Technische Universität Braunschweig

Panel - Societal Automation
Self-Awareness in Design of Cyber-Physical Systems

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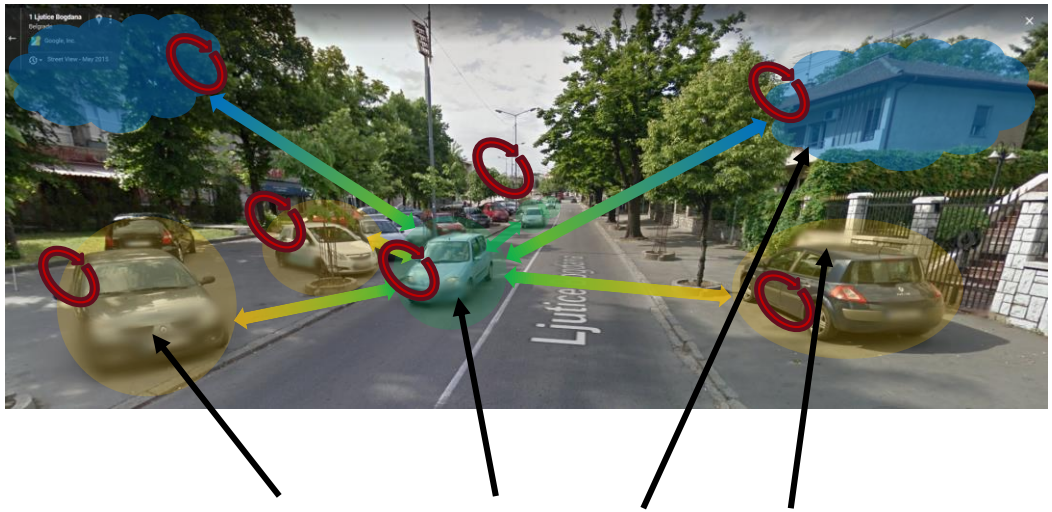
Cyber-physical systems – system trends

- **more complex applications**
  - **automatic driving, smart grid, smart cities, smart industries, ...**
- **example - features in autonomous driving in a smart city**
  - **highly interconnected systems**
    - perception via sensors
    - vehicle-to-vehicle
    - vehicle-to-parked-vehicle
    - vehicle-to-infrastructure
    - vehicle-to-cloud
  - **decision offloading/sharing**
    - vehicles, infrastructure cloud

autonomous decisions



different producers and owners

Cyber-physical systems – challenges

- **growing application and systems interaction**
  - same data and function used for many applications – mixed criticality
- **open systems with no single owner**
  - heterogenous environment
- **continuous systems evolution in the field**
  - aging, configuration, updates
  - which can be based on autonomous processes and decisions
  - in-field learning?
- **... on many more devices**
  - communicating over open and heterogenous networks
  - using huge amounts of distributed data

Design impact – conflicting trends

- **more complex HW/SW architectures**
  - new systems and software architectures including virtualization, open and never-down systems, ...
  - new algorithms w/ less predictability and evolution (machine learning)
  - systematic integration, evolution, certification, maintenance, ...
- **strongly growing physical and hardware requirements**
  - low power, performance, storage capacity and life time, ...
  - safety and security guarantees, ...
- **under constant change and adaptation**
  - platform and components
  - applications and their coordination

where do we get the engineering force for the design, adaptation, and maintenance process?

