Christian Doppler Laboratory

Software Engineering Integration For Flexible Automation Systems

Model Driven Adaptation Engineering

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Context & Motivation: Industrie 4.0

Business

Automation System Engineering (ASE)

Automation System

Adaptation Requirements

Adaptation Plan

Adaptation Model

Adaptation Capabilities

Adaptation Performance

Industrie 4.0: Digital Transformation
Cyber-Physical Production System (CPPS)


Pick and Place Unit (PPU)
https://www.ais.mw.tum.de/en/research/equipment/ppu
Ingredients for Model Driven Adaptation Engineering

Contribution Overview

System Design

- Goal Model
- System Model

(C1) CPPS Modeling

Adaptation

- Exploration Model
- Adaptation Model

(C3) Multi-Objective Adaptation Space Exploration

Adaptation

- Exploration Model
- Adaptation Model

QVT

Exchange Model

- AML Model

(C2) Performance Modeling and Analysis

Analysis Model

- PM IF

Early Validation

- Early Validation

<<fulfills>>

<<validates>>
Selected Contribution 1: CPPS Modeling

Selected Contribution 2: Performance Modeling and Analysis

Selected Contribution 3: Multi-Objective Adaptation Space Exploration

- Adaptations are complex transformation problems
  - Combinatorial Explosion
  - Contradicting Goals

- Adaptation space exploration as multi-objective meta-heuristic search process

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**Adaptation Model**

**Adaptation Rules**

**Initial System**

**Objectives**

1. \( \max \) throughPut(system)
2. \( \max \) utilizationBalance(system)
3. \( \min \) powerConsumption(system)
4. \( \min \) transformationLength

**Meta-Heuristic Search**

- Hill-Climbing, Simulated Annealing, ...
- NSGA-II, NSGA-III, eMOEA, ...

**Adapted System**

**Objective Values**

**Adaptation Sequences**

AddBuffer('Stack_4', 'Stack_3', 2)
Connect('Stack_4', 'Stack_5', 2)
Disconnect('Stack_5', 'Stack_1', 2)

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Collaboration with Enterprise Architect as Modeling & Integration I 4.0 Platform

- (1a) Model Import
- (1b) Model Export
- (2) Integrated Model Representation
- (3) Integrated Model Analysis
- (4) Integrated Model Management

Prototypes available at: http://www.sysml4industry.org
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