EPOC

Embedded Performance Analysis for Organic Computing

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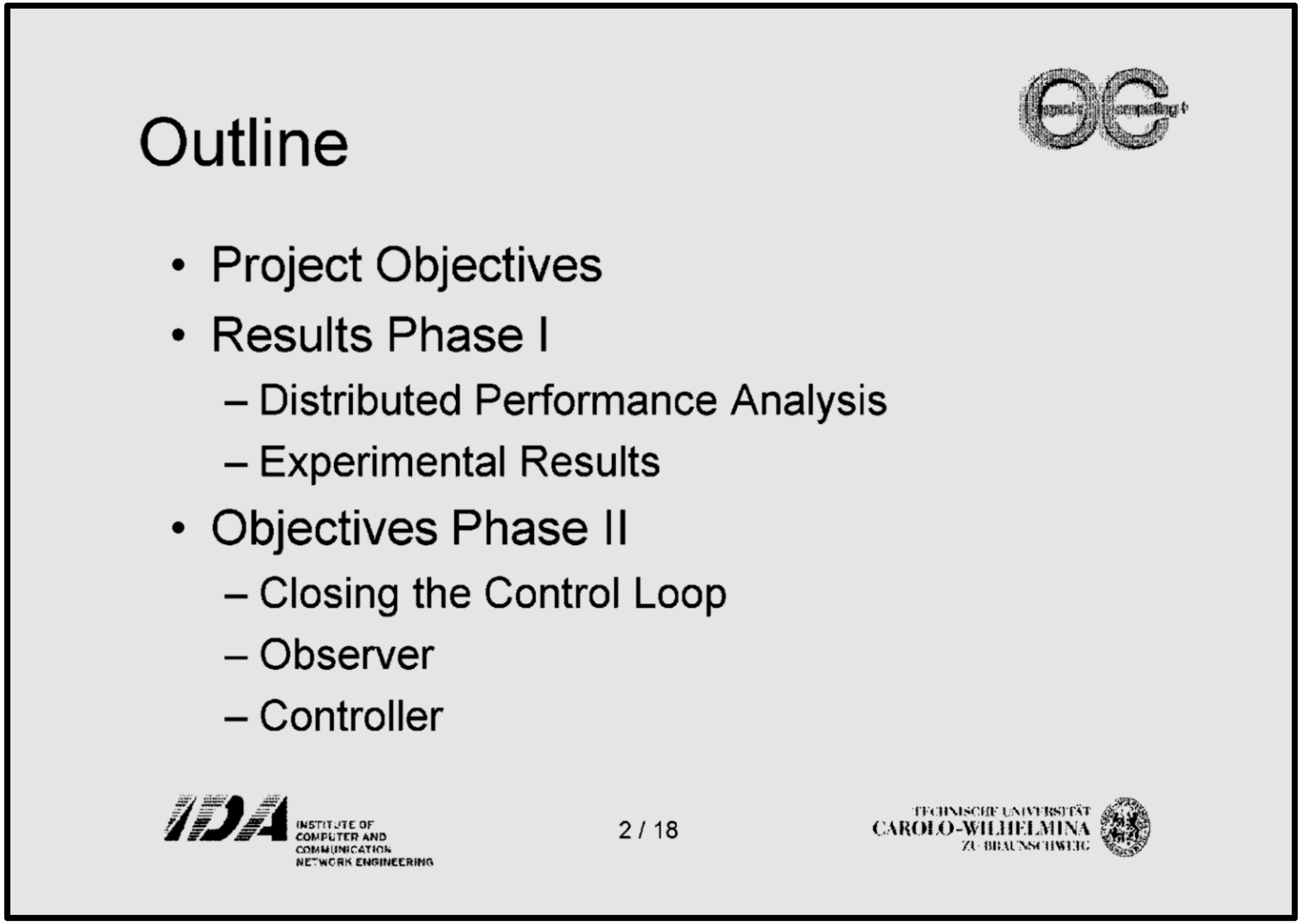
Outline

- Project Reminder
- Report on Phase II
  - Analysis Theory
  - Demonstrator
  - Contracting Architecture
  - Platform Components
- Objectives Phase III
  - Model-based Optimization
  - Contract Supervision & Management
- Dissemination
- Summary

Project Reminder



Outline

- Project Objectives
- Results Phase I
  - Distributed Performance Analysis
  - Experimental Results
- Objectives Phase II
  - Closing the Control Loop
  - Observer
  - Controller

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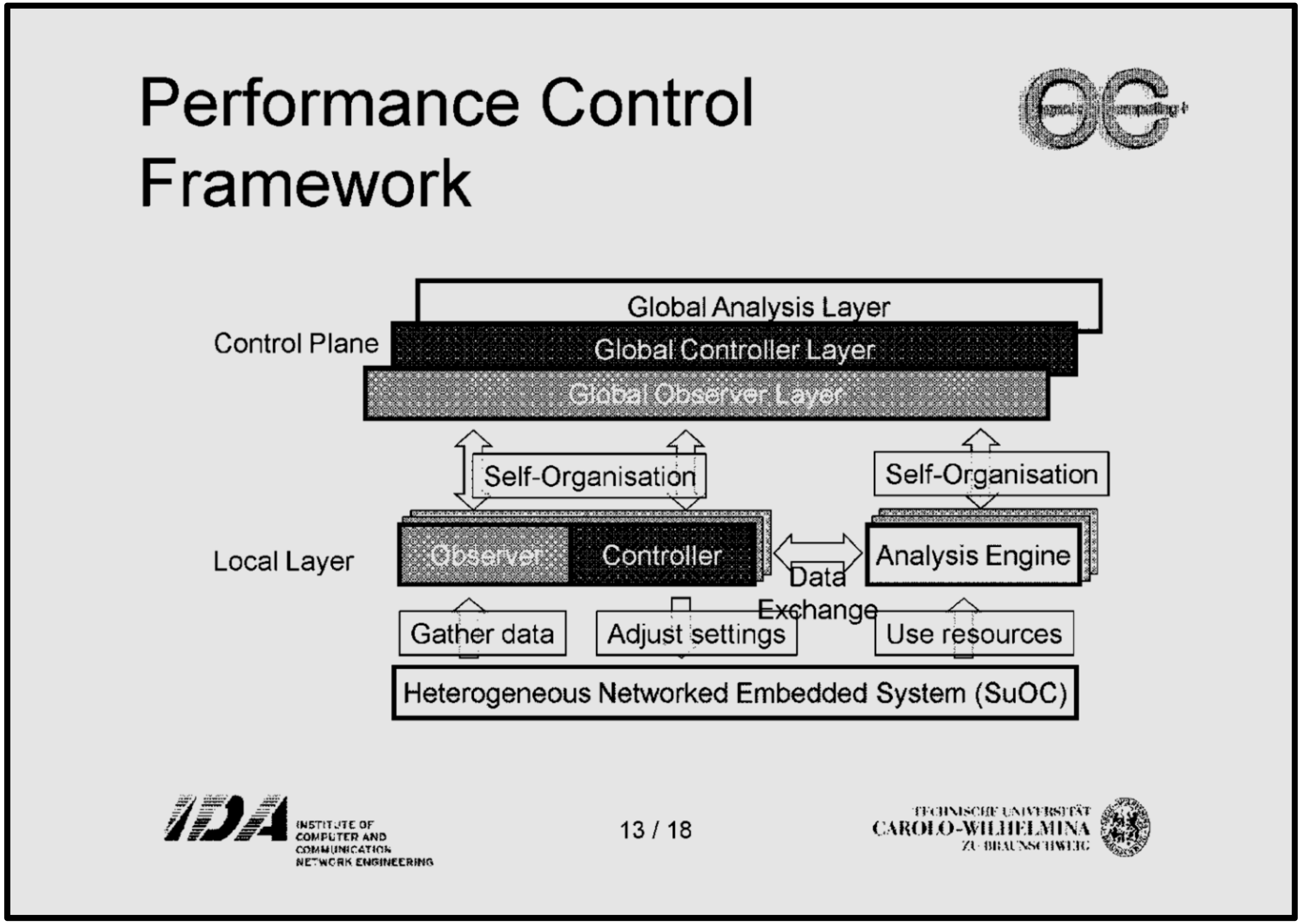
Project Reminder



Performance Control Framework

Control Plane

Global Analysis Layer

Global Controller Layer

Global Observer Layer

Self-Organisation

Self-Organisation

Local Layer

Observer

Controller

Data Exchange

Analysis Engine

Gather data

Adjust settings

Use resources

Heterogeneous Networked Embedded System (SuOC)

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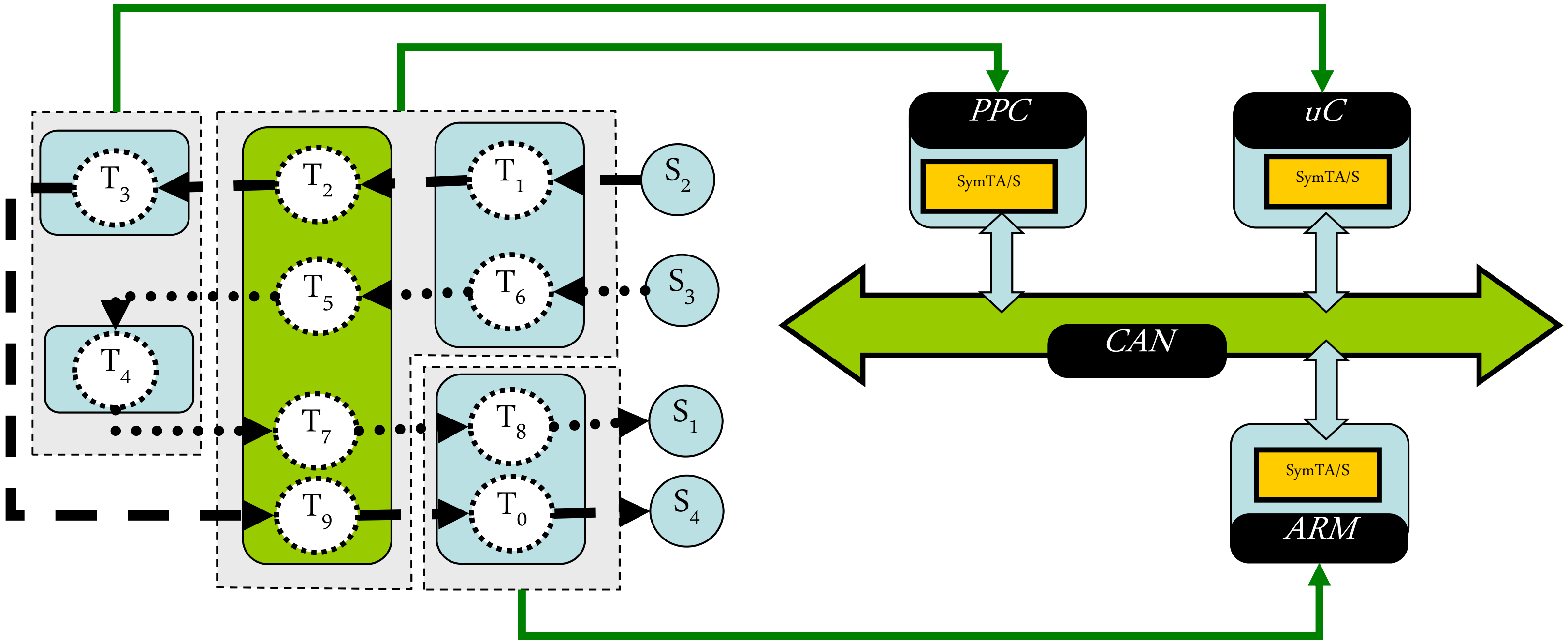
Project Reminder

Model-based performance analysis:



Global Model

Real System

Report on Phase II

ANALYSIS THEORY

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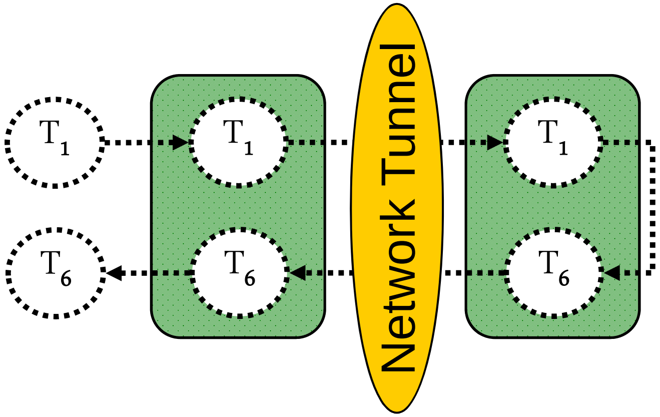
Analysis Theory

- What is the behavior of the distributed fix point algorithm?
  - does the solution depend on the order of analysis steps?
  - what is the effect on convergence?
  - in how far do we have to adapt the initial condition?
- How can we control the local analysis load
  - given an upper load bound, what happens if we terminate the local and global fix point algorithm before convergence
    - is the analysis result conservative?



