CMPE 142: Introduction to Cyber-physical Systems (CPS)

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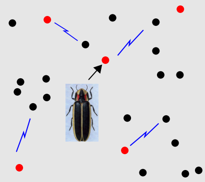
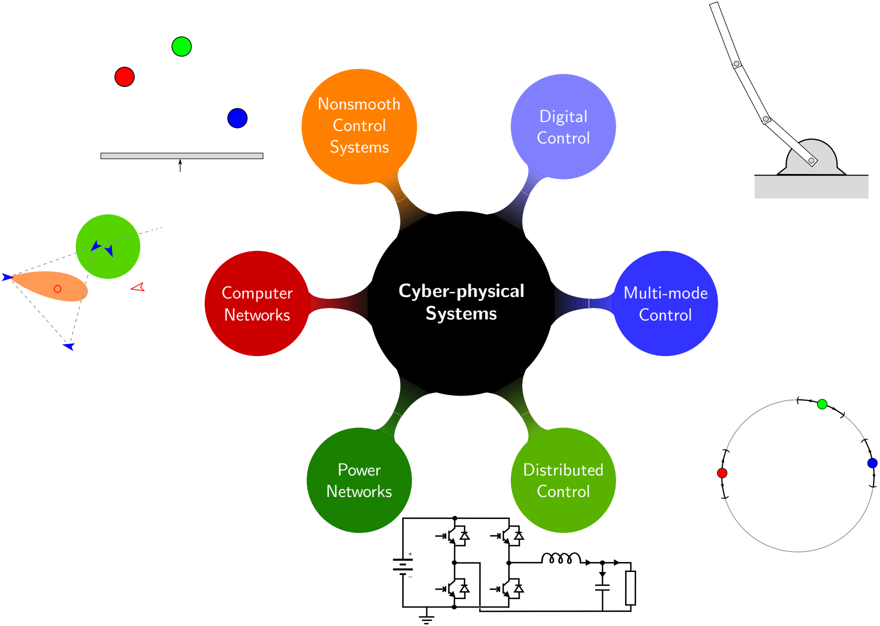


Broad Scope of Cyber-physical Systems



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- Modular hardware for flexibility and reconfigurability.
- Distributed coordination and control.

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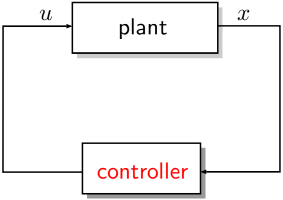

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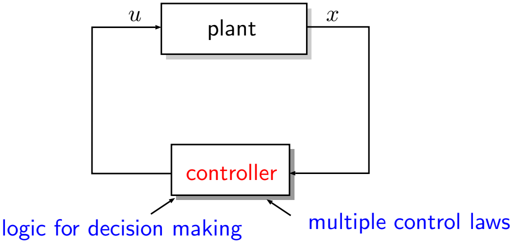

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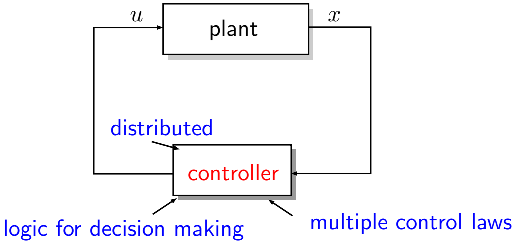

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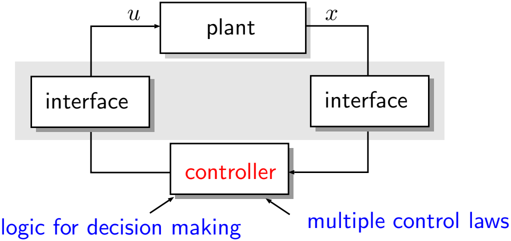

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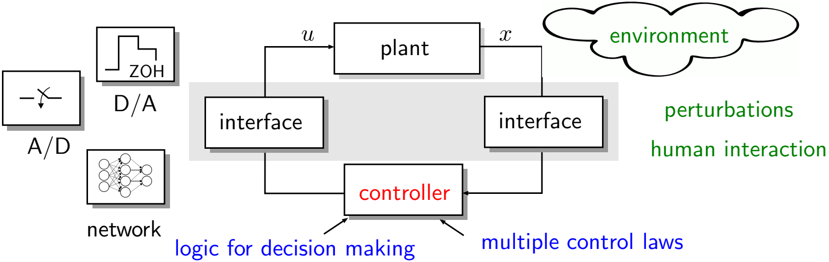


