TU Delft

Cyber-Physical Systems

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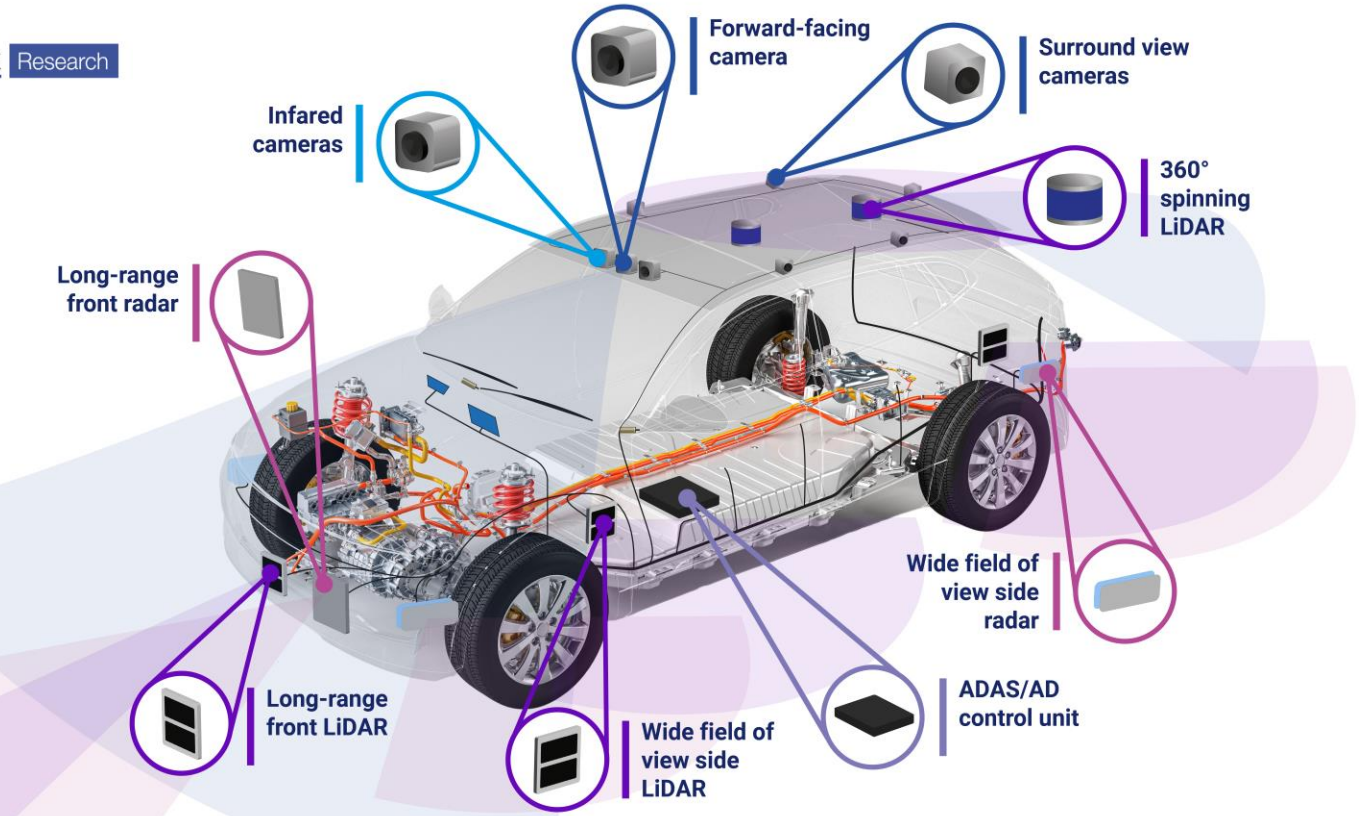
20-10-2024

Source: https://www.shutterstock.com/

What is a Cyber-physical System?

- Combination of physical and computational components
- Sensors and actuators connect the physical and computational components



Source: IDTechEx

Source: Popular Mechanics

CPS Challenges

- Heterogeneity – CPSs are a combination of vastly different subsystems!
- Concurrency – Physical processes can happen in parallel, while computers are inherently sequential
- Time Synchronization – Physical systems are continuous while computers work in discrete time steps
- Distributed systems – CPSs can be distributed in space, further adding to synchronization issues
- Opportunities for coupling errors in high-fidelity systems, amplified by system heterogeneity