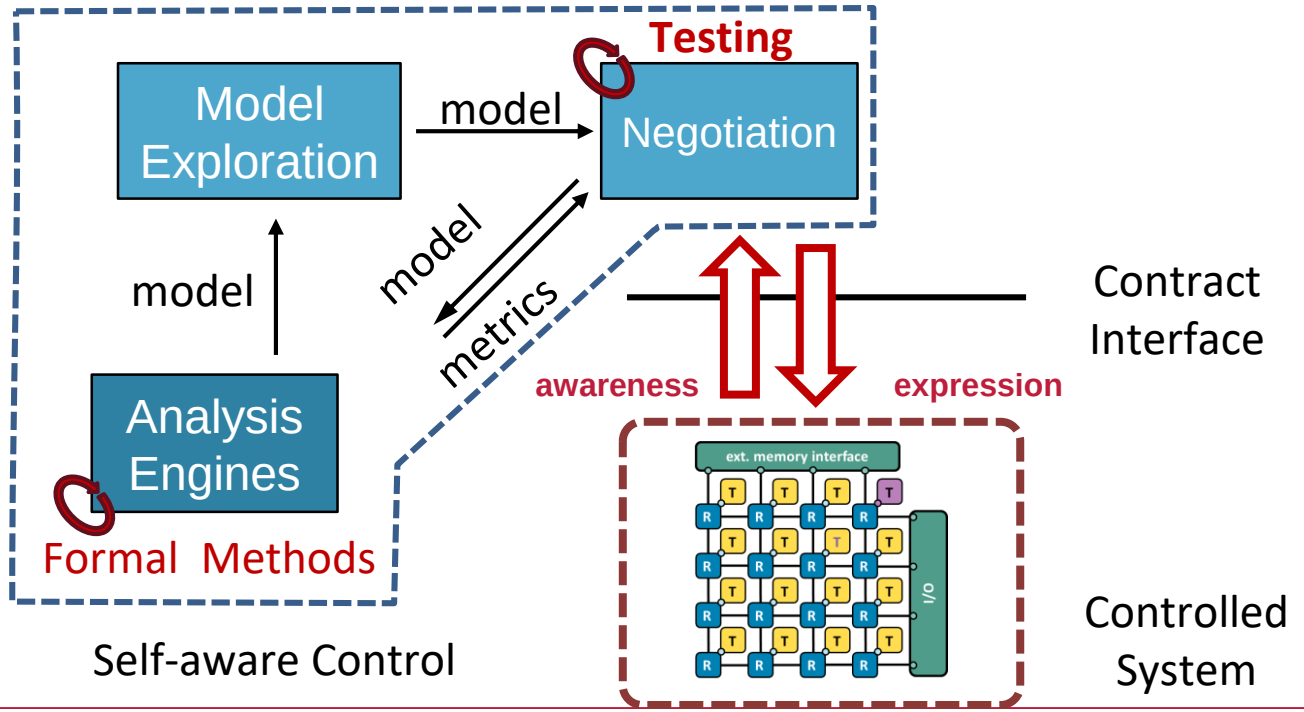
What is needed – autonomous design for autonomous systems

- **we need a fundamental change of the design process**
  - from a clear separation of design and operation to an integrated adaptive design, operation, and maintenance process
  - from a tool supported to an increasingly autonomous design process
    - controlled by objectives and constraints rather than by detailed manual design decision (cp. Autonomic Computing for IT services)
    - with clear separation of manual and automated design decisions
- **but that can be difficult**
  - cyber-physical systems design is complex
  - includes physical design with mechanical components
  - governed by various constraints including safety and power consumption with their individual design methods and legal regulations

