Cooperative Passivity-Based Control for End-Effector Synchronisation

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Outline

- Introduction
- Passivity
- Cooperative r-Passivity-Based Control
- Experimental Results
- Conclusions

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Introduction

Our Objective

Synchronise end-effectors of mechanical systems in general environments.

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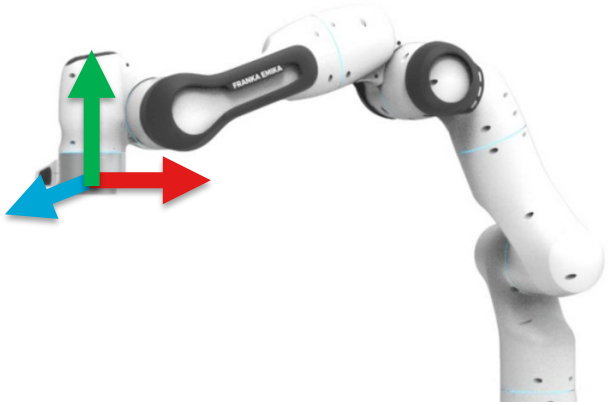
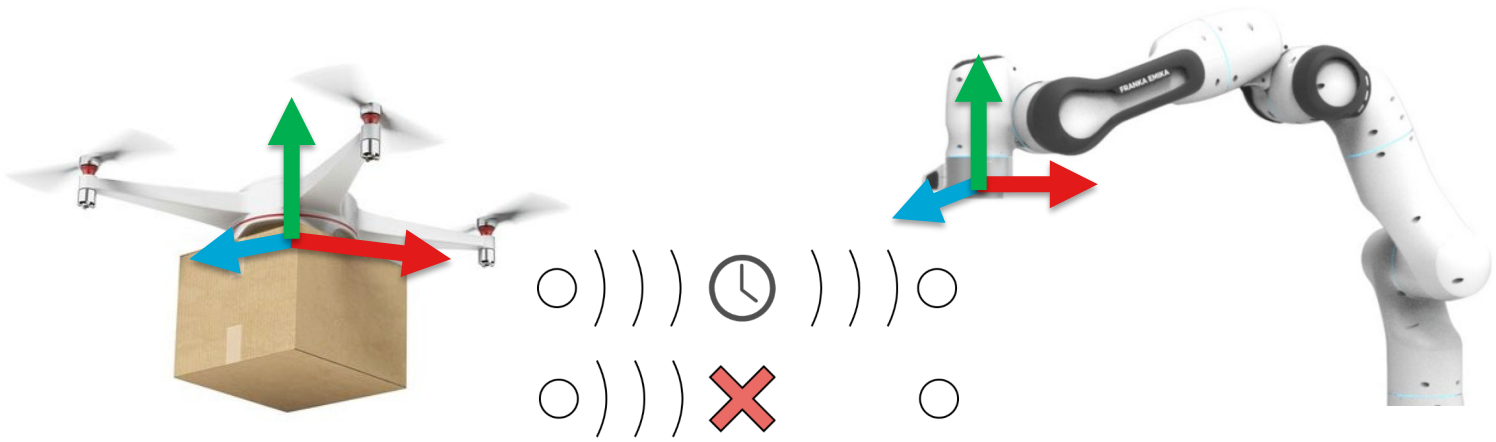


Possible applications

- Sort and packing problems
- Multi-vehicle package delivery
- Autonomous platoons
- Spacecraft alignment
- …

