Modeling and Simulation of Industrial Control Systems

Ines Ugalde
Advanced Manufacturing Automation
Siemens Corporate Technology USA

Siemens Company Structure (375,000 Employees)

Power and Gas

Building Technologies

Digital Factory

Siemens Healthineers

Energy Management

Mobility

Processes and Drives

Siemens Gamesa Renewable Energy

Corporate Technology (7,000 employees, 1,600 researchers)

CT AMA – Advanced Manufacturing Automation

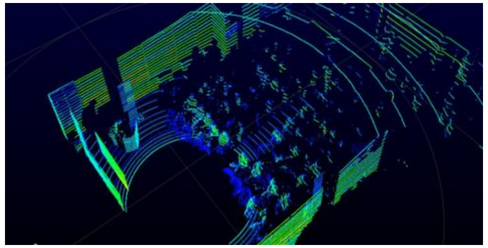
Bridging the Gap between University Research and Industry

Mission: Located in **Berkeley, CA**, we *Scout* and *Evaluate* new automation & control technologies in collaboration with leading academic institutions and government agencies.

Research Areas

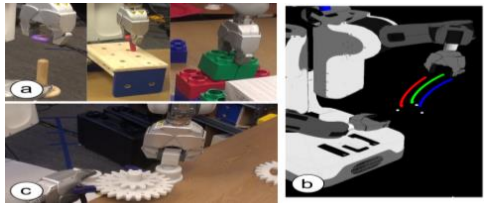
- **Advanced Robotics**
- **Advanced Control & Optimization**
- **Smart Factories**

Examples of University Collaborations



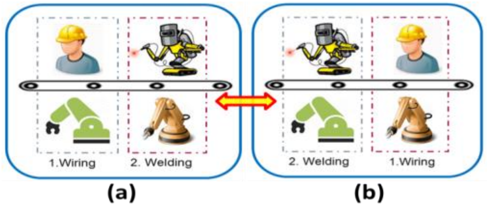
Situation Awareness in a Manufacturing Setting

Univ. Washington



Deep Reinforcement Learning of Robotic Assembly Tasks

UC Berkeley



Self-learning Manufacturing Systems

Stanford

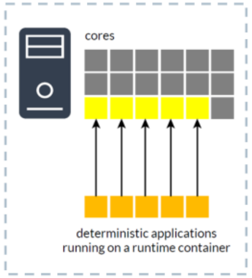
Research Collaboration: iCyPhy and Siemens

SIEMENS
Ingenuity for life

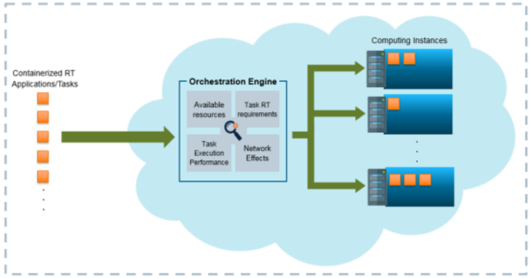
Siemens is an iCyPhy member since 2017

Real-time Virtual Containers for Industrial Control Systems

Today



Tomorrow



- **State of the art**: One task per virtual core, No RT guarantees
- **Our approach:**
  Dynamic Task Scheduler and Monitor
    Real-time guarantees
    Optimize virtual core usage (multiple tasks per core)

Prof. Alberto Sangiovanni-Vincentelli

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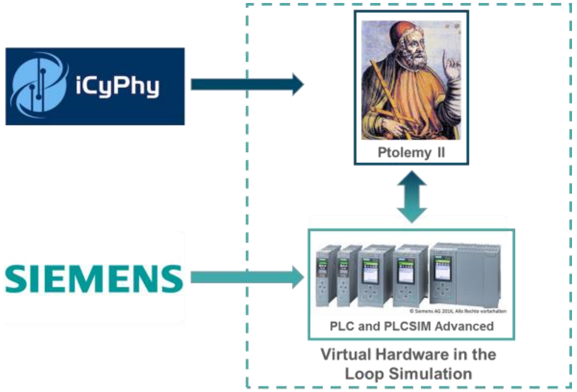


Initial Goal:
Leverage Ptolemy II Cyber-Physical System Models in Virtual Hardware in the Loop Simulation with PLCSIM Advanced