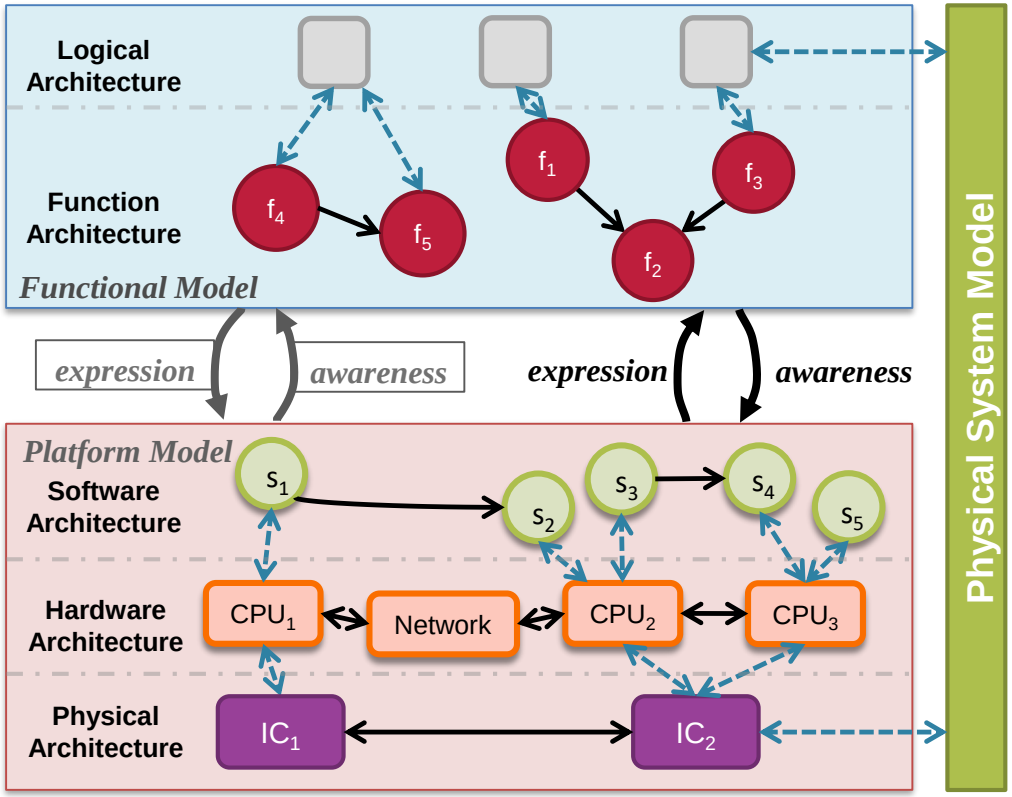
can we realistically control such a design process autonomy?