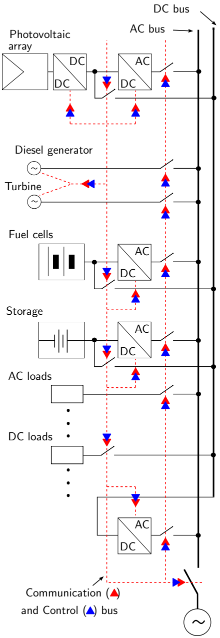
Sample CPS Projects

Feedback Control for Smart Grids

- Hetereogeneous networked power sources, buses, users, and loads
- Conversion required between different waveforms
- Dynamic demands and supplies
- Multiple time scales
  (e.g., fast and slow switching)

Classical approaches:

- Steady-state and averaged models
- Linear control design
- Bening conditions



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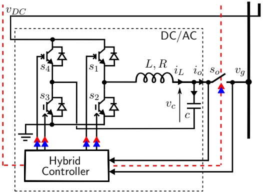
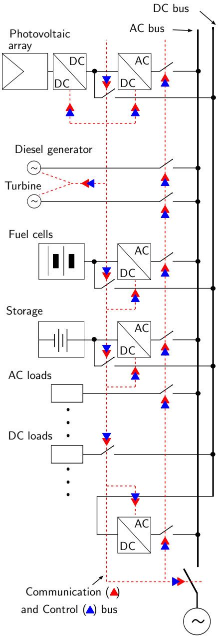
Power Conversion for Smart Grids

- Renewables provide power with high fluctuation
- DC/DC conversion is required before injection to the grid
- Adaptive DC/AC conversion





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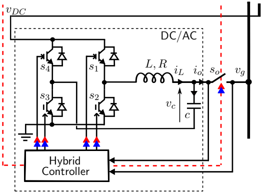

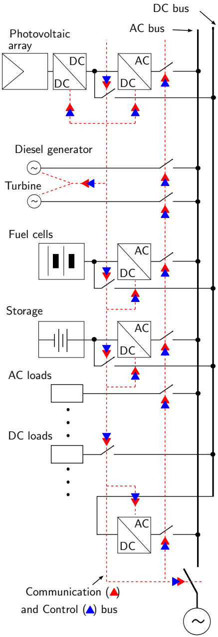

High Penetration of Renewables
U.S.: 20% by 2030
Europe: 16% by 2020

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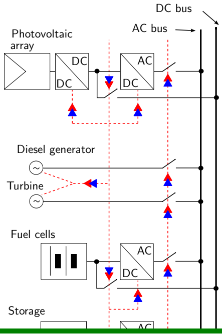

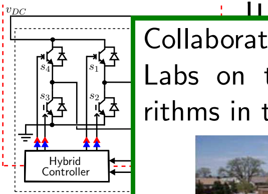

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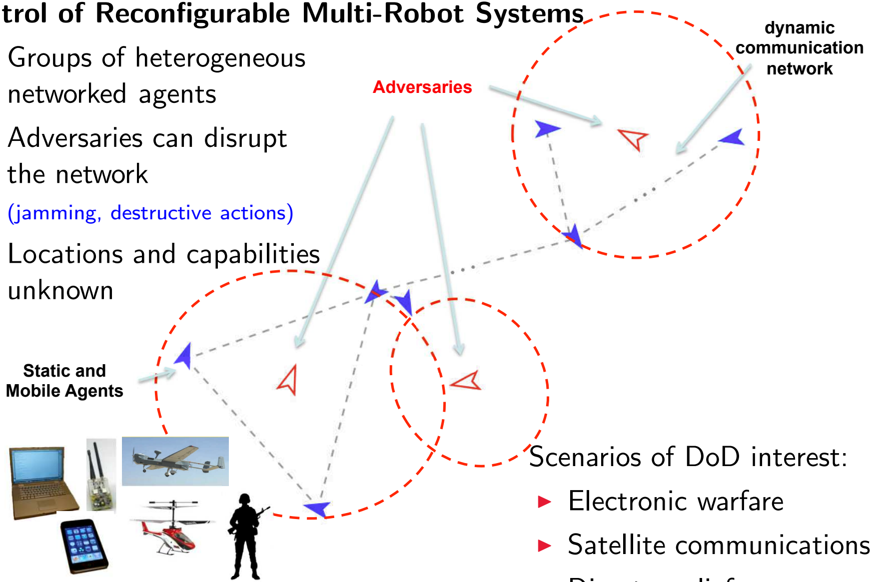
Collaboration with Sandia National Labs on testing of control algorithms in their platform (DETL)