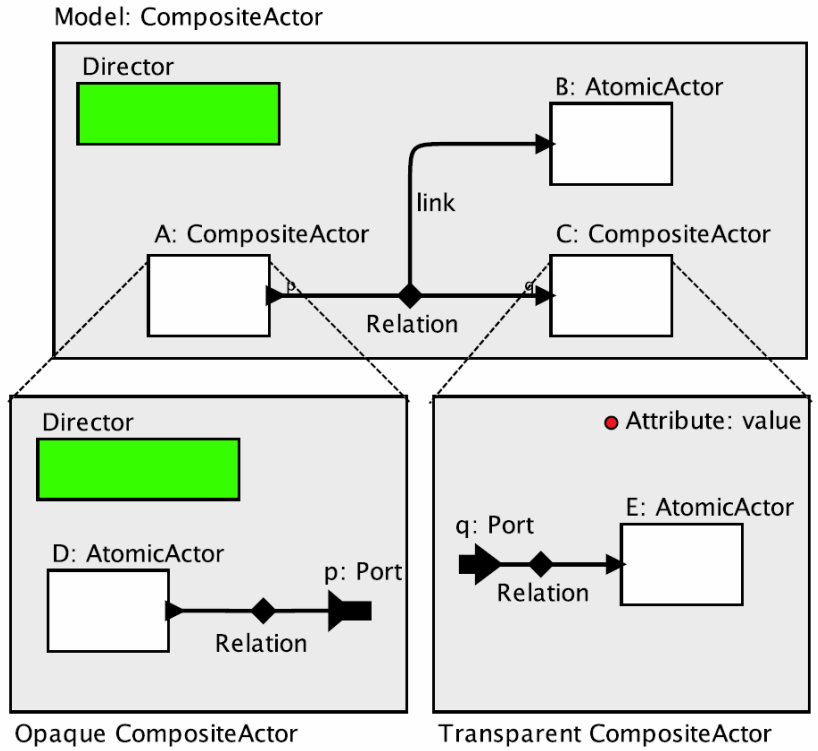
Modelling of CPSs

- Issues inherited from the system itself (previous slide)
- New issues with interaction of different formalisms
- Several attempts at generalized framework
- Often incomplete, or surface-level

Frameworks for CPS modelling

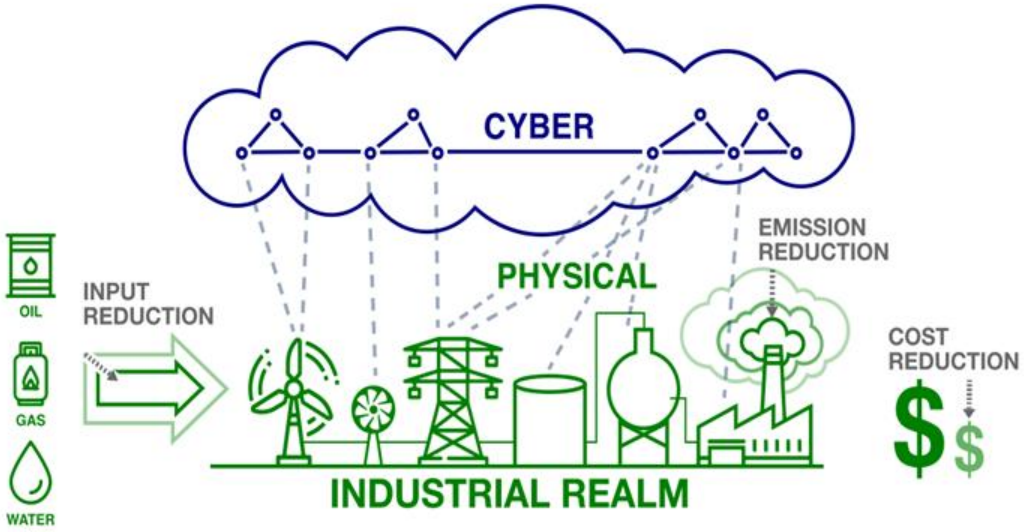
- Hierarchical model structure
- Heterogeneous modelling
- Synchronization still a prevalent issue: concurrency, different formalism, comm delays
- We argue for a combination of generalized frameworks with domain-specific practices
- Open problem: streamlining the coupling between formal frameworks and industry practices

Example for a hierarchical model:



Source: E.A. Lee (2010)

Conclusions



Source: Chuan Zhang

- CPSs are integral to modern industry, transport, infrastructure management, and many other fields
- Ambiguities: a single definition of a CPS is not agreed upon
- CPSs and CPS modelling present persistent challenges
- Existing frameworks for CPS modelling are often inadequate
- Single complete framework does not exist (yet), interim solutions possible in the meantime