New Goal:
Define a PLC Programming Model addressing *deterministic execution*

Prof. Edward A. Lee

Programmable Logic Controllers

Ecosystem for factory and industrial process

Robust, ruggedized hardware

Software Logic and IDE

RT Networks interconnecting sensors and actuators

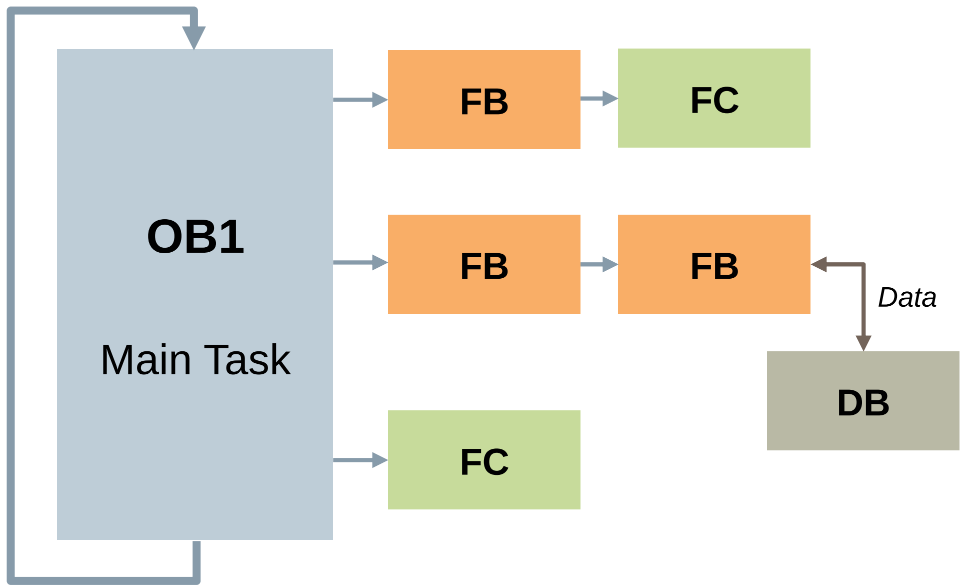
OB — Organization blocks are preemptable tasks invoked periodically or at events (*prioritized interrupts*)

FB — Function Block with persistent state, like a C++ object
Can be called from an OB

FC — Function without persistent state, like a C function
Can be called from an OB or an FB

DB — Data Blocks store variables
Same DB may be accessed by multiple FBs

The Cyclic Program



Ambiguities in current PLC Programming Scene

1. **Input signals are updated on a cycle basis of variable duration**

   Arrival time of signals in between cycles cannot be distinguished

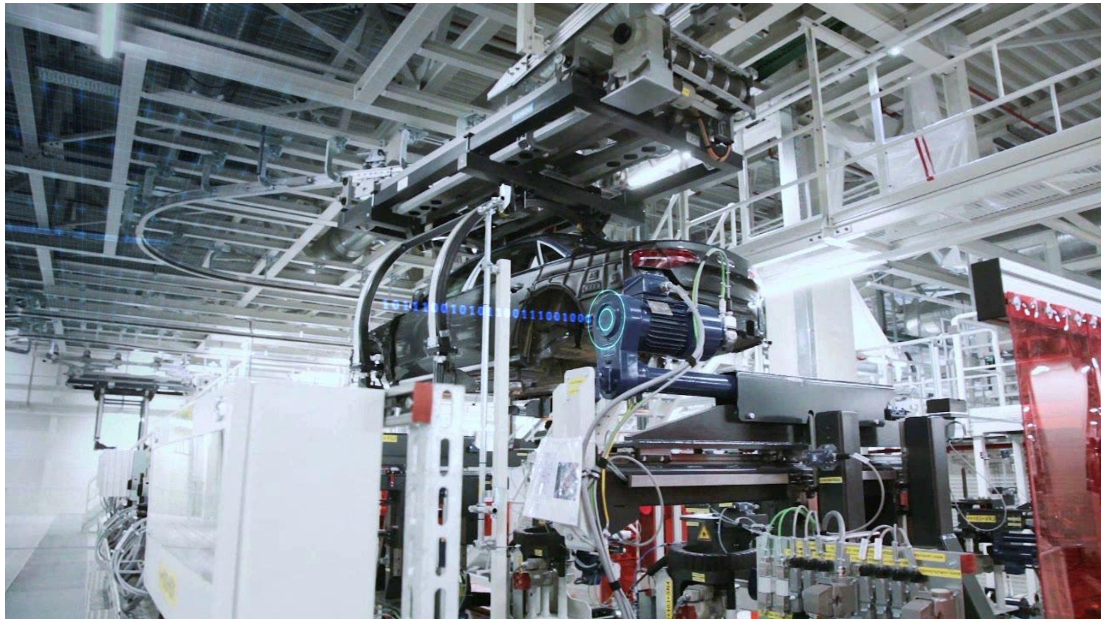
2. **Ambiguous use of memory**

   Data Blocks may be changed across tasks/FBs within the same cycle

   FB execution may not be atomic, its inputs may change during its execution and its outputs may be visible before execution is done

3. **Timing behaviors are difficult to understand**

   Coexisting clocks and synchronization methods on the network make reasoning about system behavior difficult to understand



Research Areas

1. Rely less on cyclic computations
   → Reduce network polling to check if “something has changed”
   → Favor event-based programming models, like PTIDES

2. Software components should specify timing requirements instead of (in addition to) priorities.
   Given only priorities, the actual behavior of one component may depend on other (unrelated) components

3. Software behavior should be more independent of hardware
   → Aim for more deterministic software response facilitating the job of Virtual Prototyping

4. Enforce a more disciplined use of memory
   → By means of message-passing communication mechanisms

Contact page

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