SEMINAR: MODEL-BASED SOFTWARE ENGINEERING FOR INTELLIGENT TECHNICAL SYSTEMS

Introduction – October 16, 2014

Dr. Claudia Priesterjahn – Group Manager Software Quality
OUTLINE

1. Basic Requirements
2. Preliminary Dates
3. Seminar Guidelines
4. Presentation of the Department
5. Presentation of the Topics
Basic Requirements

- Completion of a seminar thesis in English
  - 20 pages written in LaTeX
  - We provided a template
- Design and run a presentation

- Presentation is 30 min, to be held in a block seminar
  - 20 min for the contents
  - 10 min for discussion

- Reviews
  - Internal peer-review by students
  - also by supervisor
Preliminary Dates

- Th, 16.10., 10:00 a.m.: Topic presentation
- We, 22.10., 10:00 a.m.: Final topic assignment, introduction to scientific working

The following dates have their deadline 23:59 MEZ:
- Su, 23.11.: Outline and literature references (student)
- Su, 14.12.: Seminar thesis for review (student)
- Tu, 16.12.: Assignment of peer reviews (supervisors)
- Su, 21.12.: Completed peer-review (student)
- Su, 18.01.: Presentation for supervisor feedback (student)
- Su, 25.01.: Supervisor feedback: presentation (supervisors)
- Su, 15.02.: Camera-ready version of thesis (student)
- Su, 01.03.: Supervisor feedback: thesis (supervisors)
- Su, 15.03.: Final hand-in of thesis (student)

Presentations (block seminar): 02.02.-06.02.2015
Seminar Guidelines

- Wednesday, 22.10., 10:00 a.m. in ZM1.02-48
  - final topic assignment
  - presentation of seminar guidelines and rules
  - Participation is mandatory

- Topic Selection
  - Doodle poll (options yes, maybe, no)
  - We will try to minimize conflicts
  - Final conflict resolution is First-Come, First-Served
  - Poll will be opened today at 1 p.m. and will be closed Tuesday, October 21st at 4 p.m.
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Located in Paderborn, Germany
- Started in March 2011
- 52 Research Associates

Our Challenge:
- Product complexity
- Effectiveness of development methods

Our Competencies:
- **Product Engineering**: Discipline-spanning design of products and production systems (Systems Engineering), virtual prototyping & simulation, MID
- **Control Engineering**: Modeling & simulation of mechatronic systems, controller design, HiL test beds and prototypes
- **Software Engineering**: Processes, methods, and tools for development and quality assurance of embedded software
The Path to Modern Technical Systems of Tomorrow

- **Mechanics**
- **Mechatronics**
- **Intelligent Systems**
  - Swarm Intelligence
  - Industrie 4.0
  - Self-Optimization
  - Cyber-Physical Systems
The Path to Modern Technical Systems of Tomorrow

Product Complexity

Capabilities of Current Design Methods

Mechanics

Mechatronics

Intelligent Systems

Swarm Intelligence

Industrie 4.0

Self-Optimization

Cyber-Physical Systems

Zeit

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Folie 9
Leading Edge Cluster Competition

- High tech strategy of the German federal government
- Competition between areas for research and technology competence
Intelligent Technical Systems

... interact with the environment and adapt autonomously (adaptive)

... cope with unexpected situations in a highly dynamic environment (robust)

... use knowledge from experience to predict future system states and effects from external impacts (predictive),

... take into account specific user behavior (user-friendly).
Basic Structure of a Mechatronic System

- **Actuators**
- **Sensors**
- **Basic System**
- **Human-Machine-Interface**
- **Environment**

Key:
- Information flow: Light blue arrows
- Energy flow: Orange arrows
- Material flow: Black solid arrows
- Internal unit: Light blue
- External unit: Orange

VDI-Richtlinie 2206

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Folie 12
From Machenics to Networks of Intelligent Systems (Cyber-Physical Systems)

Communication system

Network

Information Processing
- Cognitive Control
- Associative Control
- Non Cognitive Control

human-machine-interface

communication system

human

environment

actuators

sensors

basic system

power supply

key
- information flow
- energy flow
- material flow

internal unit

external unit

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Folie 13
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Data Exchange in Industrial Automation
Supervisor: Anas Anis

- **Problem:**
  - Exchange standards: PLCopen, AutomationML, MTConnect
  - How do they match/differ? Interrelations?