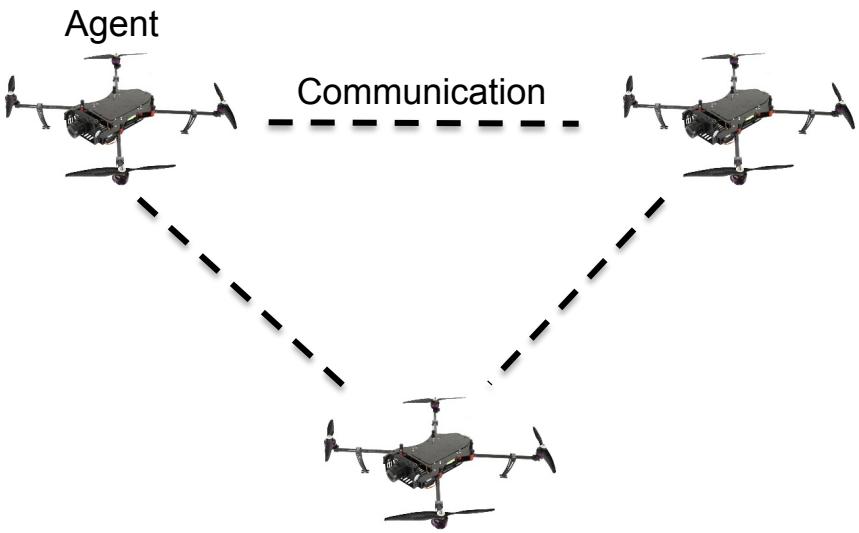
Our Objective

Synchronise end-effectors of mechanical systems in general environments.



The approach

Cooperative Passivity-Based Control



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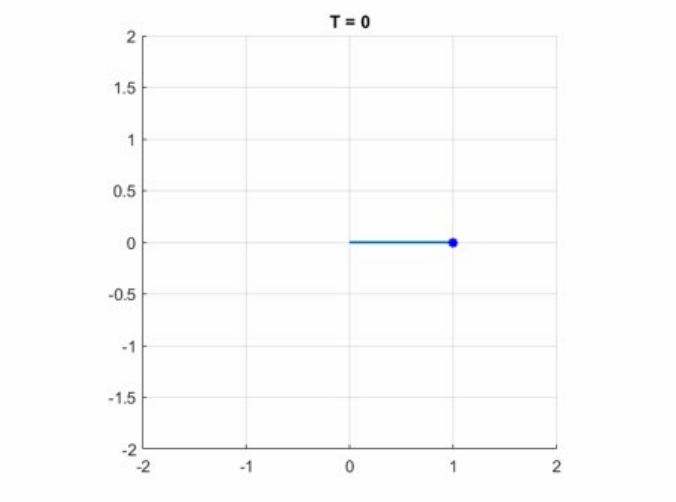