Analysis Theory

- use proofs by Tarski (55) and Kleene on fix point iterations to show
  - given a lattice L and a monotonous function F: L → L
    - *the set of event model states is a lattice, F is the analysis function*
  - the set of fixpoints of F is nonempty (and itself a complete lattice)
  - the iteration $\perp$, $F(\perp)$,$F(F(\perp))$,$F^3(\perp)$,…, converges towards the smallest fixpoint of F.
- if the initial condition is not an infimum, then a fix point can be found but might be non-minimum
- changing order of analysis steps corresponds to a different function F‘: L → L. Can be shown that $F'^{\infty}(\perp) = F^{\infty}(\perp)$ as a property of F and F‘

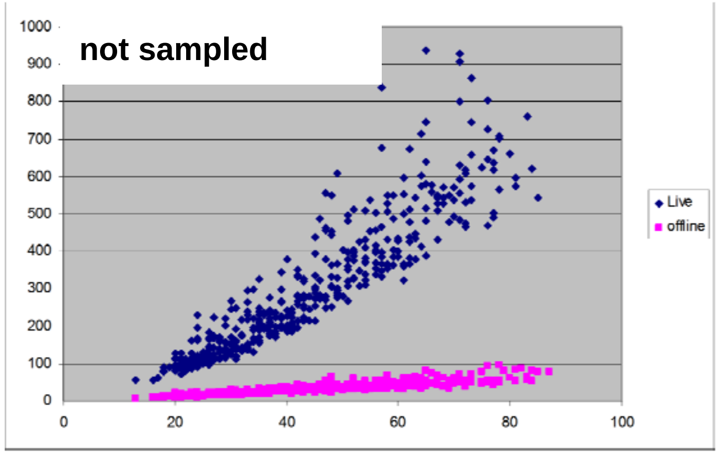
  → **order of local analysis execution does not change the fix point and solution is unique**

Analysis Theory

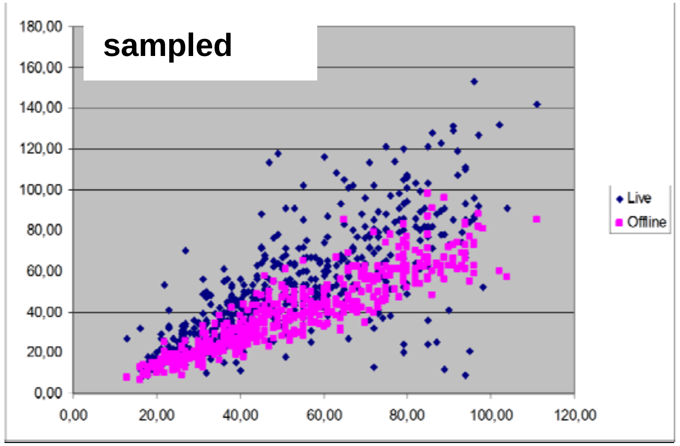
- local analysis may be executed in any order
- not every intermediate result must be evaluated as long as local analysis evaluated for changing inputs

  → local analysis results may be sampled to reduce analysis communication and computation load

local analysis activations to solution ↑



system size →

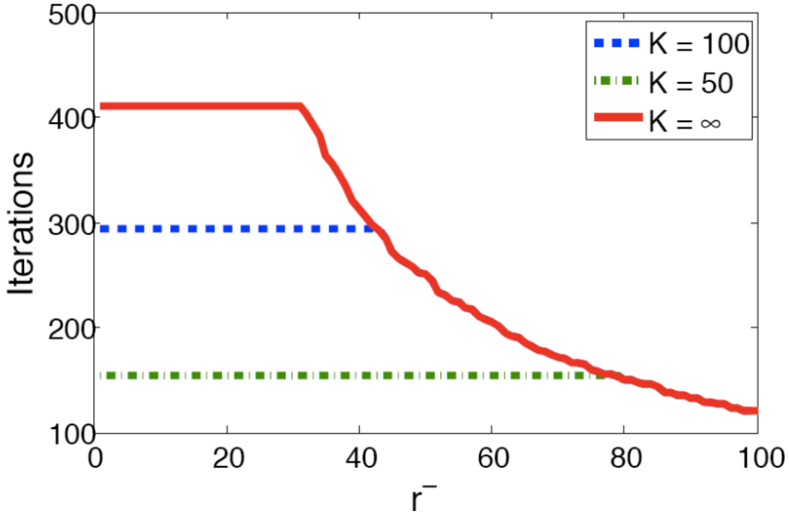


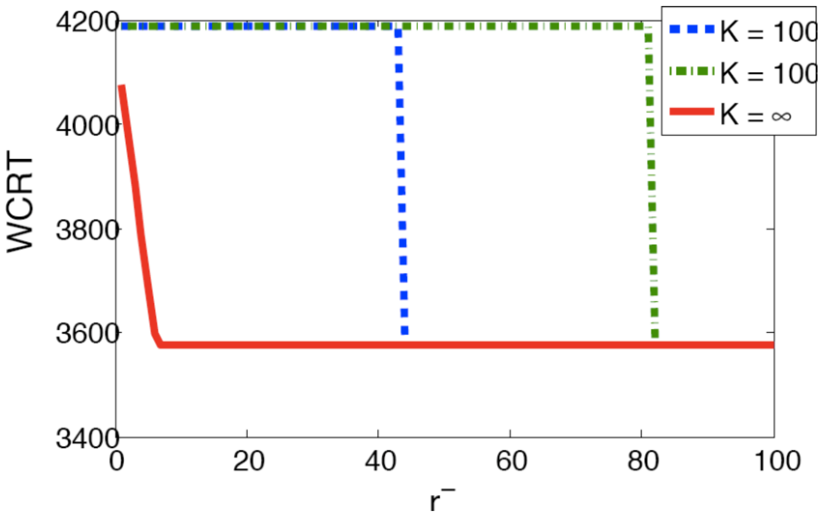
system size →

🟦 **distributed** 🟪 **centralized (SymTA/S)**

Analysis Theory

- Effects of bounding of local analysis iterations
  - Trade-off in accuracy can specified
  - Use approximations for *difficult* problems
- Bounded exact algorithm superior to approximations in most cases





