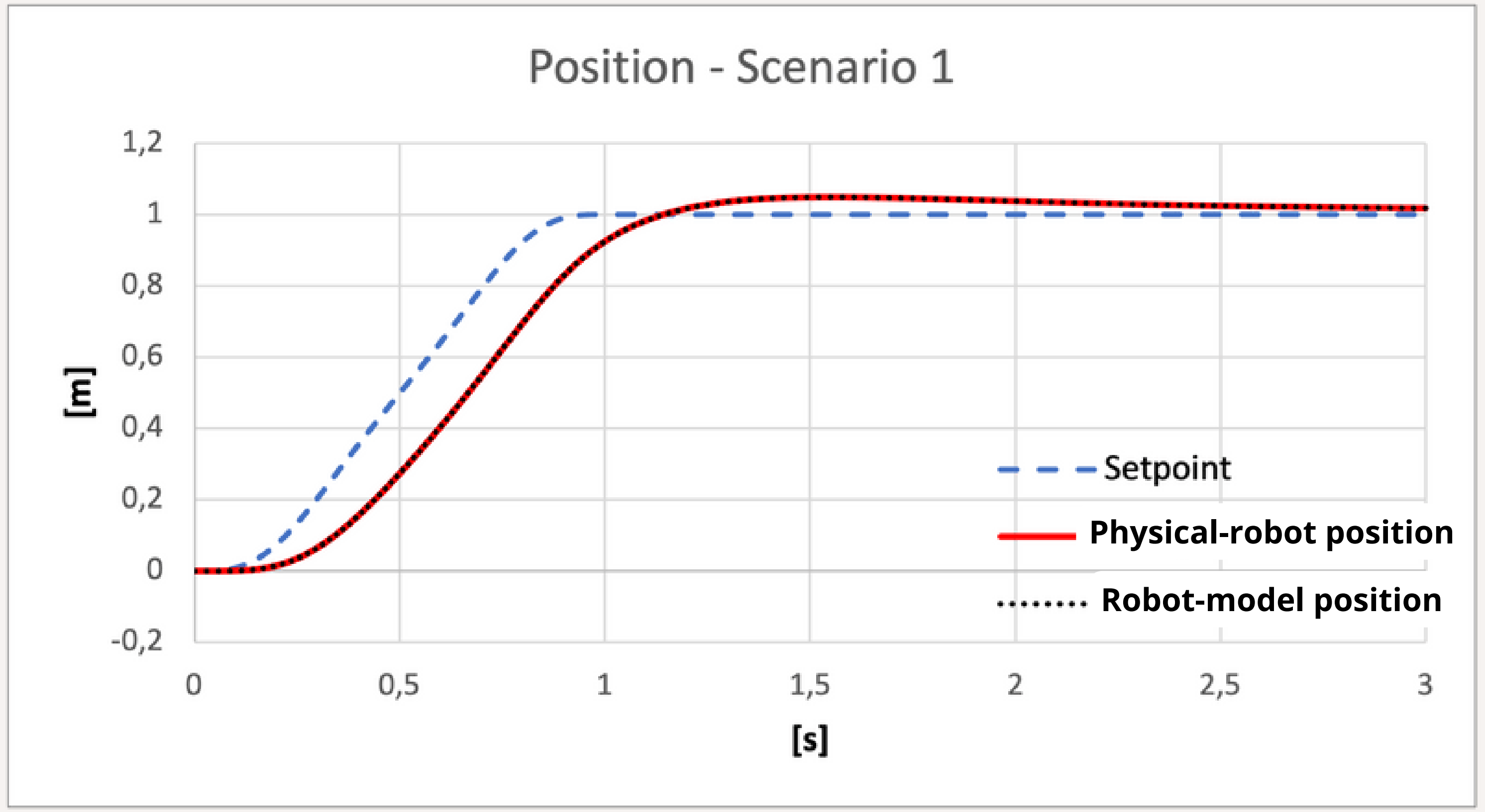
USE CASE

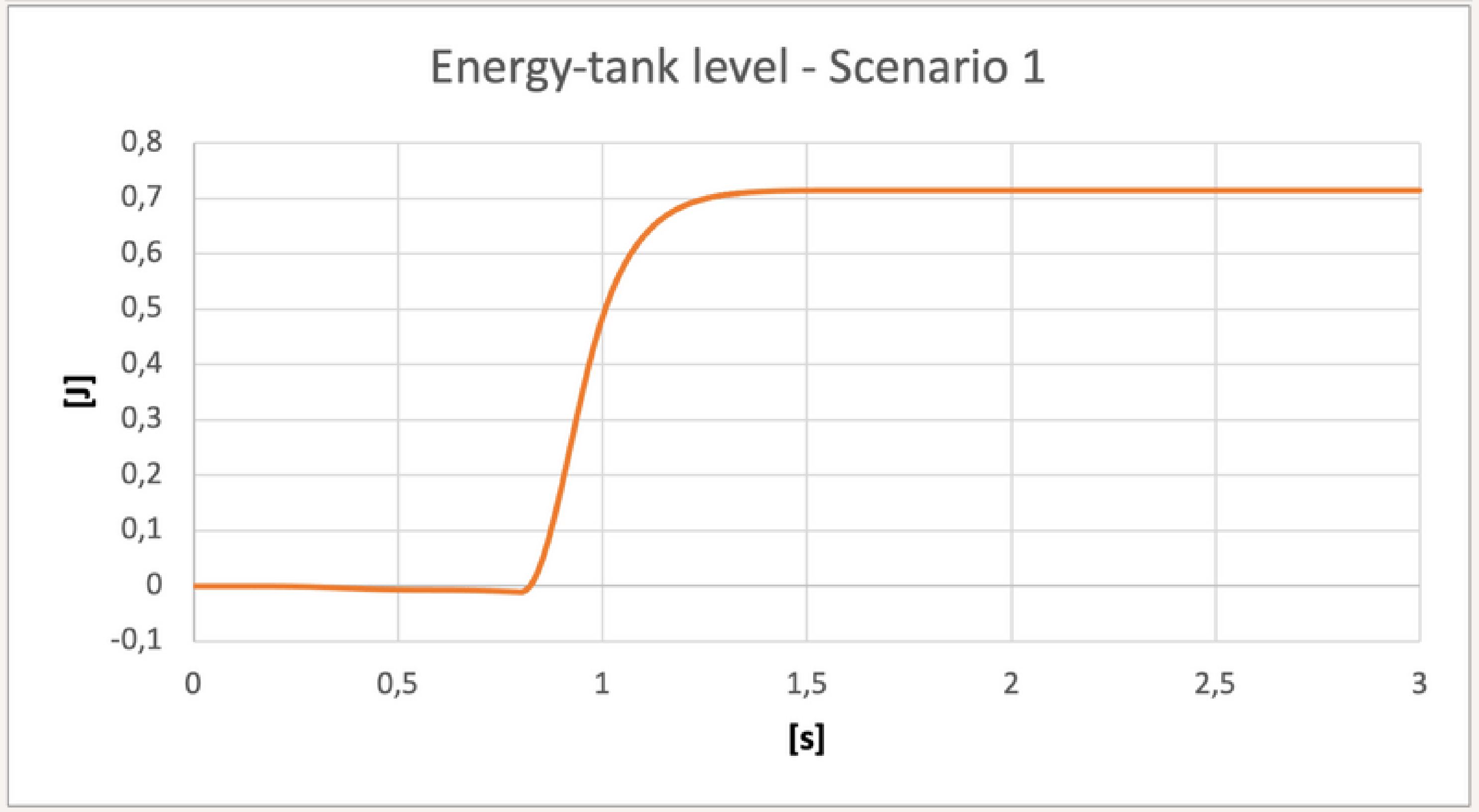
Situation I – ground truth

- Physical robot matching