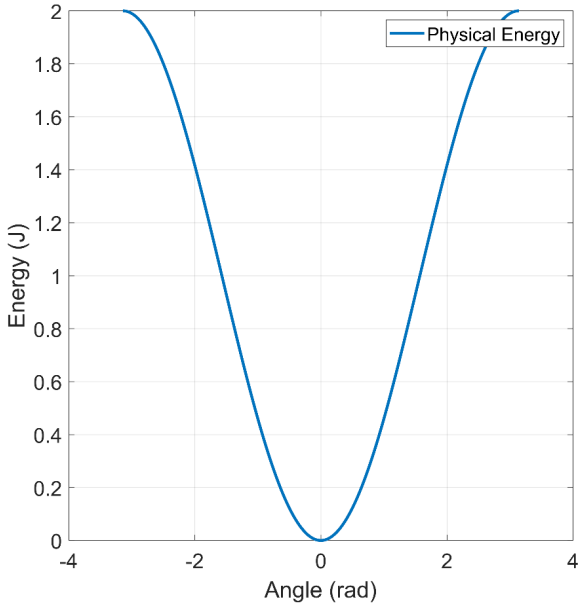

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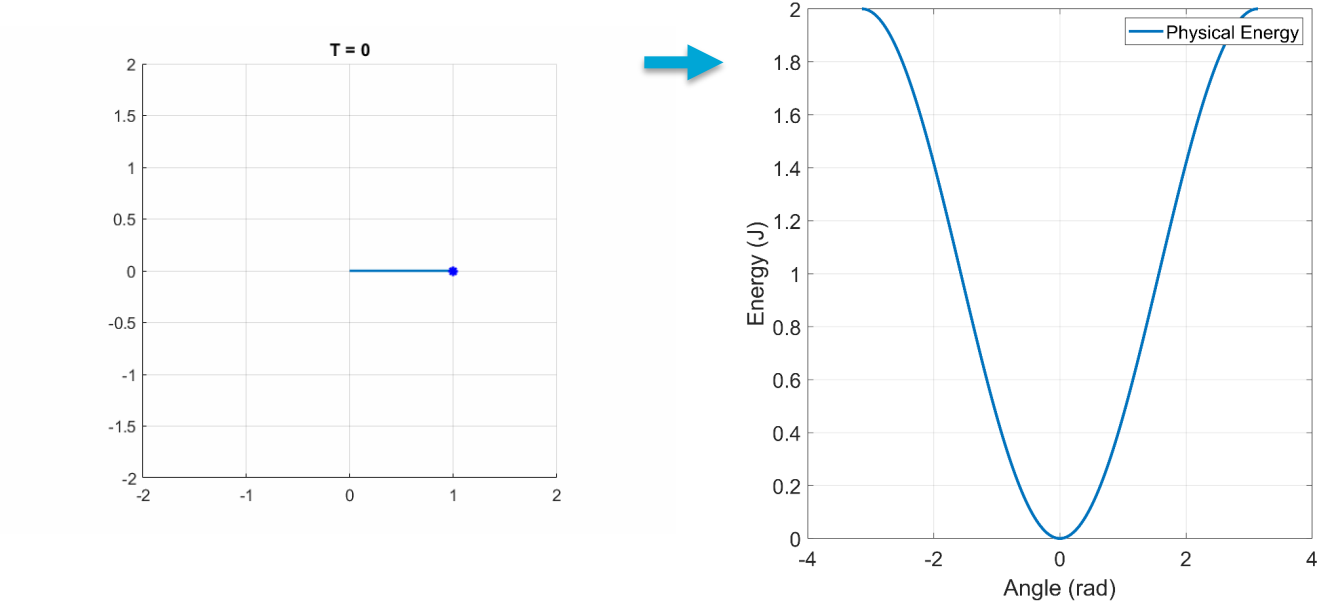

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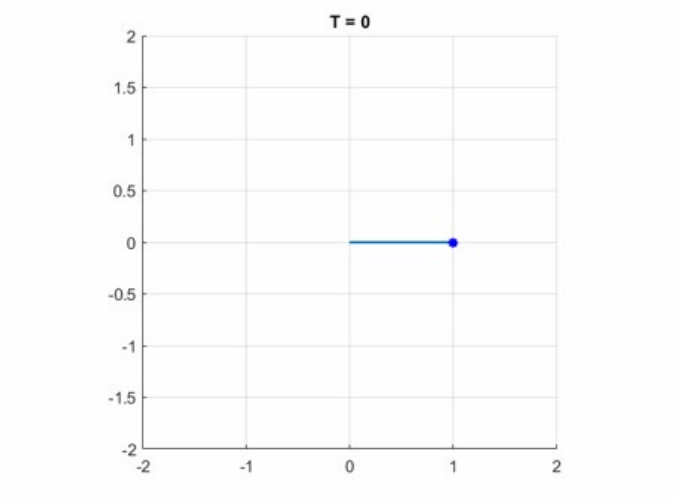