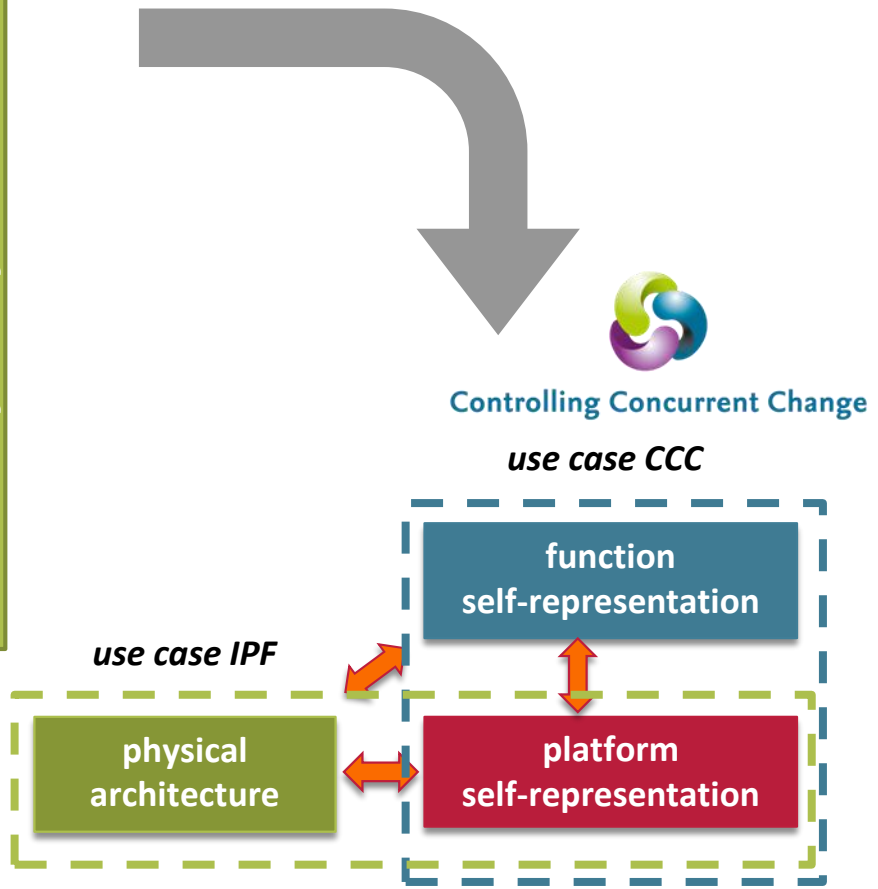
Platform self-awareness - A first step

- **a self-aware system knows its capabilities and its status**
  - modeling of current state and context
  - model prediction for actions
  - potential basis for partially autonomous design



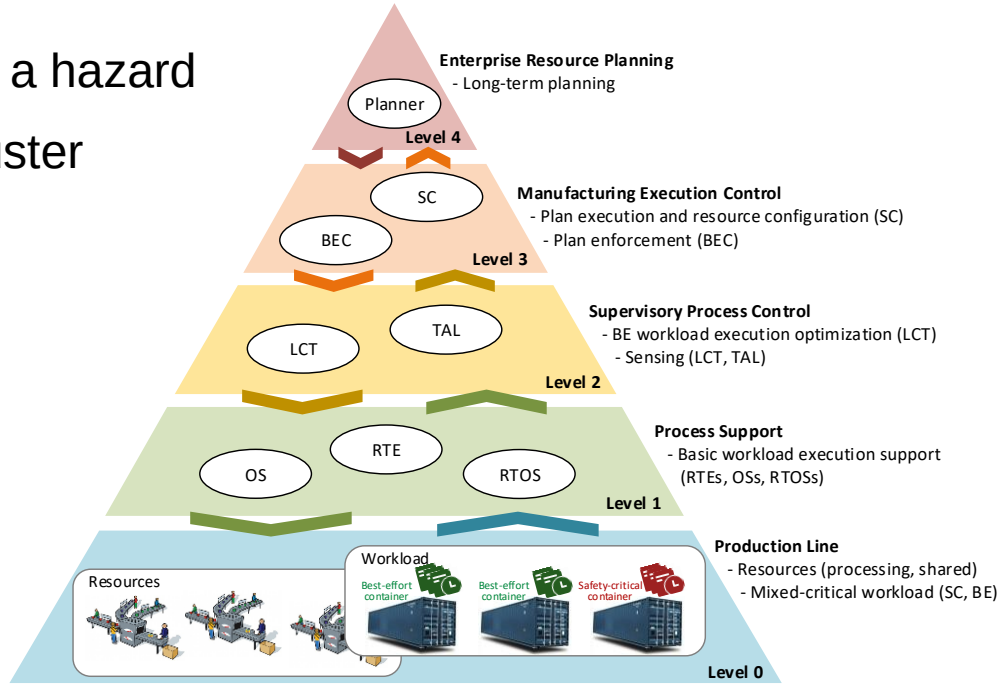
Cross-Layer Modeling and Self-representation in CPS





The Information Processing Factory (IPF)

- IPF addresses challenges with two levels of awareness
  - Long-term planning and execution
  - Local optimization (short-term)
- IPF proactively detects and handles imminent hazards
  - Risk unacceptably high of a system failure and, therewith, a hazard
- German-American research cluster jointly funded by DFG and NSF



UC Irvine

Technische Universität München

CCC applications: automatic vehicles, space robotics

- TU Braunschweig DFG research group “Controlling Concurrent Change”
  - self-aware architecture for platform self-protection and self-adaptation
  - contract based mechanisms for independent function, platform and software updates
    - under safety, availability and security constraints
  - applications: automatic vehicles, space robotic