the robot-model* position

* the robot model inside the energy estimator

- Etank ⩾ 0
  - i.e., using energy within the budget





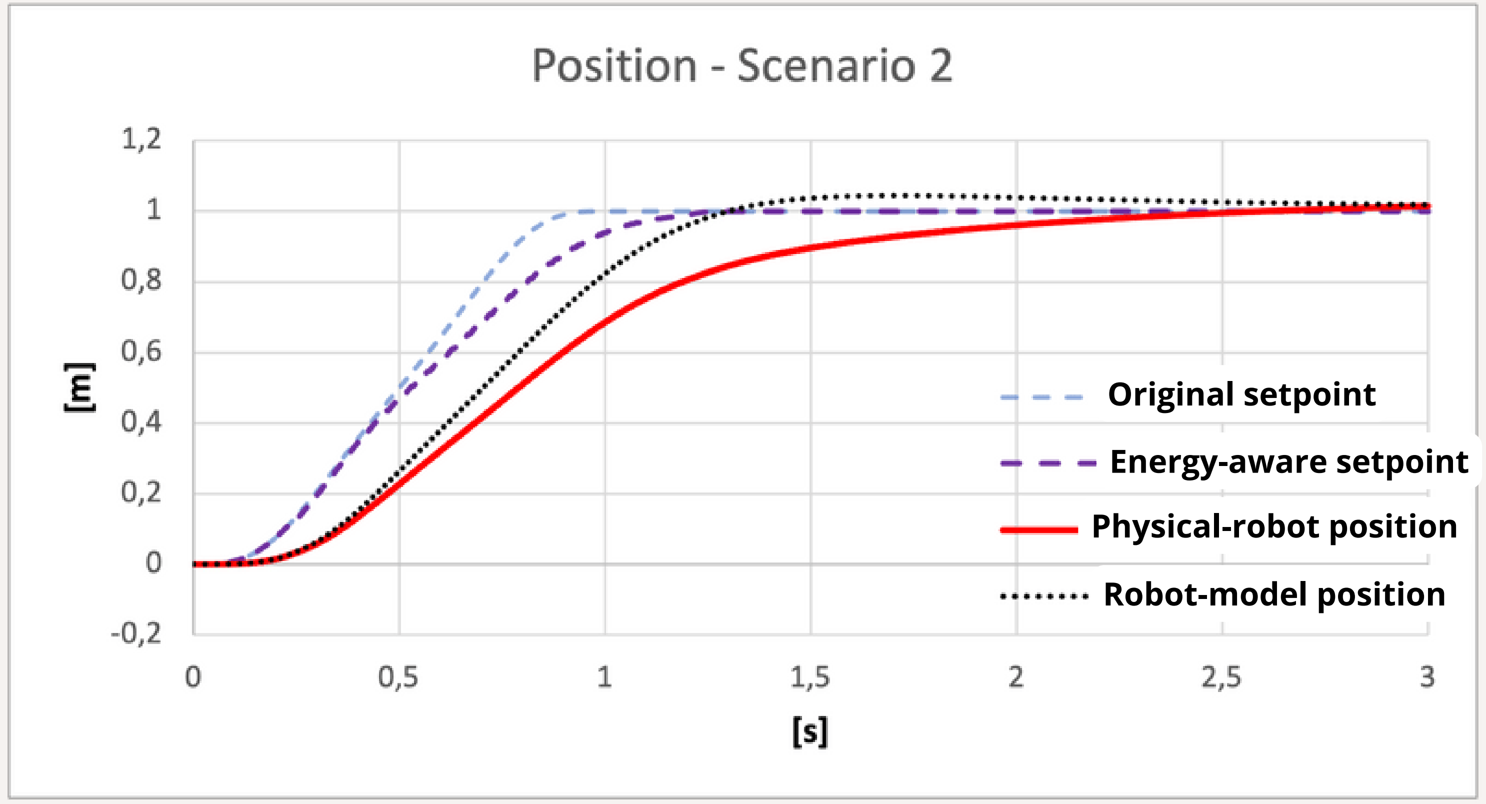
USE CASE

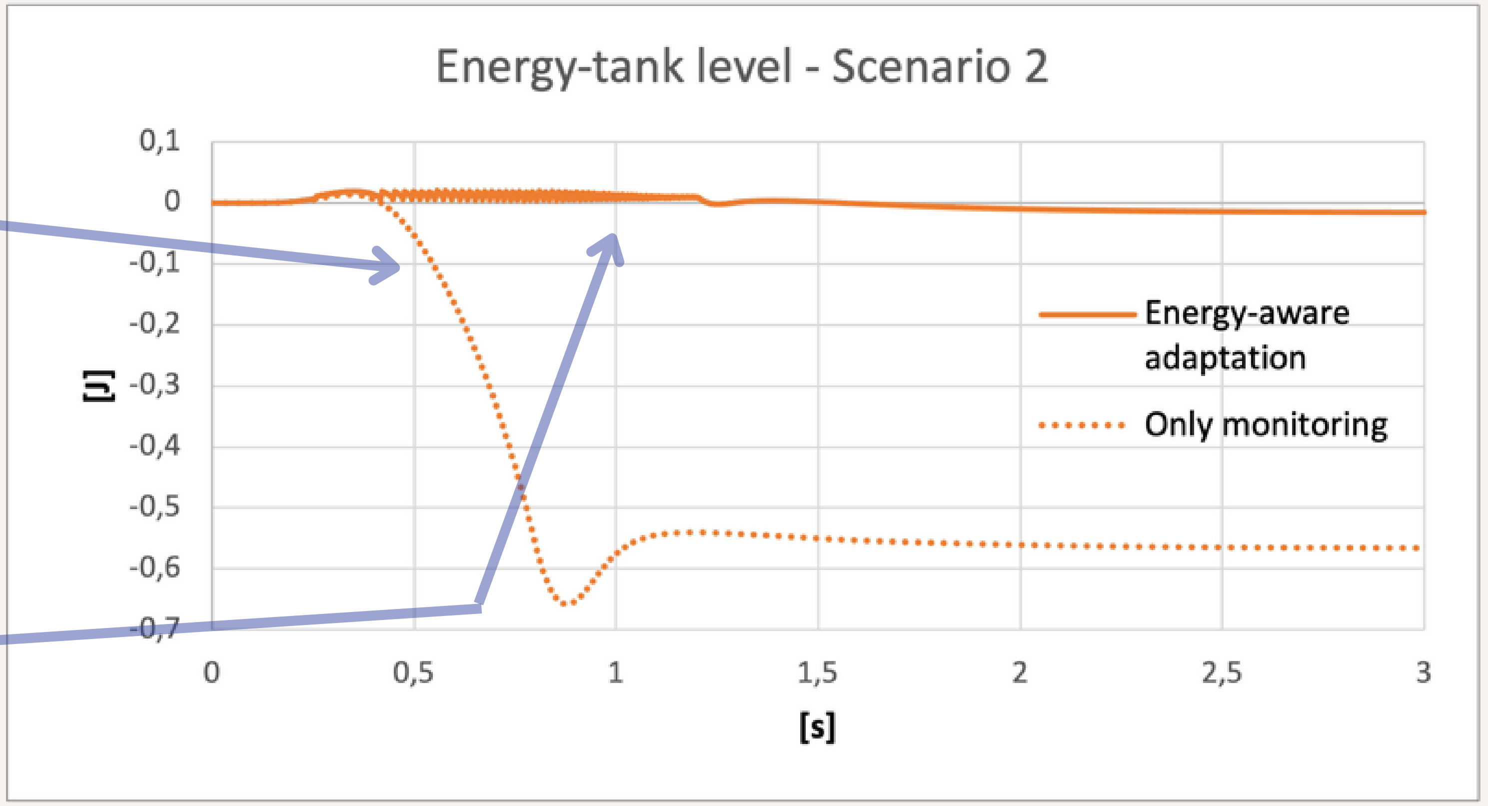
Situation 2 – higher friction

- Physical-robot not matching the robot-model position

- Only monitoring energy
  - planner takes no further action
  - results in Etank < 0
    - i.e. uses more energy than the budgeted

