



## CS500 Challenges in Programming Cyber-Physical Systems

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## Cyber-Physical Systems

What is a cyber-physical system?

Systems consisting of **software** and **physical** processes or components that cooperatively achieve an application objective. It is the **interplay** and **feedback** between cyber and physical components that defines a cyber-physical system, which may also include human interactions ("**human in the loop**") as one of its components.

### Cyber-physical systems include

- traditional “real-time” and “embedded” systems, and
- increasingly complex systems with significant communication and collaboration challenges. New technologies such as smart phones, availability of high bandwidth communication (cloud computing), sensor networks, GPS and localization, and advanced robotics are the core drivers.

### Examples of cyber-physical systems (incomplete list)

- industrial automation systems and robots
- vehicular systems
  - e.g.: collision avoidance, autonomous driving
- avionics
- medical systems
  - e.g.: integrated diagnostics and medication, remote surgery
- smart power grids
  - e.g.: load balancing between power demand and supply
- smart homes and buildings
  - e.g.: cooling, lighting
- assisted living (elderly care)

Cyber-physical systems have “**safety/correctness**” requirements

1. **real-time deadlines** (soft or hard)
2. **reliability and robustness** (dealing with uncertainty)
  - human in the loop interactions
  - limited resources (e.g.: energy budget)
3. **correctness assurance** (verification and validation)

In our group, we focus on a subclass of cyber-physical systems that have

1. **Soft real-time** execution deadlines
2. Have **power/energy** as a crucial resource constraint
3. **Allow tradeoffs** between execution-time and power/energy usage (quality-of-results tradeoffs)

In particular, we will look at

- Sarana, a programming architecture for dynamic networks
- A programming architecture for AUVs (Slocum Glider)
- Intel’s SCC many-core architecture with power/energy management features