- **Benefits:**
  - Knowledge of data exchange standards
  - Intelligent Networking: consistent data => intelligent reaction

- **Your Task:**
  - Identify the characteristics of each standard.

- **Literature:**
Distributed Control Synthesis
Supervisor: Christian Brenner

- Automatic Synthesis of Distributed Controllers
  - Input: Distributed system, modeled by petri nets
  - Output: Controller automata which ensure that global constraints are fulfilled (e.g. priorities of transitions)

- Goals:
  - Give overview of the approach
  - Identify assumptions and limitations

- Literature:
Modern software systems: complex artifacts, deployed in dynamic context

Requirements change continuously

Requirements traceability is necessary to establish and maintain consistency between software artifacts

Approach: automatic generation and validation of traces between requirements and architecture

Task: Presentation of approach

Selection of Diagnostic Techniques and Instrumentation in a Predictive Maintenance Program (PMP)

Supervisor: Faruk Pasic

- Wrong decision making: economic losses
- PMP advantages in: quality, safety, availability and cost reduction
- FA and AHP used to construct the model
- Approach: model that supports decision making in relation to the selection of diagnostic techniques and instrumentation in PMP

- Task: Presentation of proposed model
Correct Refinement of Real-time Specifications

Supervisor: Jörg Holtmann

- Base of each development project: Requirements specifications
- ITS consist of software, electronics, mechanics
- Development phases
  - **Systems Engineering**: Interdisciplinary design of overall system
  - **Software Engineering**: Design of software part
- **Multiple requirements analysis phases** for systems and software engineering
- **Correct refinement** of requirements specifications also covering real-time aspects?
- **Goal**: Describe concepts of model checker UPPAAL ECDAR w.r.t. refinement checking
Compositional Verification of Real-Time Systems Using ECDAR and MechatronicUML

**Supervisor: Stefan Dziwok**

- Real-Time Systems are safety-critical → exhaustive verification requires, e.g., model checking
- **Problem:** size of the model leads to state-space explosion
- **Solution Approaches:** ECDAR and MechatronicUML enable a compositional verification
  - Both use the Uppaal Model Checker
- **Your tasks:**
  - Assess ECDAR’s capabilities
  - Model and analyze a new example in the context of overtaking cars
  - Compare it briefly with MechatronicUML
- **Literature:**
Modern software: highly dynamic environment, often unpredictable

May degrade quality of service

Consequently, systems adapt their behavior

Adaptation influences other quality attributes as availability, performance or cost

Approach: find tradeoff between adaptability and quality of service

Task: Presentation of approach + related work

Survey: Real-Time Distribution Middleware
Supervisor: Uwe Pohlmann

- Buffer / QoS requirements are often not considered when transferring messages

**Problem:**
- Which are (important) Buffer/ QoS requirements?
- How to ensure them?

**Your Task:**
- Conduct Literature Review and Compare the Features with MechatronicUML Buffer and QoS Assumptions

**Literatur:**


Survey: Safe Allocation Optimization Methods
Supervisor: Uwe Pohlmann

- Allocation of mechatronic software components are constrained
- Safety requirements must be fulfilled by an allocation

Problem:
- Which constraints / requirements must be fulfilled?
- Which are (good) optimization objectives?
- How to optimize objectives and fulfill all constraints?

Your Task:
- Conduct Literature Review for safe allocation optimization methods

Literatur:
Model-driven Engineering in Automation
Supervisor: Jens Frieben

- Due to the rising complexity of software, model-driven techniques become more and more attractive, even for the conservative automation domain

- Goal of the seminar: read and give an comprehensive overview of the SysML-based modelling technique

- Vogel-Heuser, Birgit; Schütz, Daniel; Frank, Timo; Legat, Christoph: Model-driven engineering of Manufacturing Automation Software Projects – A SysML-based approach. Mechatronics, 2014

- Vogel-Heuser, Birgit; Folmer, Jens; Legat, Christoph: SysML Model of the Pick and Place Unit for Papyrus UML: Scenario Sc11. , Hrsg.: Institute of Automation and Information Systems: Institute of Automation and Information Systems, Technische Universität München, 2014,

- Feldmann, Stefan; Kernschmidt, Konstantin; Vogel-Heuser, Birgit: Combining a SysML-based modeling approach and semantic technologies for analyzing change influences in manufacturing plant models. CIRP CMS, 2014
Vielen Dank für Ihre Aufmerksamkeit

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