Report on Phase II

DEMONSTRATOR

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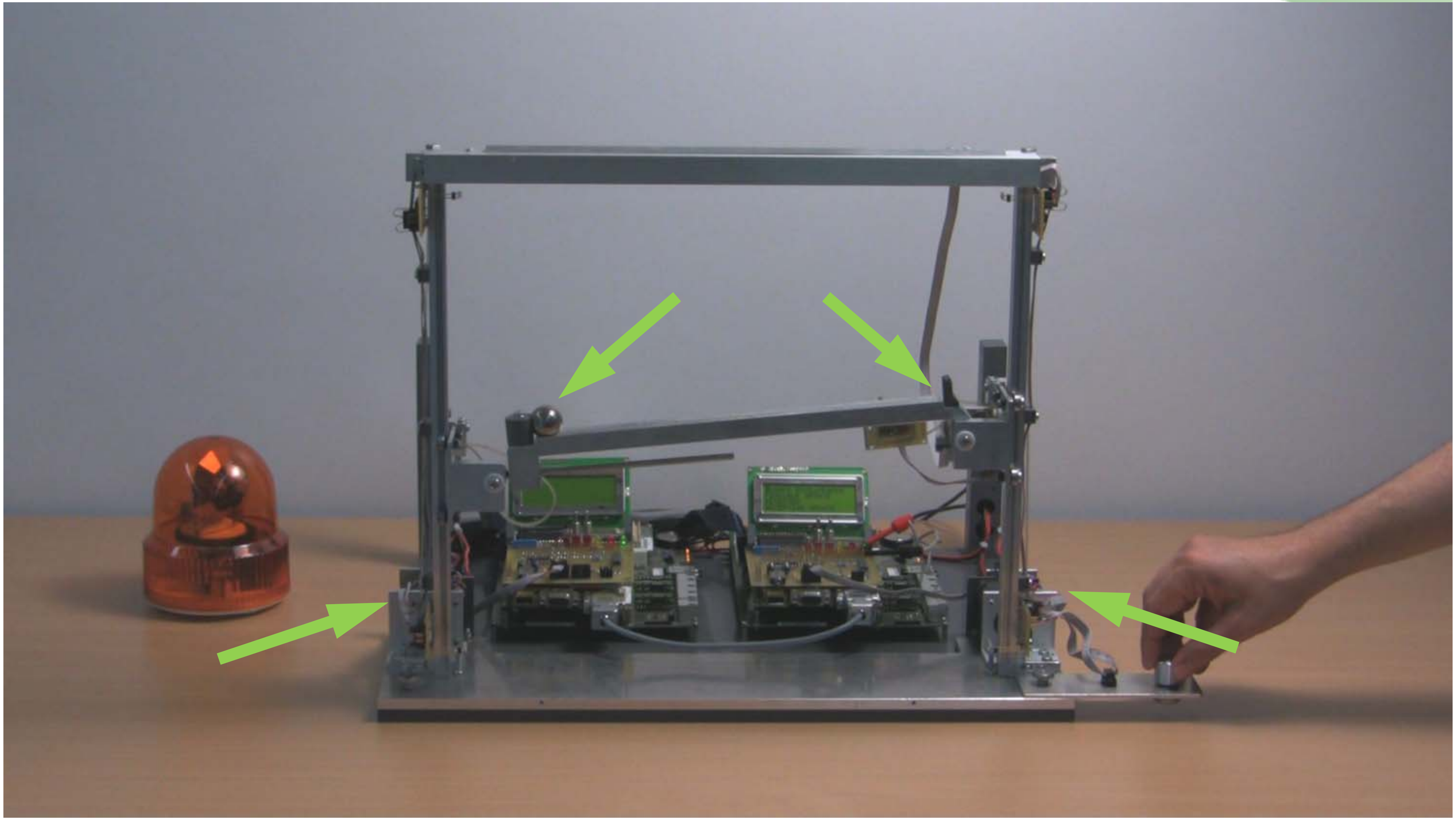
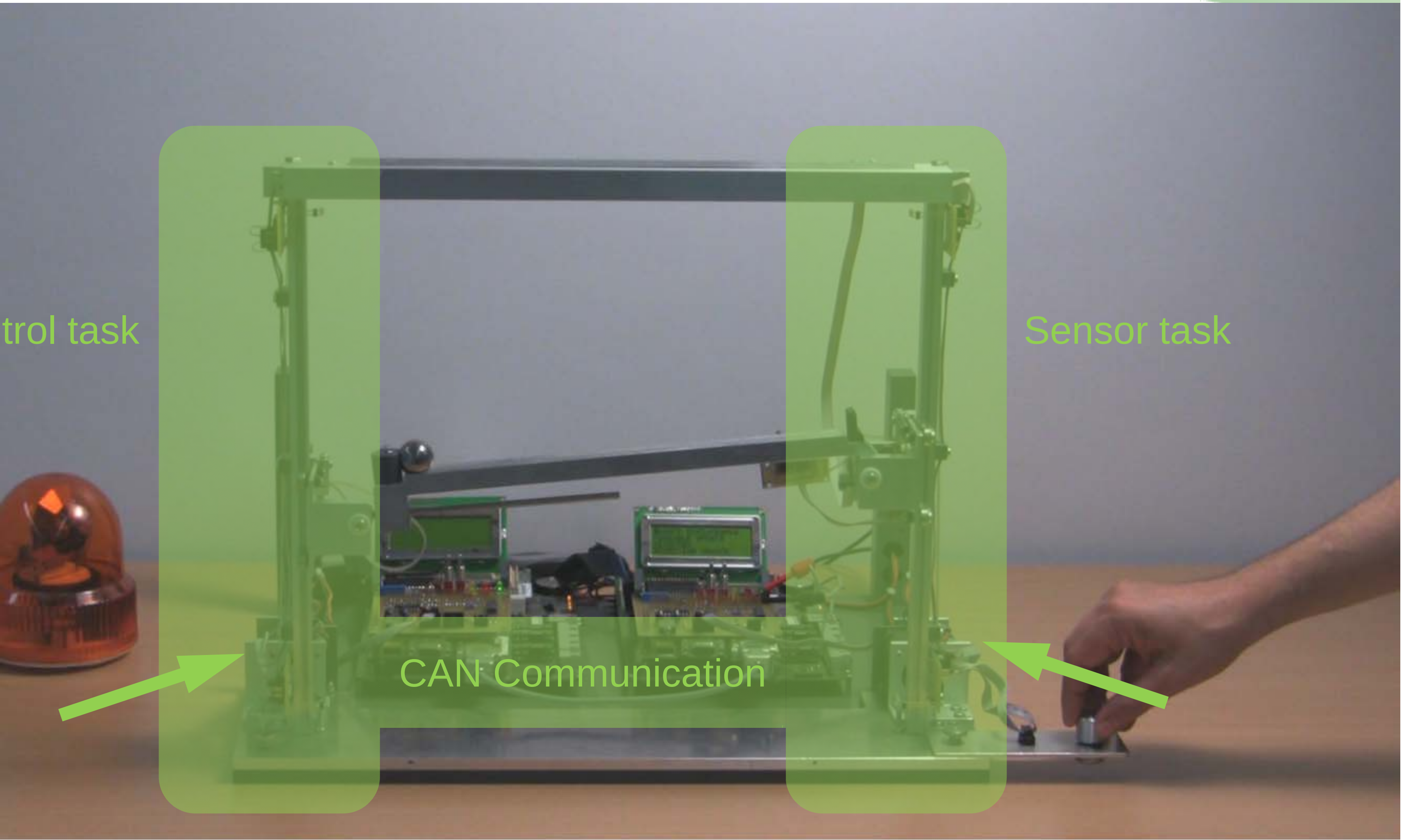
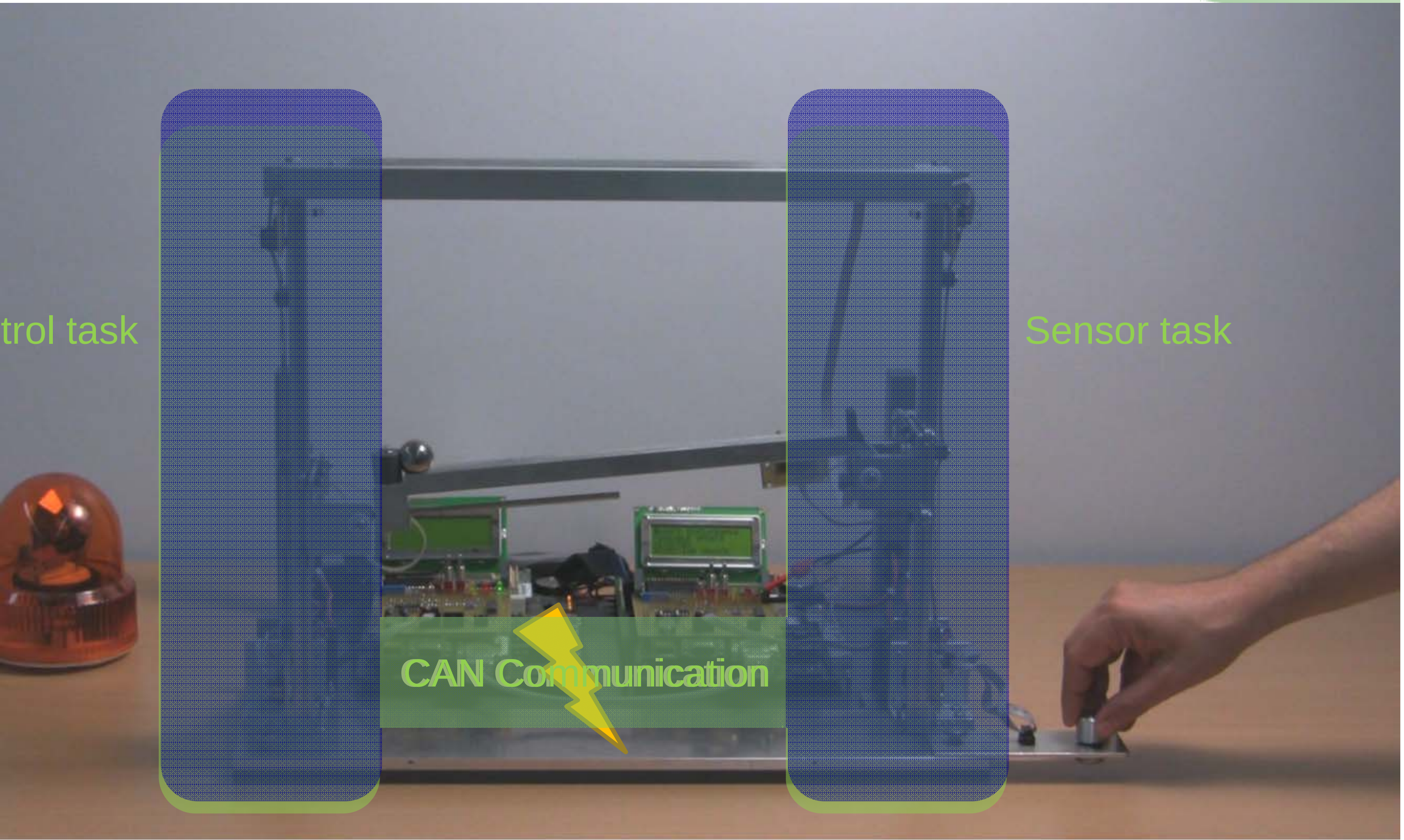




