Scheduling Analysis Modeling with MARTE

Rémi Schnekenburger

CEA LIST, LISE Labs
27 mai 2009
Journées Neptune 2009, Paris, France
Embedded Systems Design

- **Embedded systems trends:**
  - Distributed/Multiprocessor
  - Resource-constrained
  - Safety-critical &…Time-critical!

- **Timing problems:**
  - Response times miss deadlines
  - Messages are lost (buffer overload)
  - Processors and buses overloaded

- **Analysis techniques/tools help to calculate:**
  - Response times of functions and tasks on processors.
  - Latency of signals and messages on networks.
  - End-to-end delays (e.g., from sensor to actuator over a network)

- …in presence of complex interactions!
Scheduling Analysis Advantages

- Calculate timing parameters based on a multi-task model:
  - Allows early evaluation, before simulation is even possible.

- High analysis speed...
  - It becomes feasible to explore many scheduling alternatives in search of an optimal solution

- Analysis provides “worst case” coverage
Domain-Specific Modeling Languages (DSML)

- Use of domain concepts as language constructs
  - E.g. concepts of “memory”, “task”, “bus”, instead of general ones “components”, “nodes”, “classes”…

- Ability to specify timing information in models
  - Automate the generation of analysis models (time savings!)
  - Not deep knowledge of mathematical aspects.
MARTE Scope

- UML is not sufficient for the real-time systems domain!
  ➔ The "Profile" mechanism allows for creating UML-based DSMLs…

- MARTE: A UML Profile for
  ➔ Design:
    ➔ Modeling HW and SW platforms
    ➔ High level abstraction “application” constructs (specific models of computation)
    ➔ Component-based design
    ➔ A rich model for logical time, real-time and time mechanisms
  ➔ Analysis:
    ➔ Support for Performance Analysis (Queuing theory, Petri nets, …)
    ➔ Support for Scheduling Analysis (Rate Monotonic Analysis: RMA, Offset-based techniques, Compositional techniques,..)

MARTE is to the real-time and embedded systems domain as UML to the system and software domain: the standard modeling language!
Schedulability Analysis Modeling in MARTE
Context of the SAM Sub-profile
MARTE’s Generic Modeling Approach

Application Model with Non-Functional Constraints

- Structure and Behavior
- Timing Requirements
- Time- and resource properties and constraints

Platform Models (Libraries)

- MARTE data types: NFP Types, units,…
- RTOS Libraries
- HW Component Models

Allocation

Validation of Non-Functional Properties

Integrated and Validated System Model

Generated Code

Input Files for Analysis

Analysis Tools
Application Layer

Application Model with Non-Functional Constraints

Allocation

Application Layer

Platform Layer

Application_RobotArm

: GUIRefresher

: CommandInterpreter

: Reporter

: CommandManager

: ServosController

: Reporter

: ServosController

: GUIRefresher

Papyrus UML

best and worst-case execution times
Platform: Software Resources

Robot_SwPlatform

<schedParams=[fp(priority=18)]
<schedParams=[fp(priority=16)]
<schedParams=[fp(priority=12)]
<schedParams=[fp(priority=22)]
<schedParams=[fp(priority=24)]

task1

channel1

<schedParams=[fp(priority=20)]
<schedParams=[fp(priority=24)]

channel2
Allocation Model: Analysis Context

Allocation mappings

Application Layer

Platform Layer
Deployed Model: Analysis Context

Robot Arm Model

{$\text{RespT} = 7 \text{ ms}$}

Schedulability Analyzer

Alternative B, and so on...

Result: a new model with analysis variable values set
The **MARTE SAM (Schedulability Analysis Modeling)** package factorizes expressiveness of a set of well-established techniques and tools…
questions