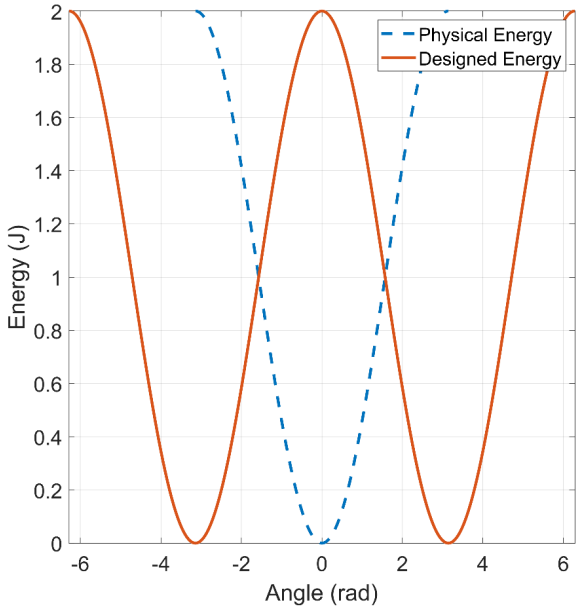

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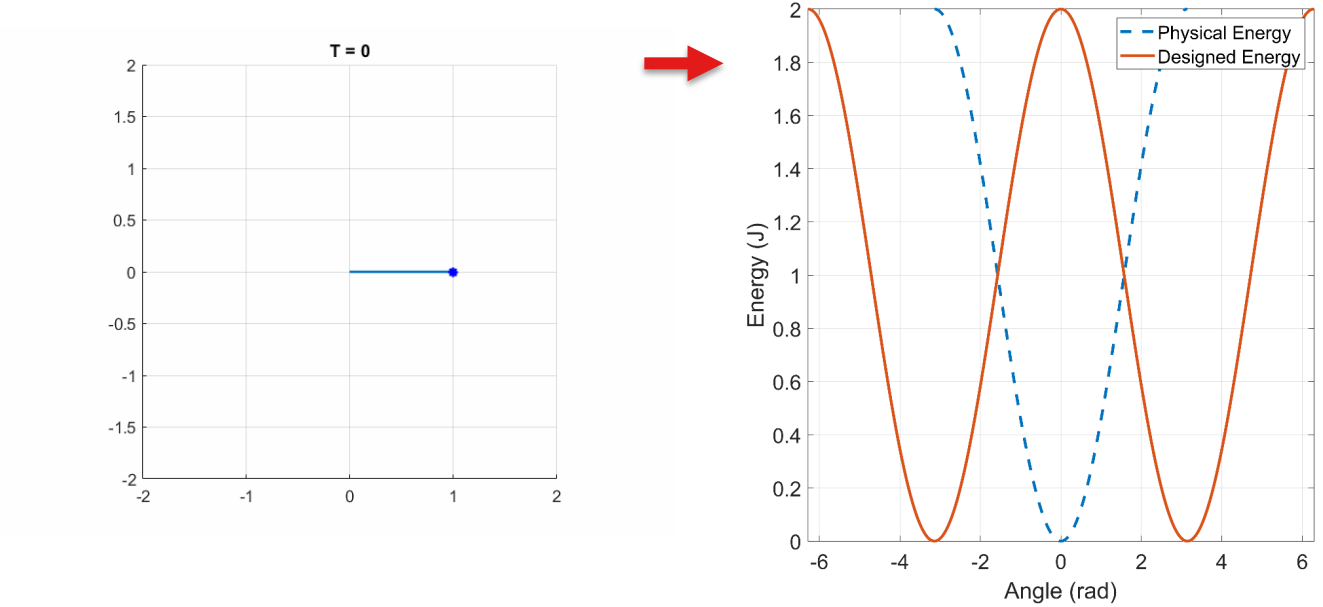