trol task

Sensor task

CAN Communication



trol task

Sensor task

CAN Communication

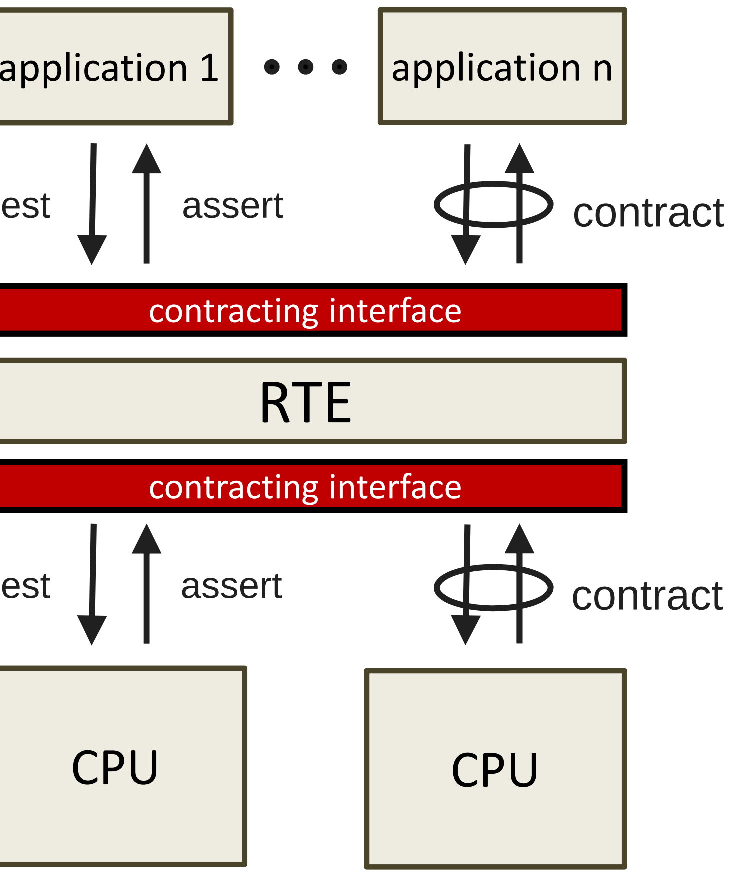
monstrator

Demonstrator without self-protection

eport on Phase II

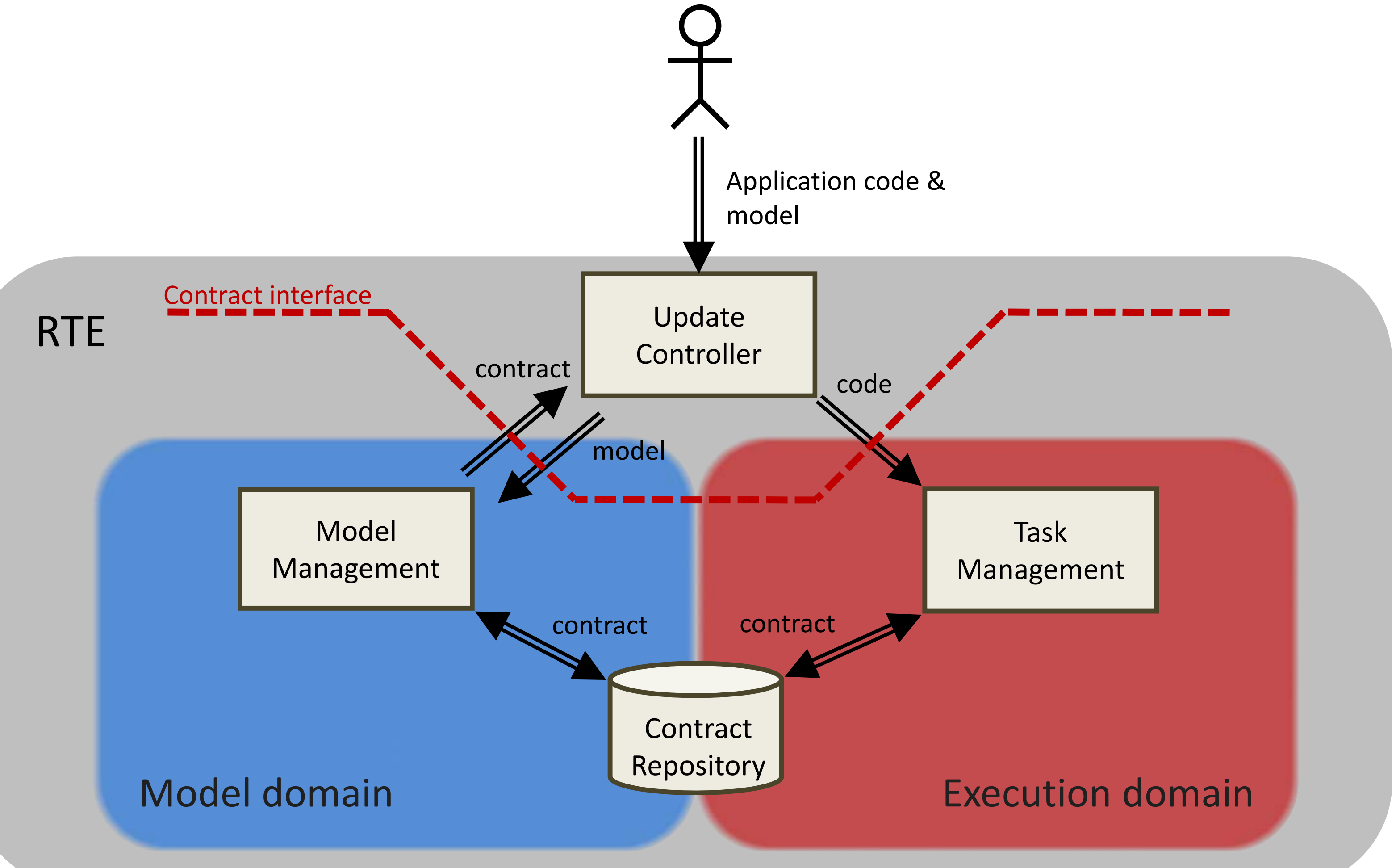
CONTRACTING ARCHITECTURE

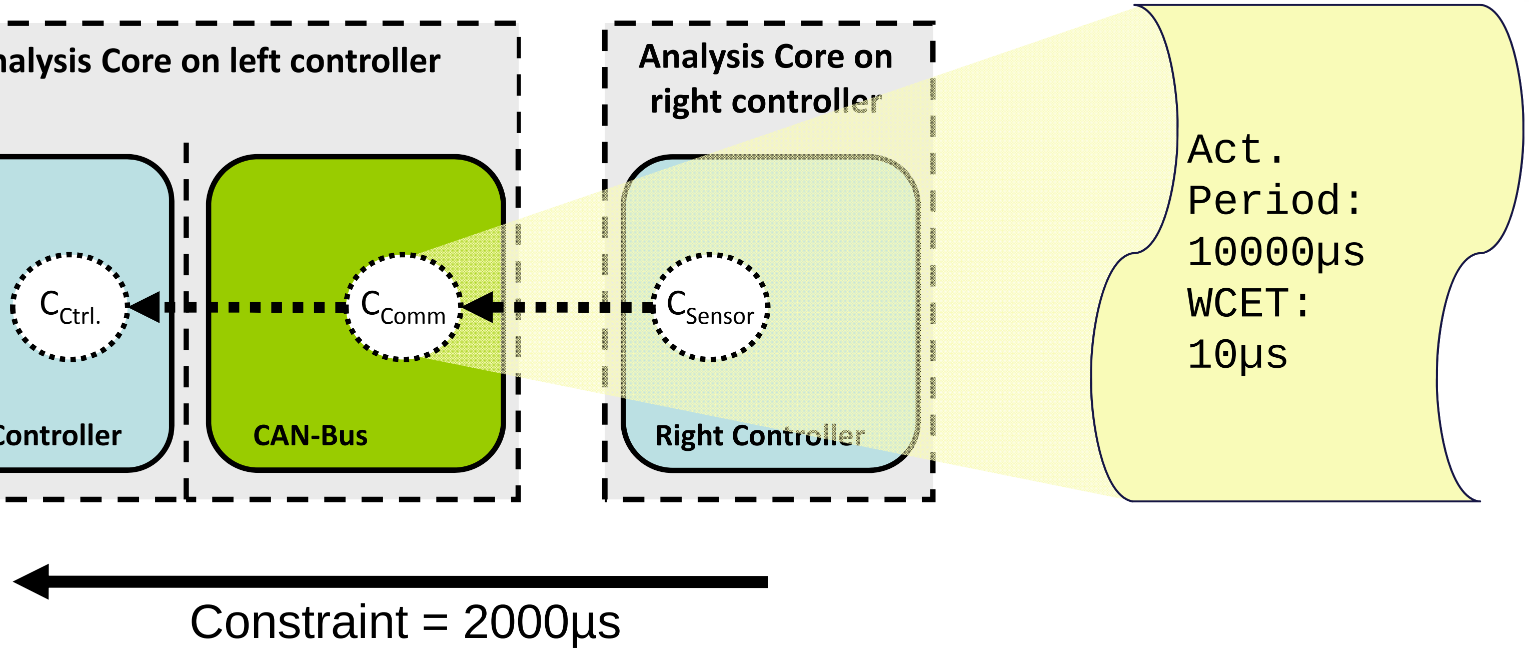
ntracting Architecture



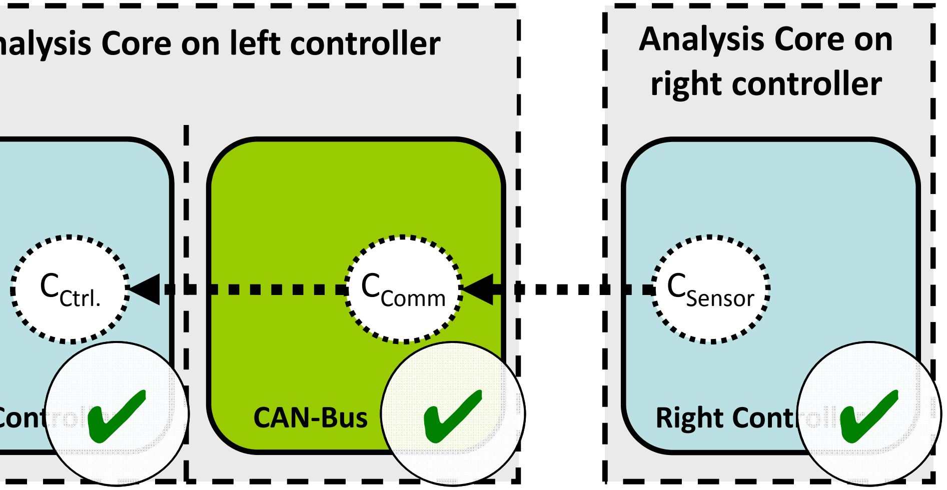
- Applications request Service from RTE
  - Latency
  - Throughput
- RTE asserts properties of Applications
  - worst-case response time
- Platform contracts similarly
- Extend RTE by Contracting Layer
  - For applications
  - For platform
- Violation → Renegotiation

ntracting Architecture

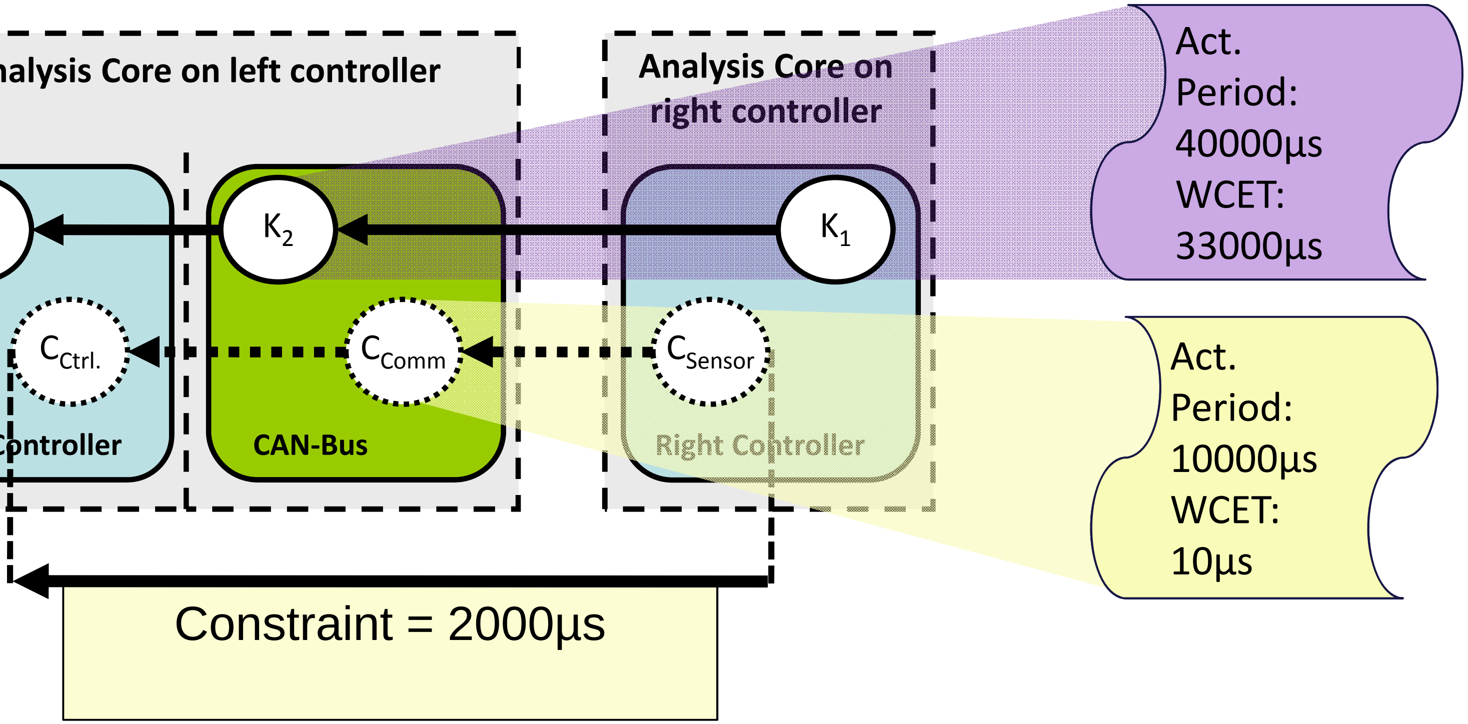



alysis Core on left controller
Analysis Core on right controller
C_Ctrl.
C_Comm
C_Sensor
Controller
CAN-Bus
Right Controller
Act. Period: 10000µs WCET: 10µs
Constraint = 2000µs

