

My (biased) Perspective on CPS

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My definitions of CPS

- Definition 1: CPS = Cyber + Physical
- Corollary: *non*-CPS
 - Cyber only: traditional real-time scheduling theory
 - Physical only: traditional feedback control theory

Definition 2: CPS > Cyber + Physical

- Holistic *co*-design of cyber and physical subsystems
- non-CPS: traditional approach to digital control
- CPS: Scheduling-control co-design
 - Leverage, but go beyond theories for scheduling and control
 - Challenge: Networked, wireless

What really matters?

- But definition may not be the important thing
- Neither are applications
- CPS = Embedded Systems?
 - **Yes**, they refer to the same applications / systems.
 - **No**, they focus on different methodologies
- Important: **CPS co-design methodology**
 - Embedded computing works on cyber abstractions.
 - **CPS breaks the barrier between cyber and physical design.**

Structural Health Monitoring

- Localize damages on structures using wireless sensors.
- Traditional: **separate** network and civil engineering
 - Cyber: Wireless network streams all data to a base station
 - Physical: Base station runs damage localization algorithm
- Clean separation of concern, but ineffective
 - Streaming raw data consumes too much energy
 - Simple in-network aggregation does not work for sophisticated signal processing.

G. Hackmann, W. Guo, G. Yan, C. Lu, S. Dyke, Cyber-Physical Codesign of Distributed Structural Health Monitoring with Wireless Sensor Networks, ICCPS'10.

G. Hackmann, F. Sun, N. Castaneda, C. Lu and S. Dyke, A Holistic Approach to Decentralized Structural Damage Localization Using Wireless Sensor Networks, RTSS'08.



CPS Co-Design

1. Design a damage localization method suitable for distributed processing.
2. Model the data flow.
3. Optimally embed the data flow in a sensor network.

- Get hands dirty
 - Understand the data flow of damage localization
- But still employ clean abstraction and methodology
 - Optimal data flow embedding in a network
- Highly effective [RTSS'08]
 - Reduces energy consumption by 71%
 - Reduces latency by 66%

Concluding remarks

- CPS is about co-design of cyber and physical subsystems
- CPS co-design will drastically improve embedded systems
- Positive side effects
 - Multidisciplinary research
 - Holistic perspective on systems design
 - Get real: real requirements and challenges
 - Direct impact on society
- Leverage (instead of replacing) traditional approaches to real-time and embedded computing