Sample CPS Projects

Control of Reconfigurable Multi-Robot Systems

- Groups of heterogeneous networked agents
- Adversaries can disrupt the network

  (jamming, destructive actions)
- Locations and capabilities unknown



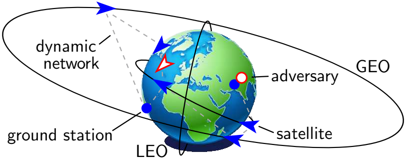
Scenarios of DoD interest:

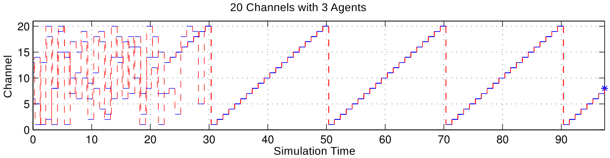
- Electronic warfare
- Satellite communications
- Disaster relief

Sample CPS Projects

Reconfigurable Satellite Communications

- Dynamic ground-satellite links
- Dynamic signal-to-noise ratio on communication channels
- Jamming attacks (MILSATCOM)





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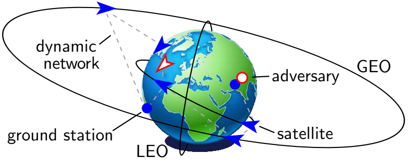

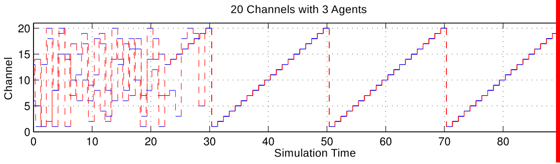

Recent initiatives, such as the **National Broadband Plan**, challenge the traditional FCC approach to allocating spectrum, requesting a new U.S. spectrum policy allowing for dynamic allocation and utilization.

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Control of Aerial Vehicles with Limited and Faulty Sensors

- Autonomous recovery control
- Low cost sensing for autonomous navigation
- Sensor failures affect stability and performance

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UAVs in the National Air Space (NAS): 2012 bill giving FAA three years to "integrate" UAVs into the NAS (set policies, standards, etc.)

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- Understand core theoretical concepts needed to study CPS

- Apply tools and concepts to a CPS application

Course Description

Cyber-physical systems combine digital and analog devices, interfaces, networks, computer systems, and the like with the natural and man-made physical world. The inherent interconnected and heterogeneous combination of behaviors in these systems makes their analysis and design a challenging task. Safety and reliability specifications imposed in cyber-physical applications, which are typically translated into stringent robustness standards, aggravate the matter. Unfortunately, state-of-the-art tools for system analysis and design cannot cope with the intrinsic complexity in cyber-physical systems. **Tools suitable for analysis and design of cyber-physical systems must allow a combination of physical or continuous dynamics and the cyber or computational components***, as well as handle a variety of types of perturbations, such as exogenous disturbances, time delays, and system failures.*

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- Concurrency
- Invariants
- Linear temporal logic
- Verification

Some Items in Fine Print

Prerequisites: The course is self contained. Students are expected to have basic background on logic circuits (CMPE 100 or equivalent), programming (CMPE 13 or equivalent), mathematical modeling of dynamical systems (CMPE 8 recommended), differential equations, linear algebra, and basic calculus. Knowledge of Matlab/Simulink will be useful.

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Talk about the Project...