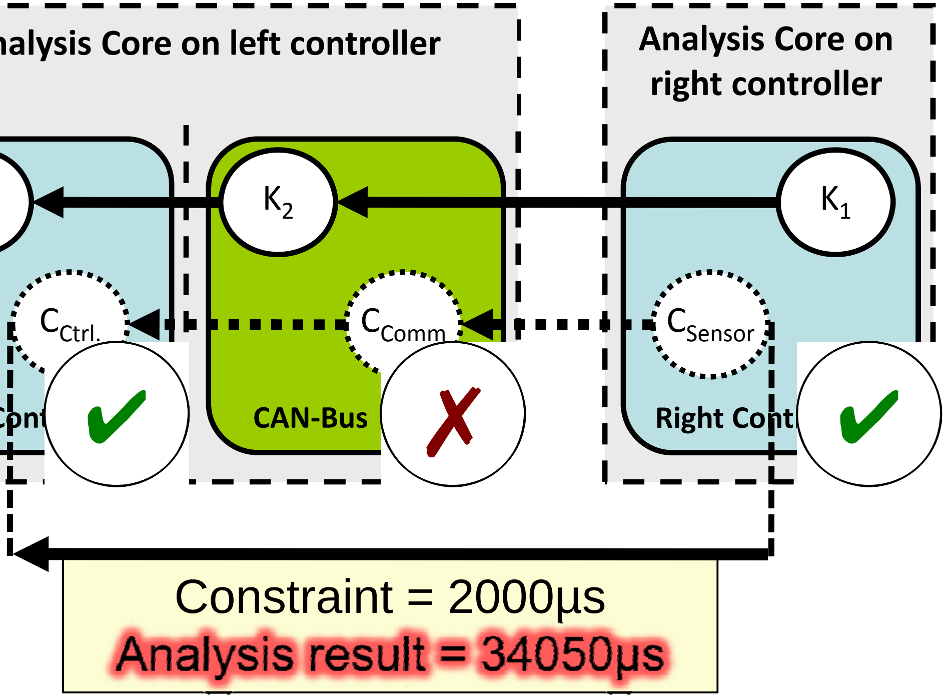
The control application is inserted into the system to compensate the disturbance. The application is composed of a sensor and a control task that communicate over the CAN-bus.


nalysis Core on left controller
Analysis Core on right controller
$C_{Ctrl.}$
C_{Comm}
C_{Sensor}
Control
CAN-Bus
Right Control
✓
✓
✓

A distributed timing analysis is performed.
All temporal constraints are met and the application is admitted to the system.



The second application with high priorities and high load on the CAN-Bus is inserted into the system.



Constraint = 2000µs

Analysis result = 34050µs

The third application would cause the control application to fail its latency constraint.

The third application is rejected.

monstrator

Demonstrator **with** self-protection

Summary of Phase II

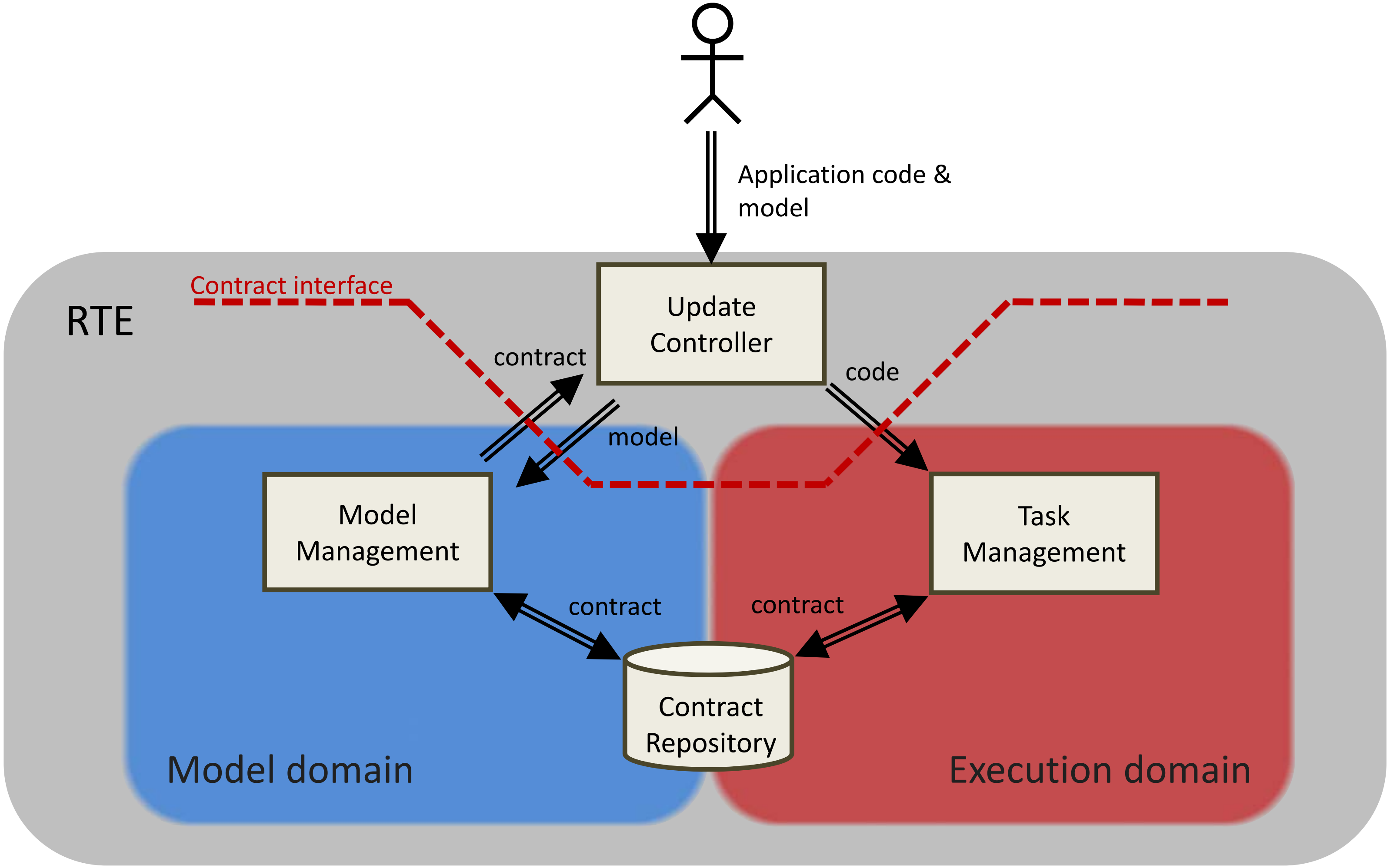
Accomplishments

- Distributed model-based analysis
  - Proof of convergence
  - Analysis in bounded time
- Contracting Architecture providing self-protection for real-time systems
- Demonstrator with self-protection capability