The approach

Cooperative Passivity-Based Control

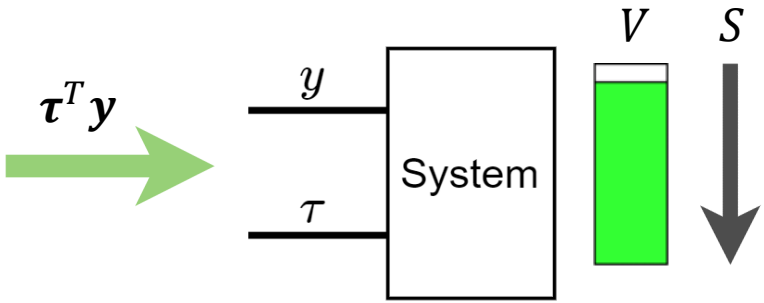
- Zero energy → Control objective

Passivity

Notion of Passivity

Supplied energy is either *stored* or *dissipated*

$$\dot{V} + S = \boldsymbol{\tau}^{\boldsymbol{T}} \boldsymbol{y}$$



Cooperative Control

- No energy supply

  $\dot{V} = -S \leq 0$ (Lyapunov)

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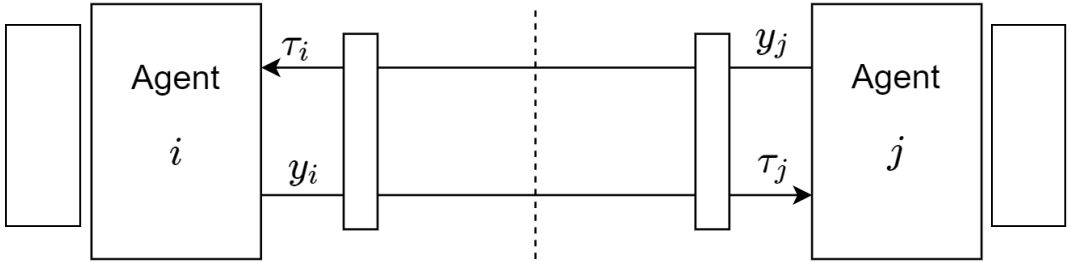
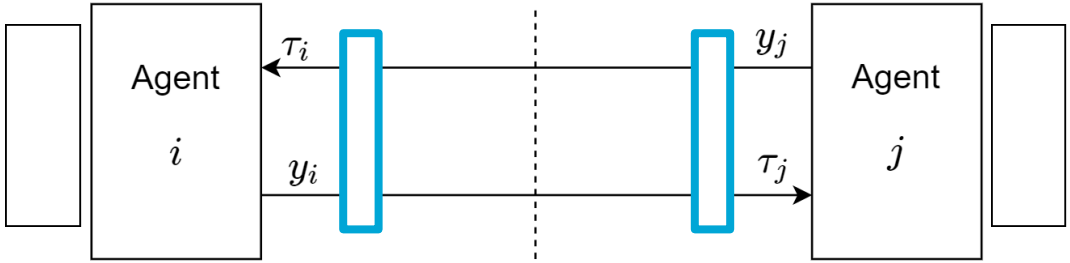


Cooperative Control

- No energy supply

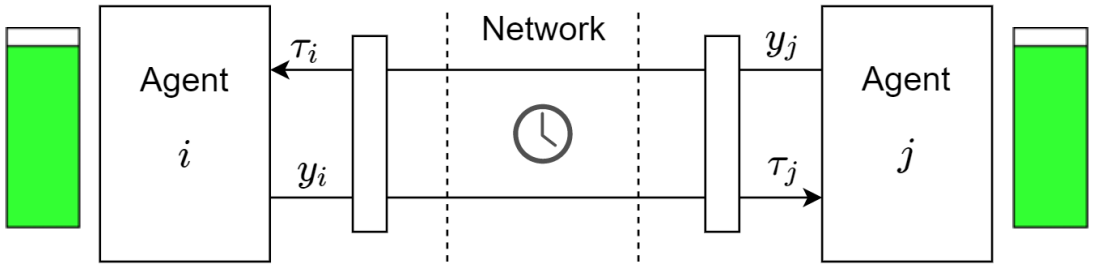
  $\dot{V} = -S \leq 0$ (Lyapunov)

