Stabilization and Optimization of Decentralized Systems

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Decentralized control characterized by:
- Multiple agents / subsystems / nodes / controllers / decision makers
- Each with access to possibly different information
- Global objectives

Myriad applications include:
- Irrigation networks
- Smart structural systems
- Large array telescopes
- Smart building management
- Formation flight / multi-vehicle systems
- Power distribution grids

Typical analysis and design breaks down:
- Time-varying control may be needed to stabilize linear time-invariant systems
- Optimal controllers are typically not linear, even with simplifying assumptions
- Finding optimal controller is typically not a convex problem

Massively interconnected systems pose additional challenges:
- Distributed computation / synthesis needed along with distributed control
- Coordination inherent in time-varying schemes not possible

Work in Progress

Robustness:
- Stabilizable system may actually require large effort to move state and/or require large state to enable observation
- Developing non-binary measures of how controllable and observable is a system with a given information structure

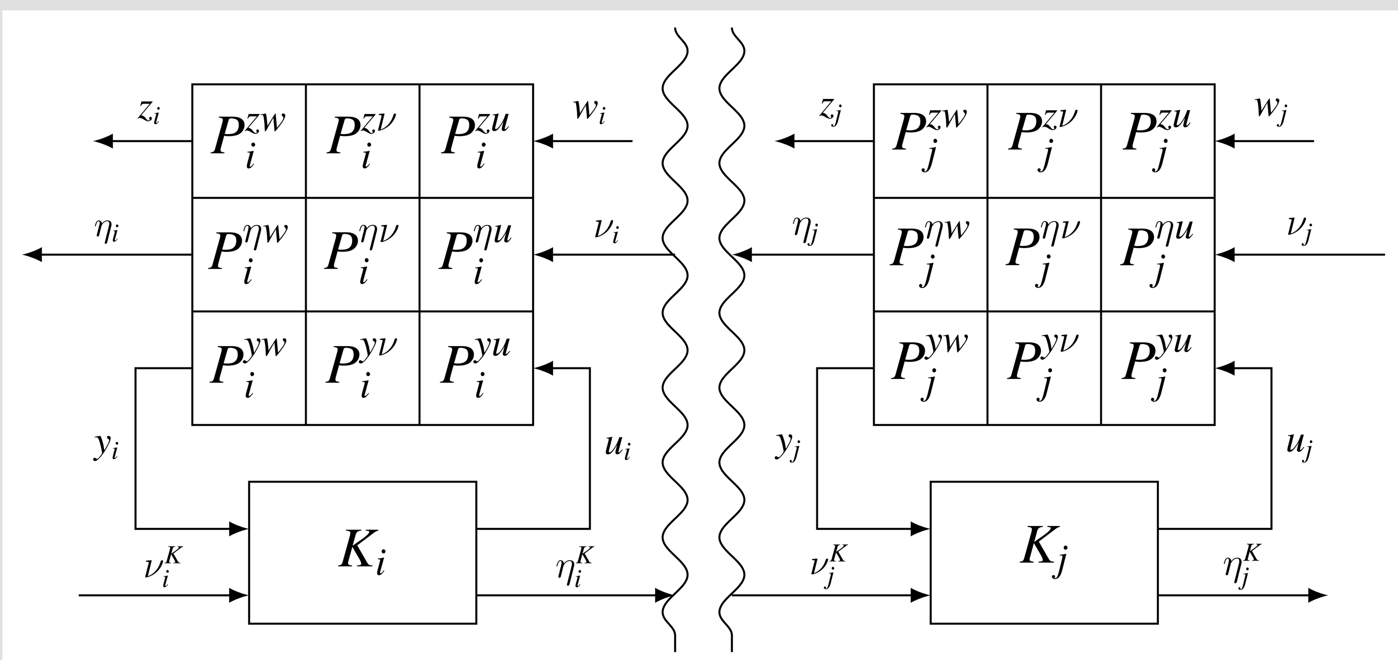
Computation:
- Large gaps exist between theory and what is used for implementation or even computation
- Developing methods/software to bridge the gap

Simultaneous design / analysis of network topology and control synthesis
- Understand which additional connections would be most helpful
- Leverage results from compressed sensing

General work in large-scale optimization:
- Recursive optimization – rapid adjustment to additional data for large problems
- Sampling approaches
- Expanding duality approaches to the types of constraints crucial to decentralized control

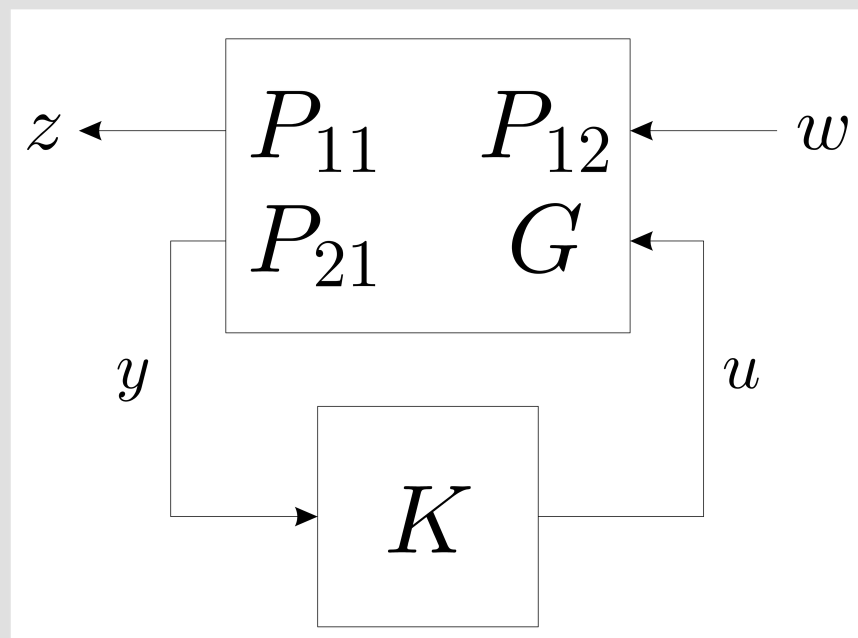
Main abstractions / modeling perspectives

- Consider subsystems and their controllers individually



- Dynamical structure captured in outgoing and incoming plant signals
- Information structure encapsulated in outgoing and incoming controller signals

- Consider entire system and controller



- Dynamical structure captured in plant structure
- Information structure encapsulated as controller constraints

Fundamental established results

Stabilization:
- A mode which cannot be moved with a static controller (a *fixed mode*) with given information structure cannot be moved by a dynamic one either
- A mode which can be moved can then be moved to a chosen location
- When a stronger notion of stability is required, whereby the state must always be diminishing in size, then a convex problem determines both stabilizability and (when it exists) a stabilizing controller

Optimization:
- Optimal decentralized control cast as convex problem when a simple condition holds
- Cast as otherwise-convex problem with single complicating constraint for arbitrary problems

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