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Generative tools for automated software development and modernization

Delta Software Technology provides Europe's leading companies with state-of-the-art software generator technology for more than 30 years

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GPCE4QoS Workshop Portland, Oregon, 2006

Process Family Engineering in Automotive Control Systems – A Case Study

Cord Giese

Delta Software Technology GmbH

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Process Family Engineering

- PESOA
- The Windshield Wiper Case Study
- QoS in Automotive Product Lines

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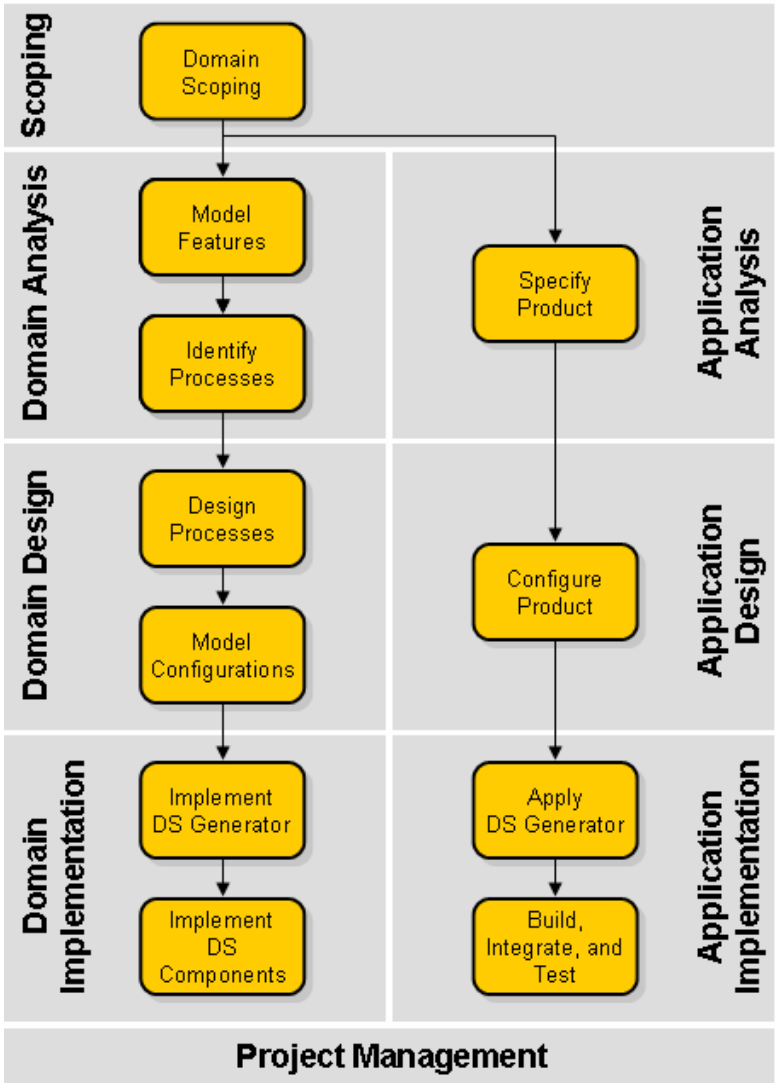
Research Project: PESOA



- **P**rocess Family **E**ngineering in **S**ervice-**O**riented **A**pplications
  - Product line architecture for variant-rich processes
  - Tool chains for **e-business** and **automotive** domains
  - www.PESOA.org
- Delta Software Technology:
  - Generator concepts
  - HyperSenses™