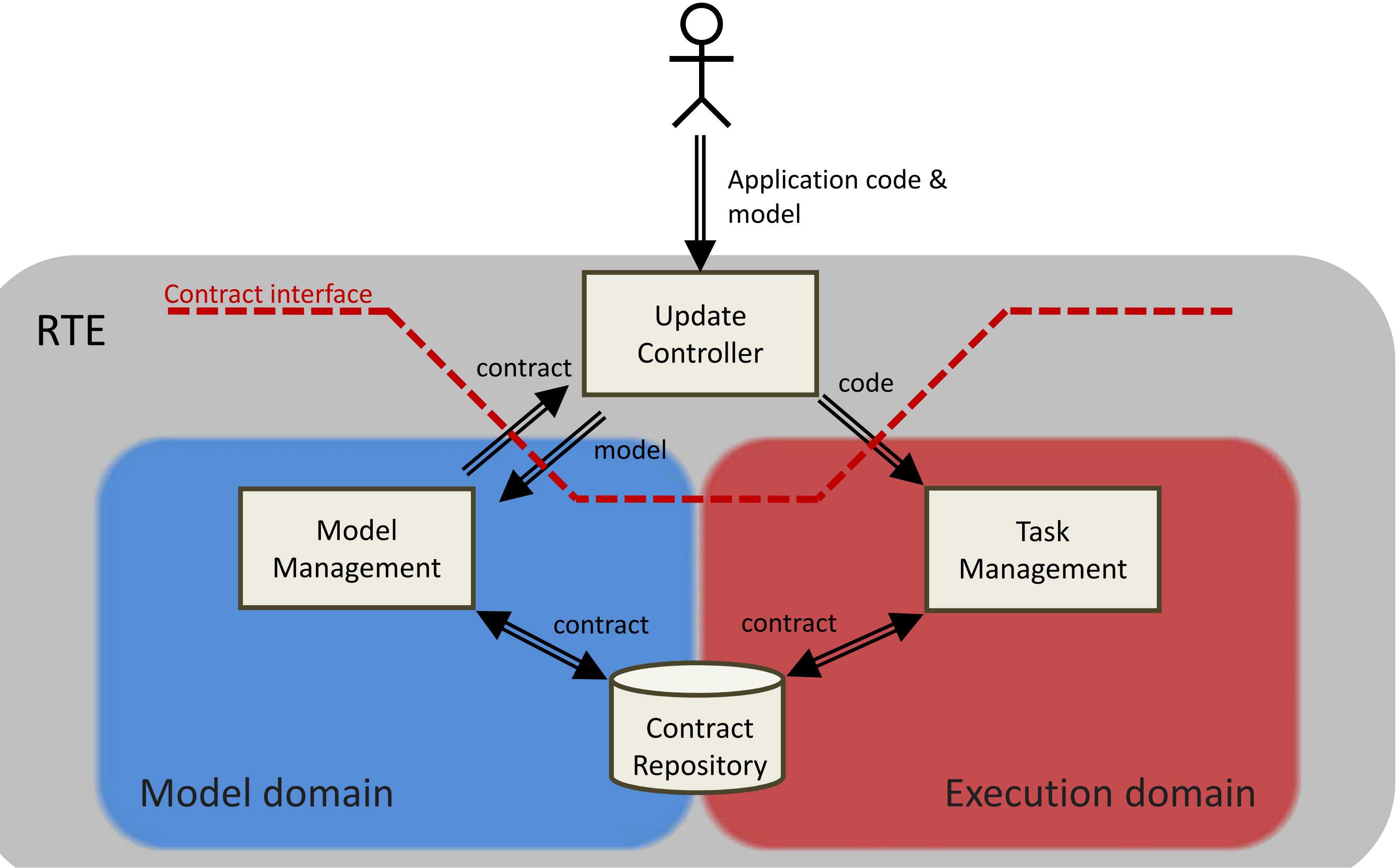
Objectives III

ADDITIONAL PLATFORM COMPONENTS

Contracting Architecture



ntracting Architecture



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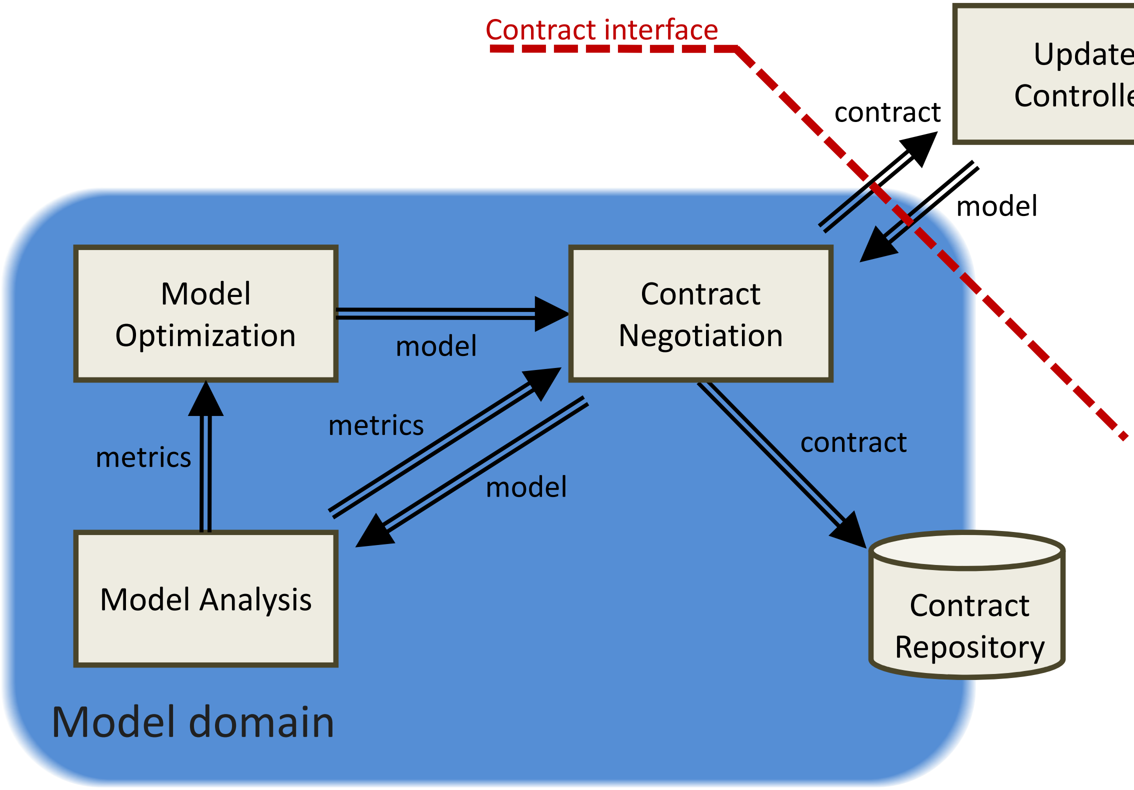

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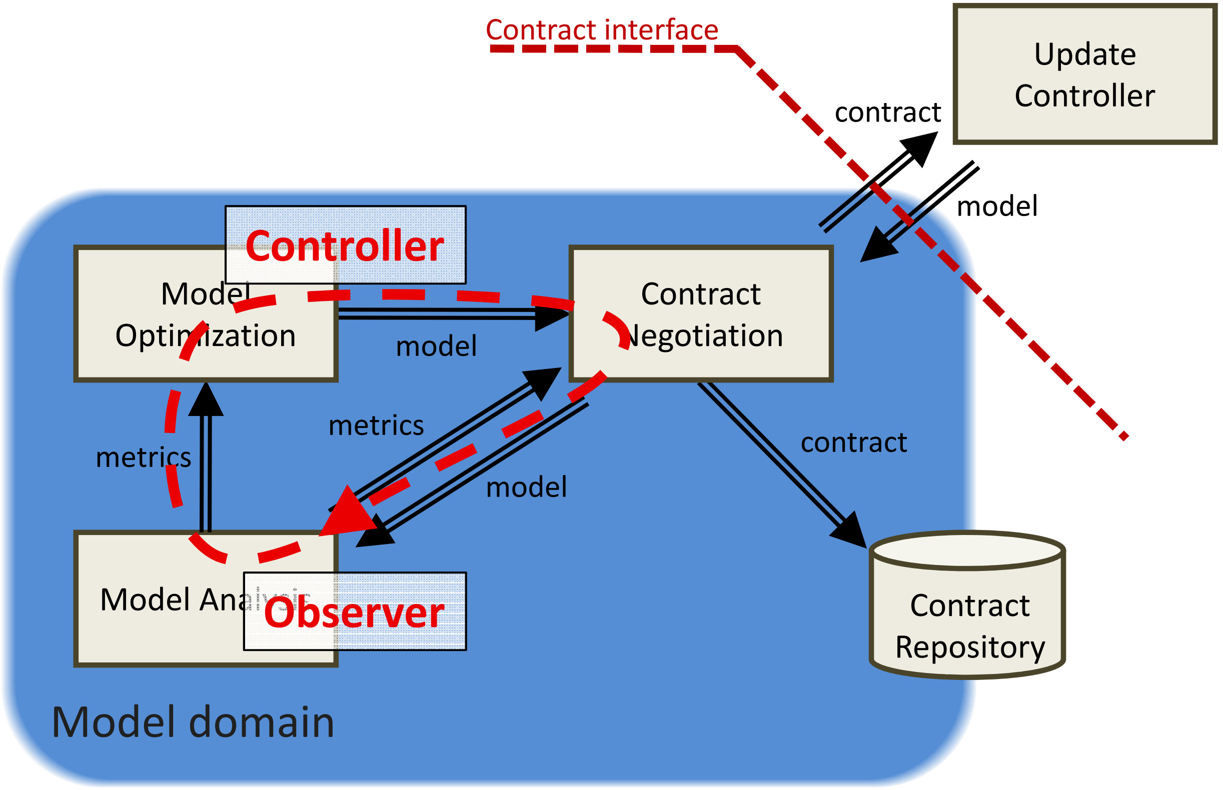
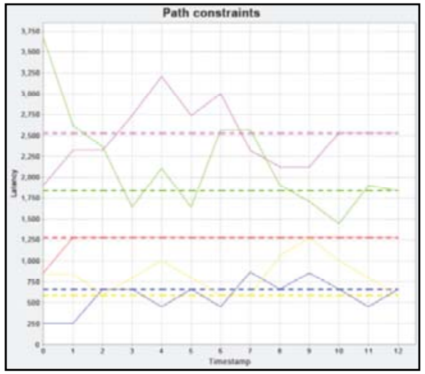


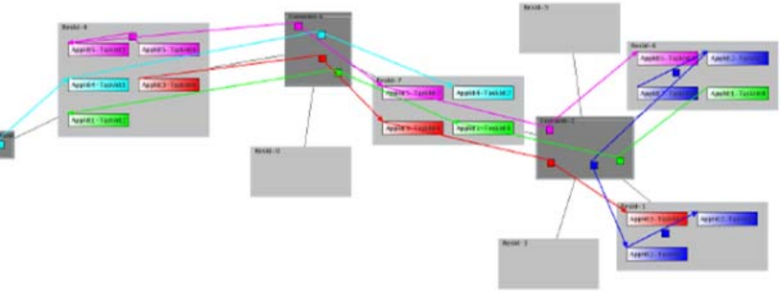
del-based Optimization

- t optimization approach
  - Constraint Solver for end-to-end latency constraints
  - Reassigns priorities on processors and communication media

- er objectives:
  - Robustness optimization
  - Power optimization
  - ..

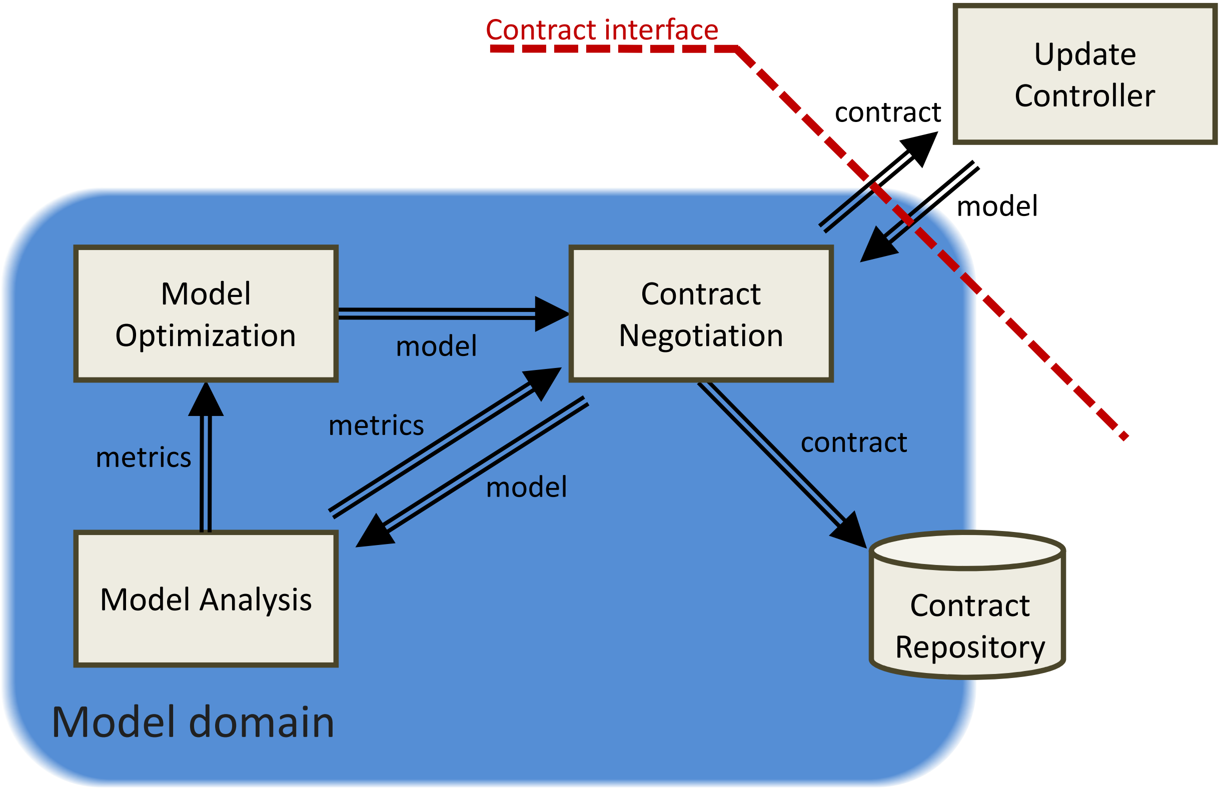
del-based Optimization





- First results on model-based distributed optimization
- Optimizes completely distributedly without global model knowledge
- created simulation framework to evaluate distributed algorithms

ntracting Architecture



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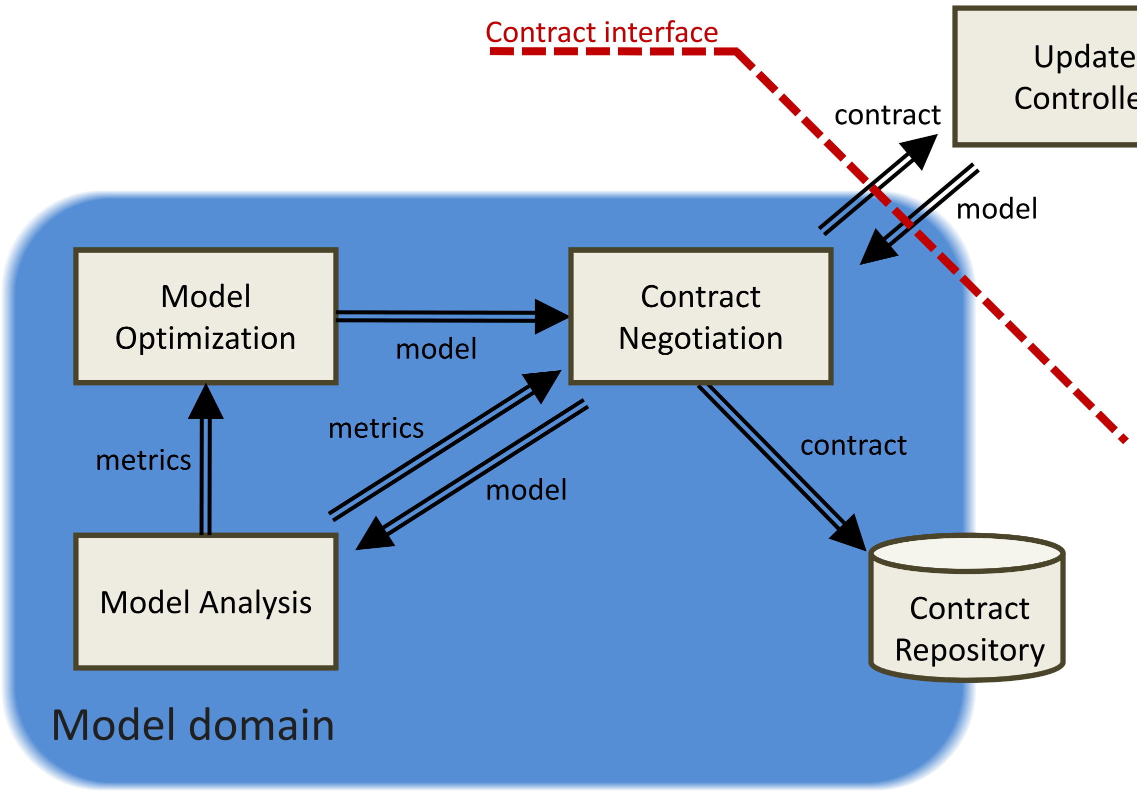