- Energy-aware sequence-control action
  - planner decreases setpoint velocity
  - keeps energy consumption within budget
  - results in Etank ⩾ 0





4. Conclusions

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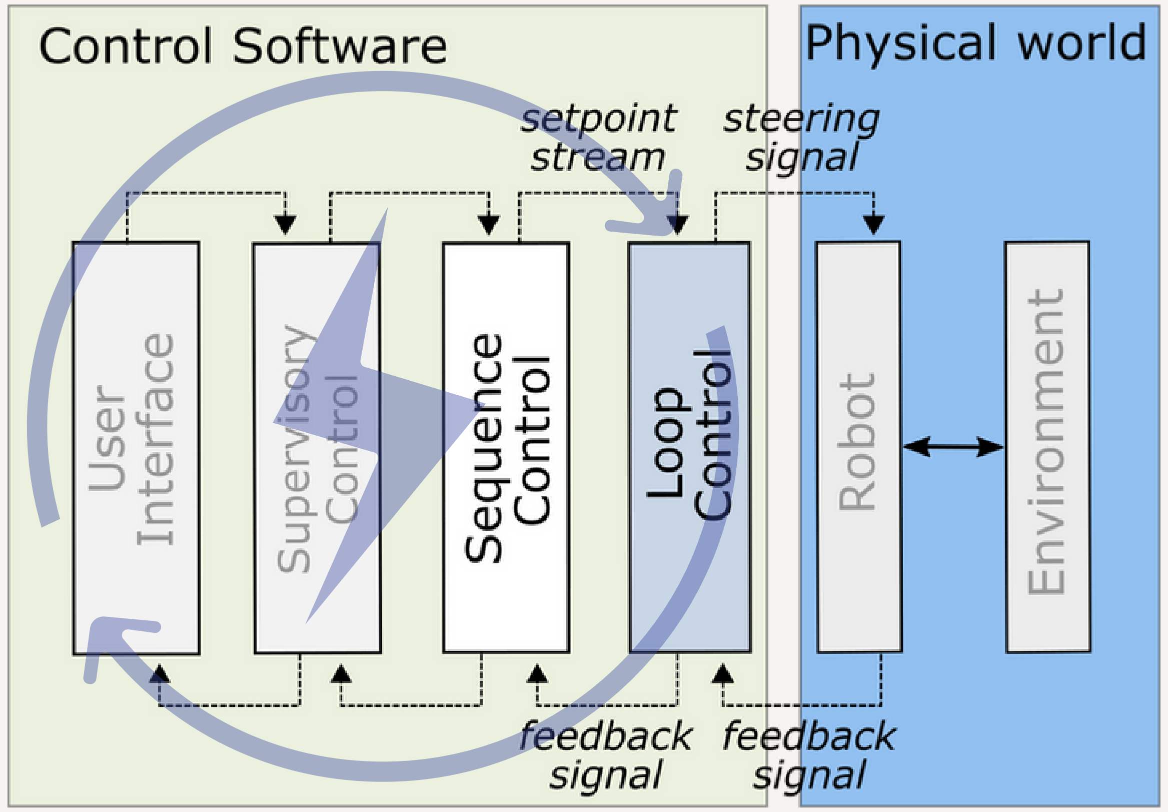
CONCLUSIONS

This framework allows...

- structuring controllers to make decisions based on energy
- estimating the energy required for trajectories
- using energy information for better control behaviour

Further work

- extending energy awareness in the control structure
- communicating energy information across the system
- configuring and coordinating controllers based on energy



Thank you!

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