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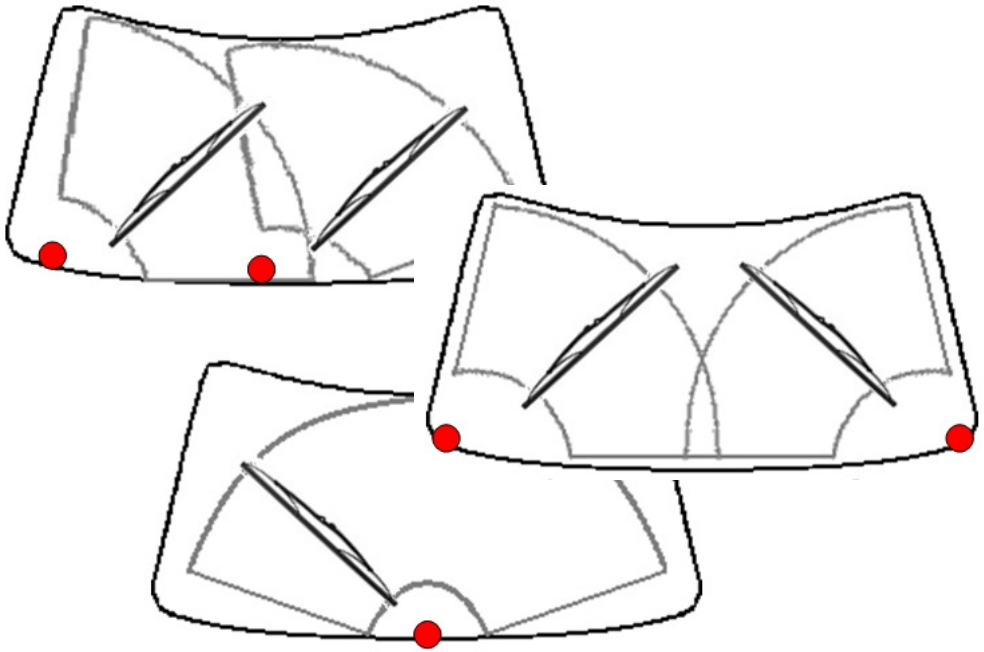
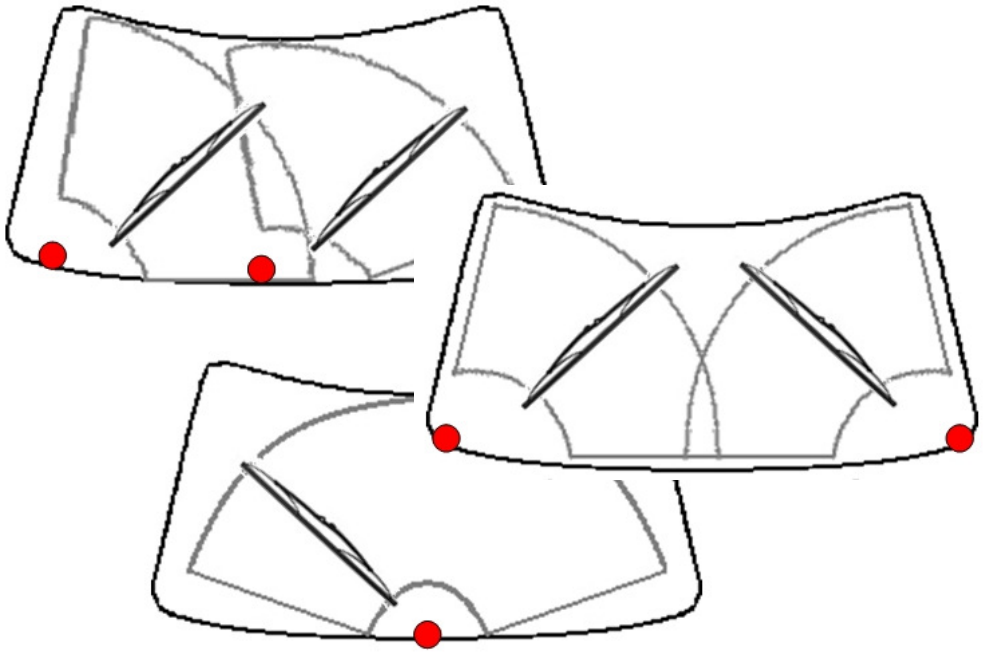
Windshield Wiper: The Task