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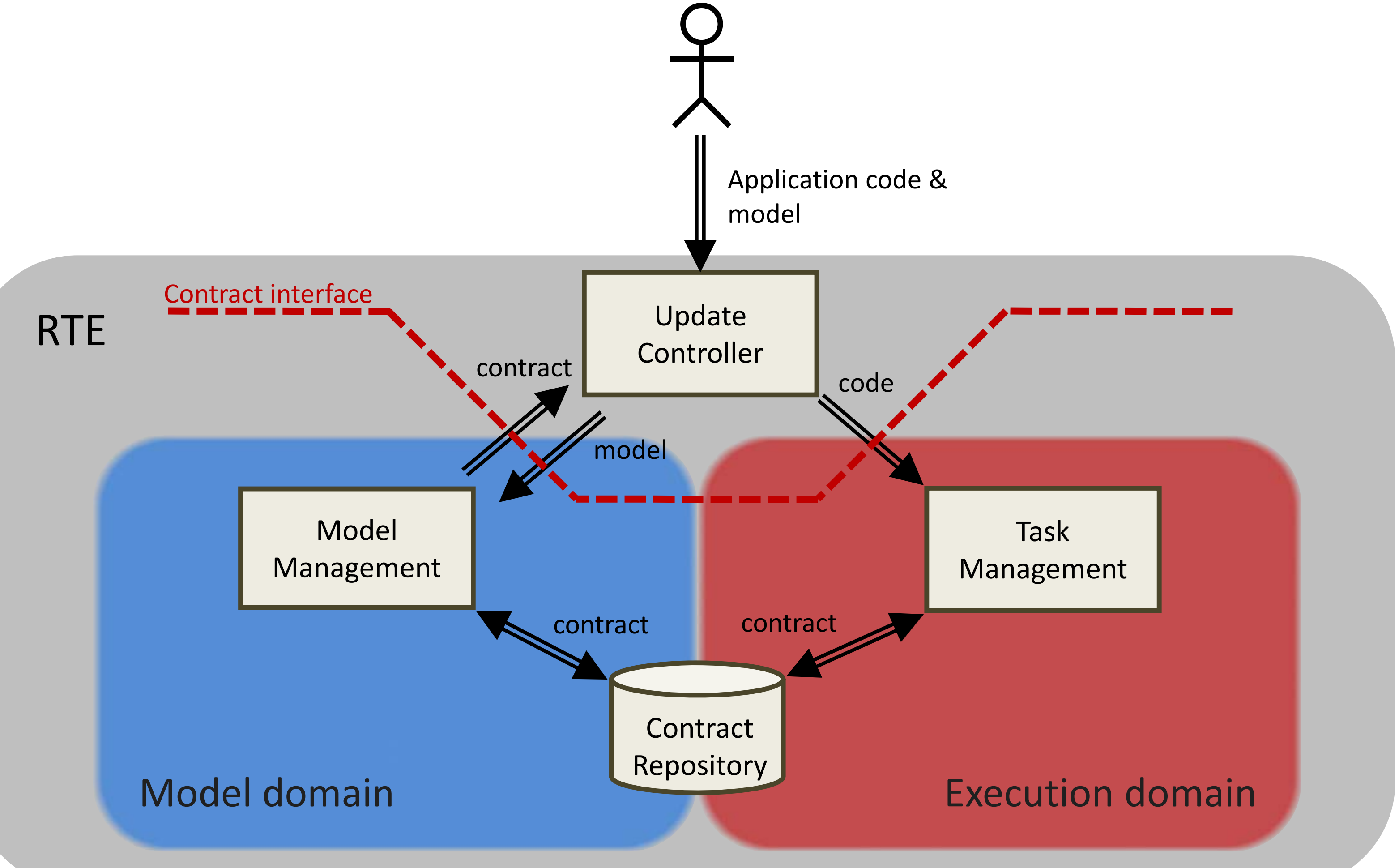

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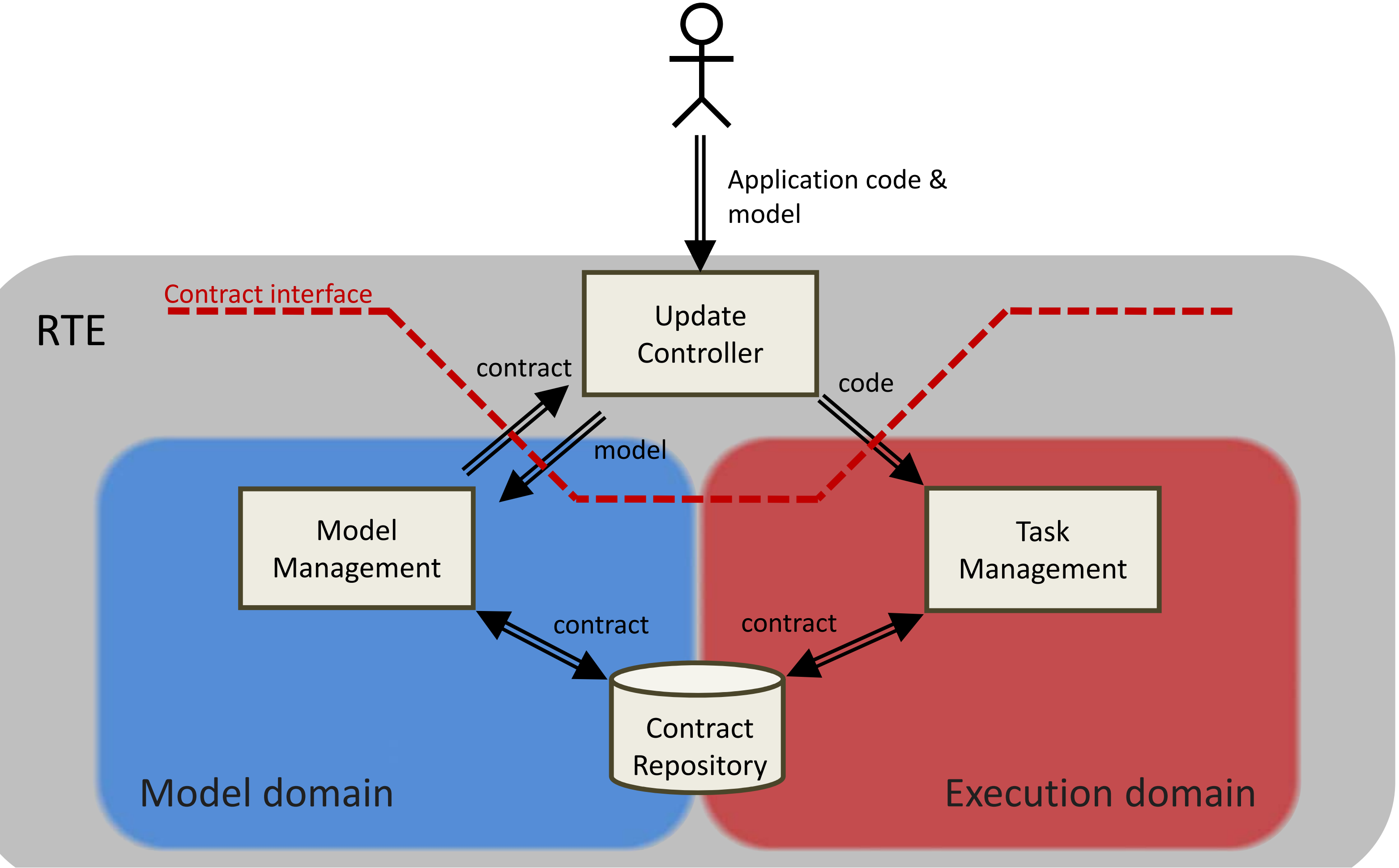

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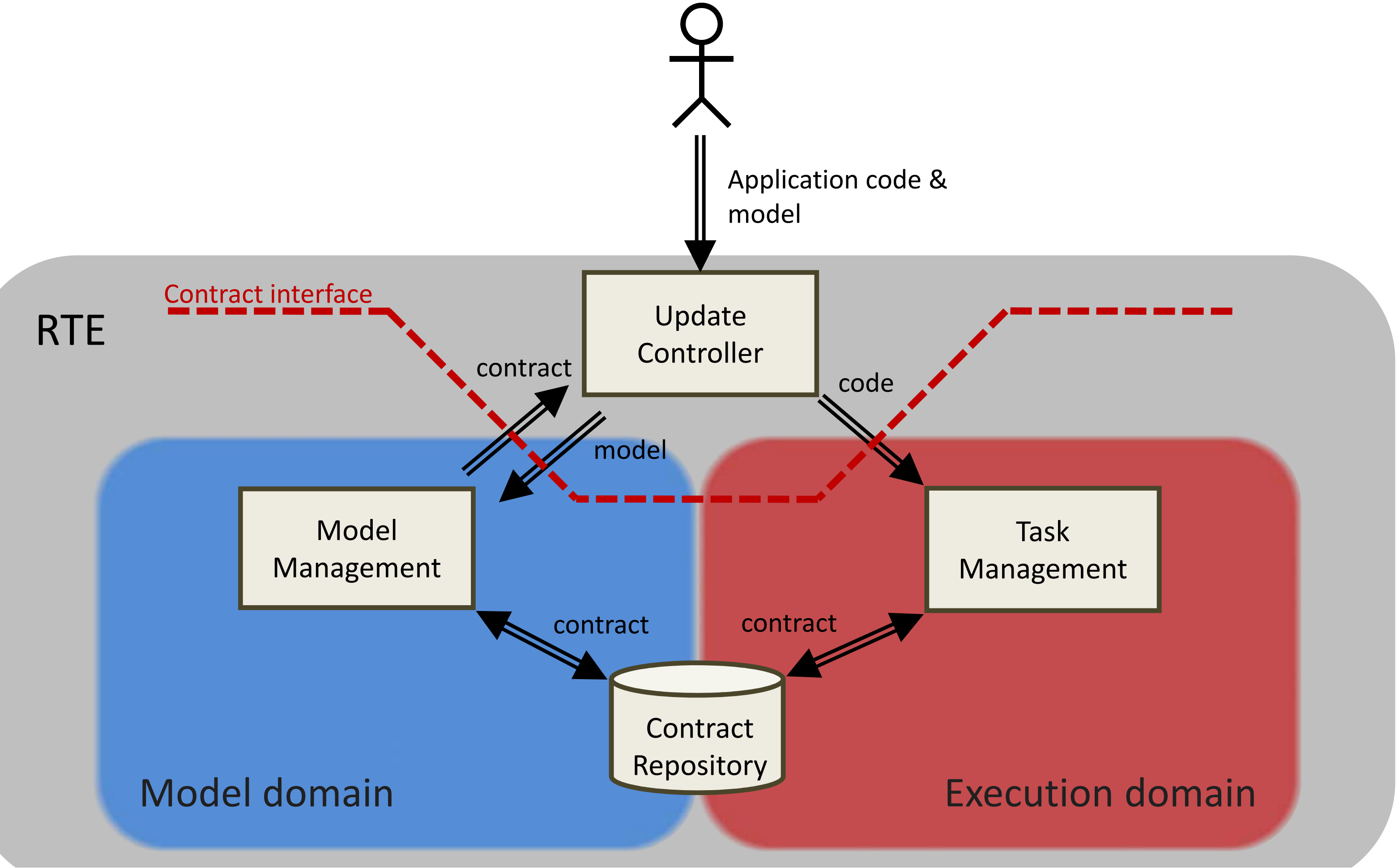