- Zero energy → Cooperative control objective



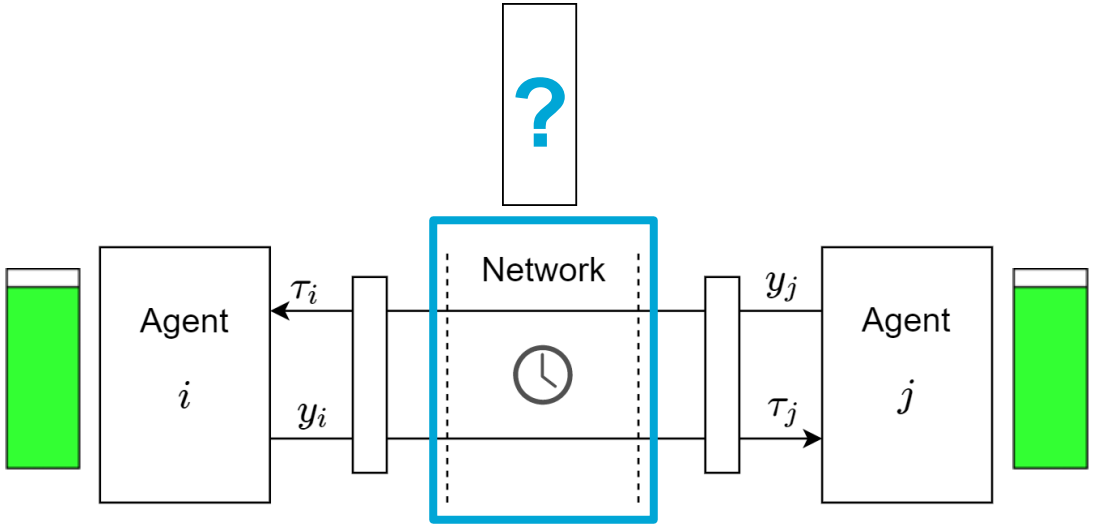
PBC with Delays

- What if delays are present?



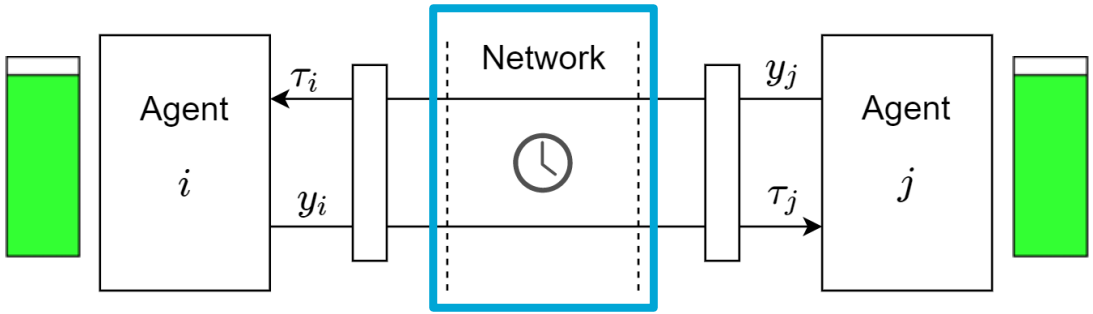
PBC with Delays

- No description of the energy in the network.