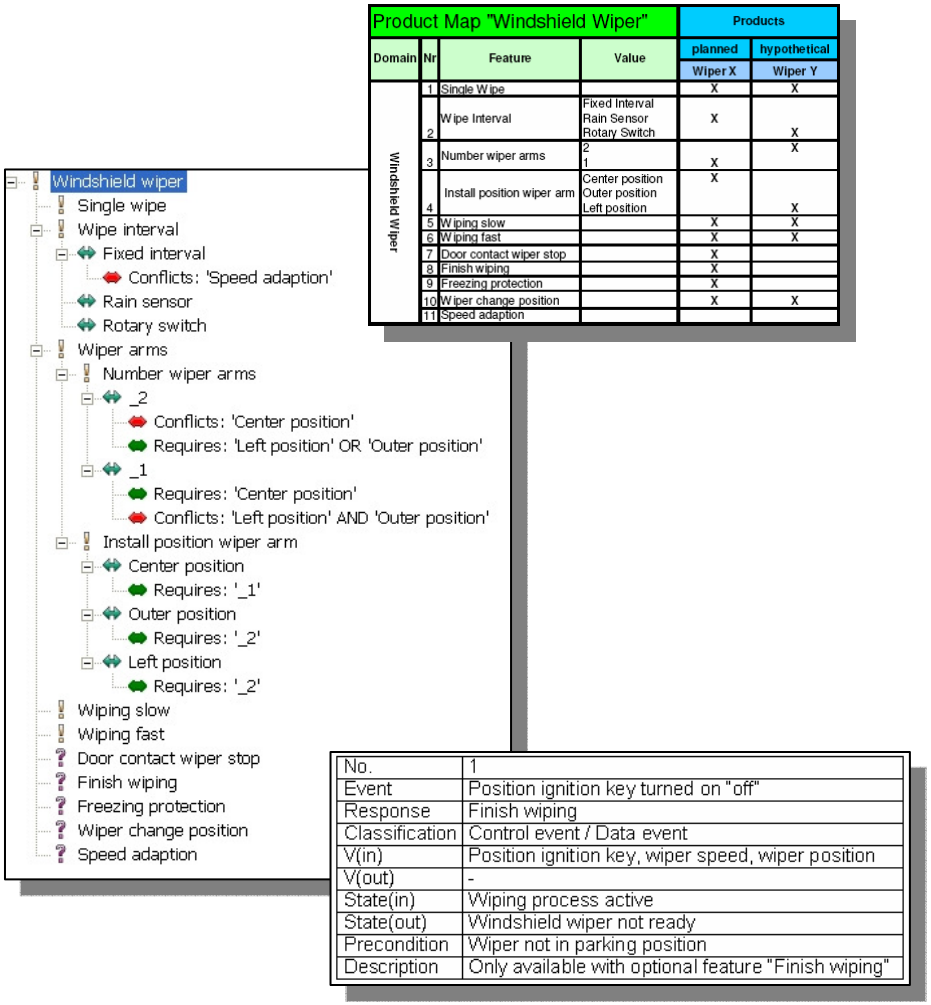
- Example taken from the PESOA project: windshield wiper control system
  - Microcontroller
    - 8-bit RISC processor
  - PURE operating system
  - C++ source code
  - **Generation of several variants**

Windshield Wiper Options



- 1 or 2 wiper arms
- Install positions
  - Left, center or outer
- Intervals fixed or adaptable
- Rain sensor
- Freezing protection
- Automatical wiper stop if front doors are opened