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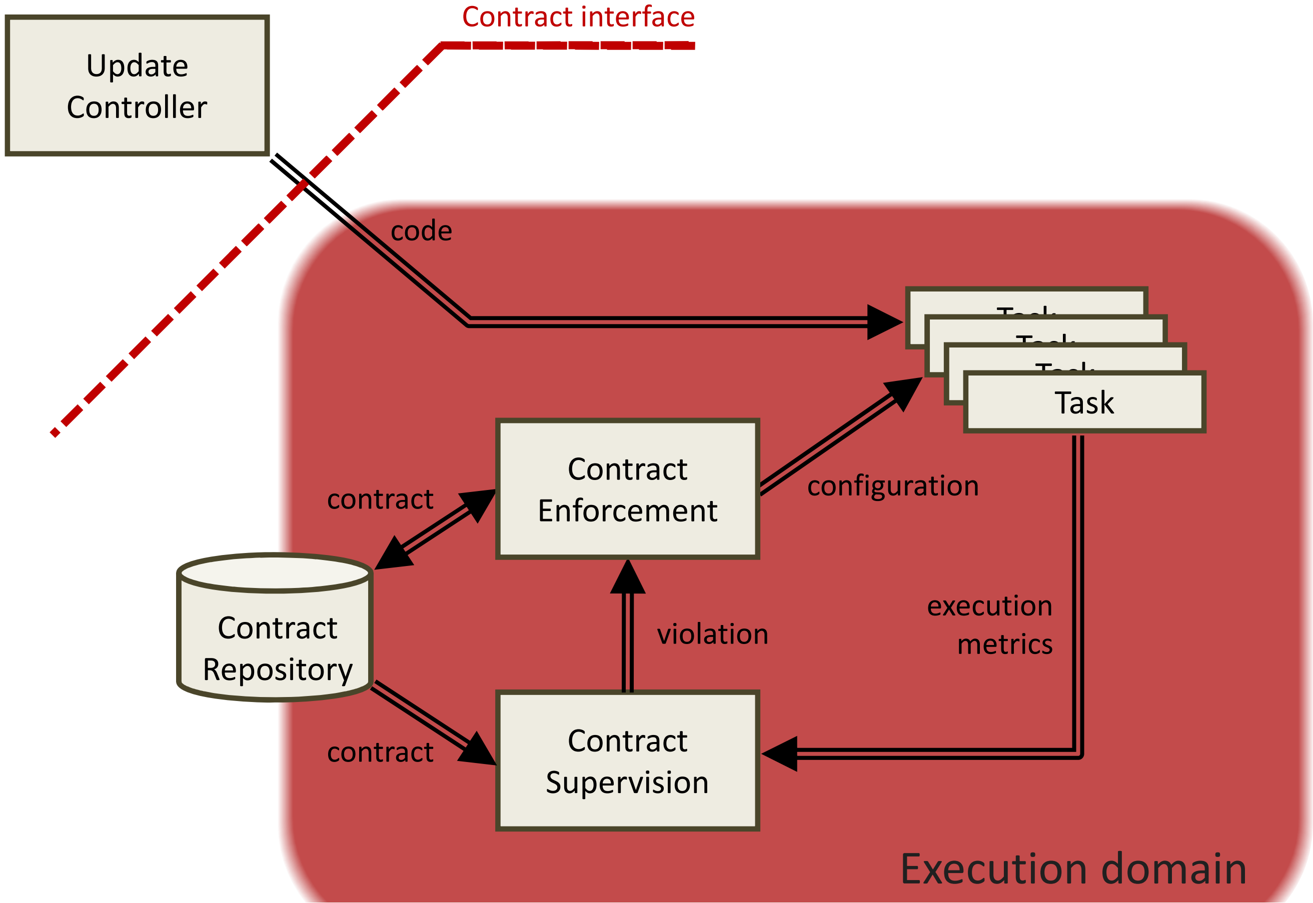

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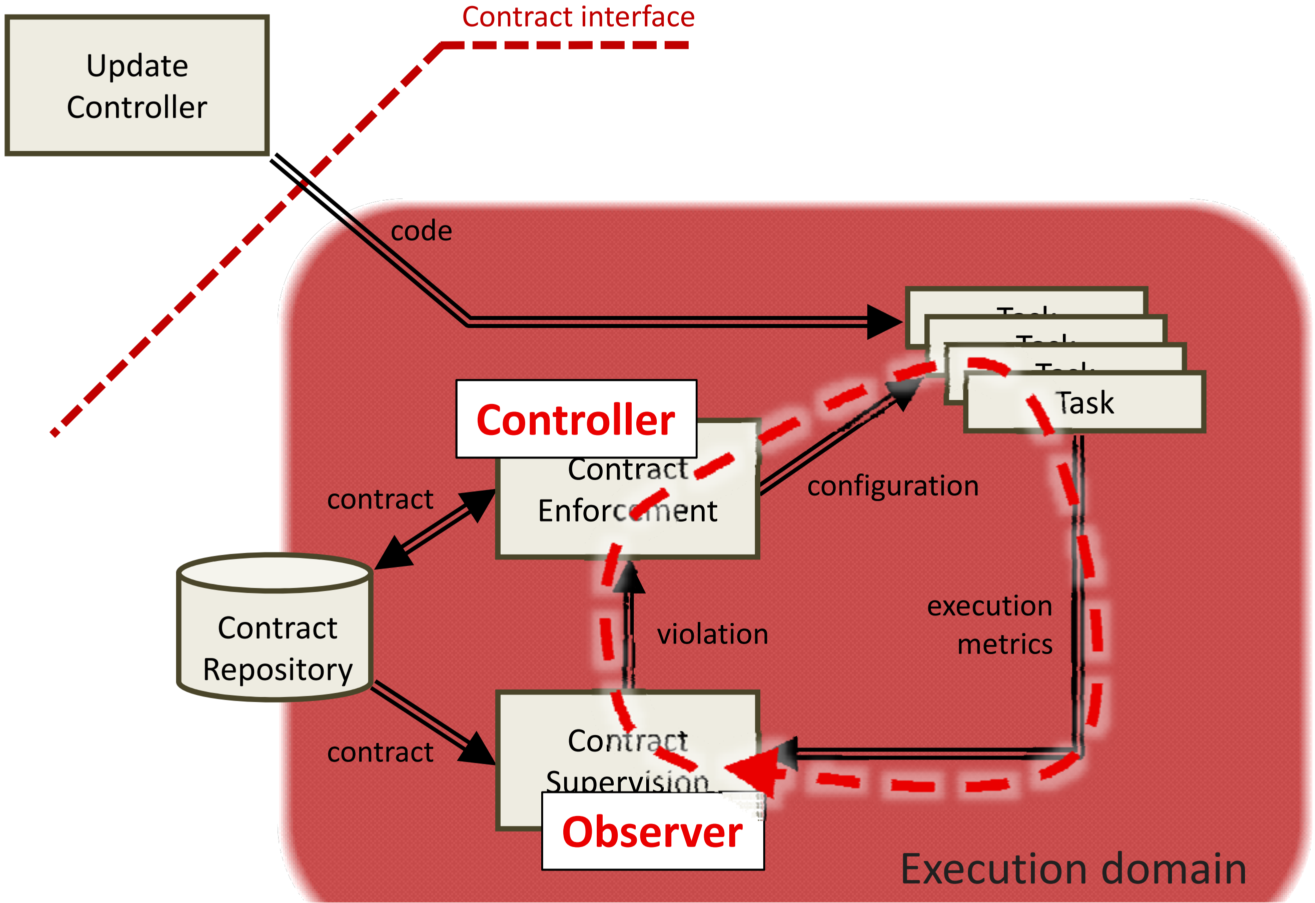

Contract Supervision and Management

- Supervision of adherence to contracts
  - execution time monitoring
  - communication monitoring
- Adaptation strategies for violated contracts
  - e.g. stopping execution, exploiting sensitivity information
  - mixed criticality systems

Analysis Theory

- Proof of Convergence
  - already proven – under submission
- Detection of Convergence
  - some approaches from distributed computing exist
  - adaptations to specific requirements needed
- Bounding Time of Analysis
  - When can we abort analysis and deem a system infeasible?
  - What kind of systems will be false negatives?

Dissemination

- Patents on detailed update protocols pending
- Steffen Stein and Rolf Ernst. "**Mostly Exact Schedulability Analysis in Bounded Time**" submitted to *Design Automation and Test in Europe (DATE)*, Dresden, 2010
- Moritz Neukirchner, Steffen Stein, Harald Schrom and Rolf Ernst "**A Software Update Service with Self-Protection Capabilities**" submmitted to Design Automation and Test in Europe (DATE), Dresden, 2010
- Steffen Stein, Moritz Neukirchner, Harald Schrom, Rolf Ernst. "**Safe Evolution in Real-Time Systems**", University Booth at Design Automation and Test in Europe, Nice, 2009
- Steffen Stein and Jonas Diemer and Matthias Ivers and Simon Schliecker and Rolf Ernst. "**On the Convergence of the SymTA/S analysis**." Braunschweig, Germany, November 2008
- Rolf Ernst, Steffen Stein. "**Real-time Components in Organic Computing". **ARTIST Workshop on Foundations of Component Based Design 2008, Atlanta, Oct. 2008.
- S. Stein and R. Ernst. "**Distributed Performance Control in Organic Embedded Systems**." In Autonomic and Trusted Computing (LNCS), Volume 5060/2008, pp 331-342, June 2008.

operations

- Prof. Teich (Erlangen)
  - – Task migration
- Prof. Thiele (Zürich)
  - – Theoretical foundations of analysis

ort Summary

NE:

- Analysis Theory
- Contracting Architecture – with most components
- Distributed model-based analysis
- Demonstrator with self-protection capability

DO:

- Optimization
- Contract Supervision & Management
- Analysis Theory

THANK YOU FOR YOUR ATTENTION.