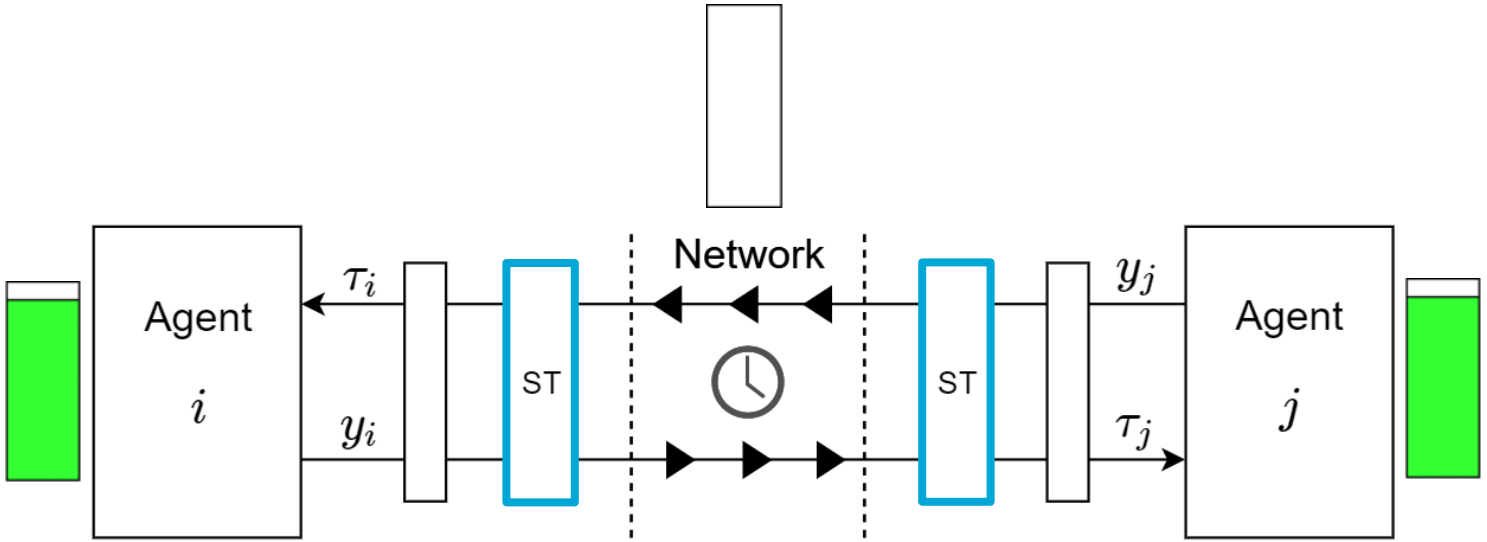
PBC with Delays

- No description of the energy in the network.
- **Solution:** Convert network signals to energy packages



Scattering Transformation

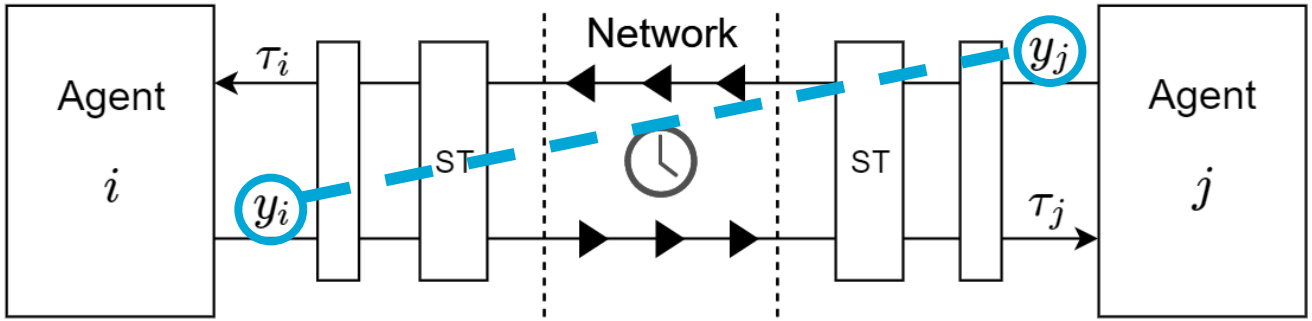
- Convert network signals to energy packages using the Scattering Transformation (ST)



PBC with Delays

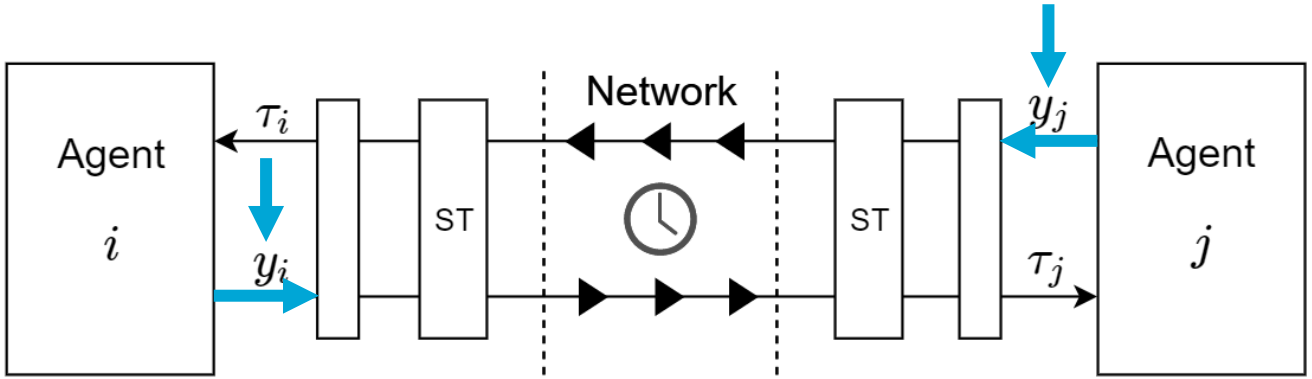
- Output synchronization:

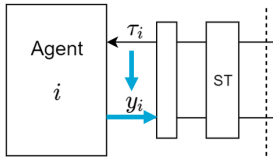
$$\lim_{t\to\infty} \boldsymbol{y_j}(t - T_{ji}) - \boldsymbol{y_i} = \boldsymbol{0}$$



Cooperative r-Passivity-Based Control

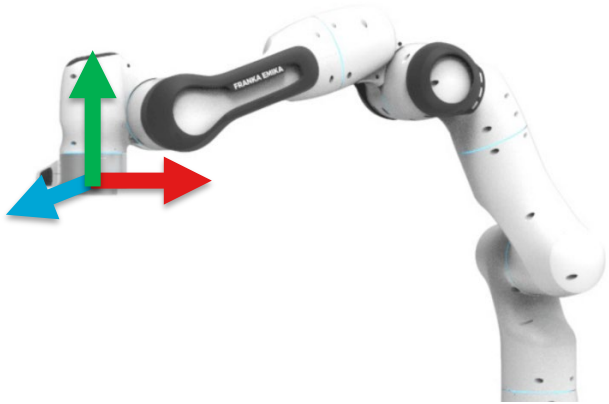
Output Selection

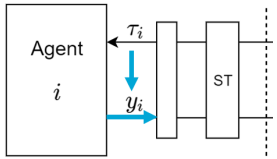




Output Selection

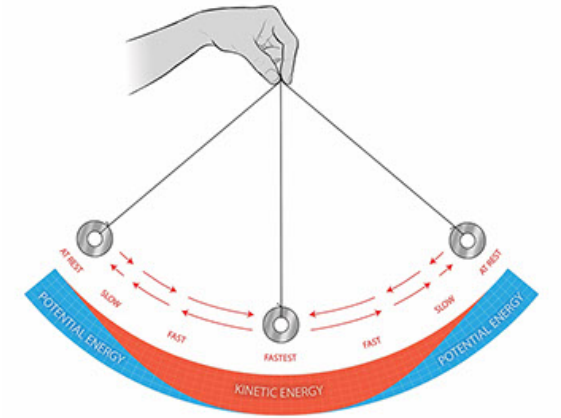
- Synchronisation of end-effector coordinates





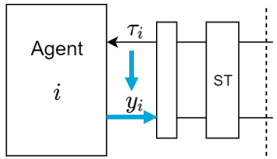
Output Selection

- Passive outputs contain velocities



Potential Energy

Kinetic Energy



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