Scoping + Domain Analysis

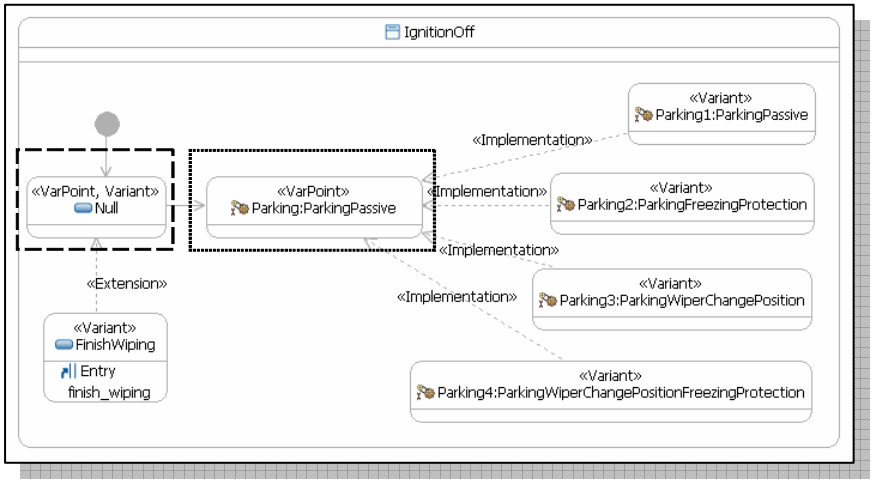


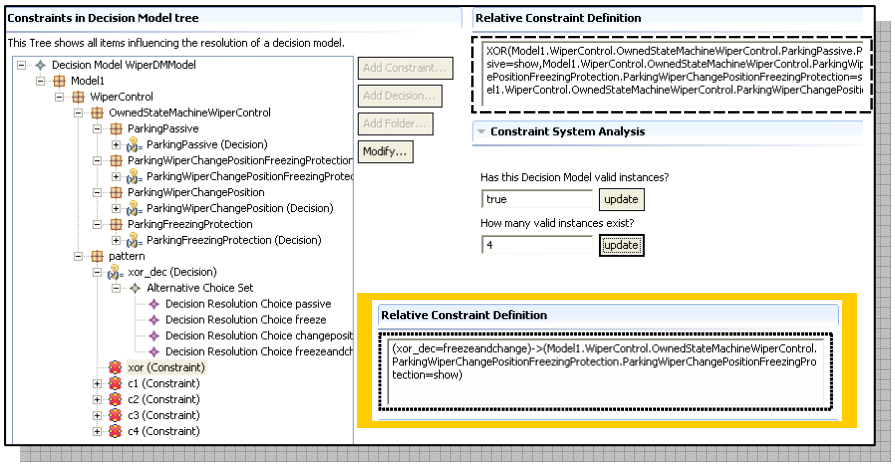
Product Map "Windshield Wiper"				Products	
Domain	Nr	Feature	Value	planned	hypothetical
				Wiper X	Wiper Y
Windshield Wiper	1	Single Wipe		X	X
	2	Wipe Interval	Fixed Interval Rain Sensor Rotary Switch	X	X
	3	Number wiper arms	2 1	X	X
	4	Install position wiper arm	Center position Outer position Left position	X	X
	5	Wiping slow		X	X
	6	Wiping fast		X	X
	7	Door contact wiper stop		X	
	8	Finish wiping		X	
	9	Freezing protection		X	
	10	Wiper change position		X	X
	11	Speed adaption			

No.	1
Event	Position ignition key turned on "off"
Response	Finish wiping
Classification	Control event / Data event
V(in)	Position ignition key, wiper speed, wiper position
V(out)	-
State(in)	Wiping process active
State(out)	Windshield wiper not ready
Precondition	Wiper not in parking position
Description	Only available with optional feature "Finish wiping"

- Scoping
  - Product map
    - Variants, features
  - Event list
    - Oustside-In modeling
- Domain Analysis
  - Feature model
    - Constraints

Domain Design





- UML State Machines and Activity Diagrams
  - Variant-rich
  - Variation points and variant elements
- Decision Model
  - Constraints
  - Derived from feature model
  - Considering items of UML model

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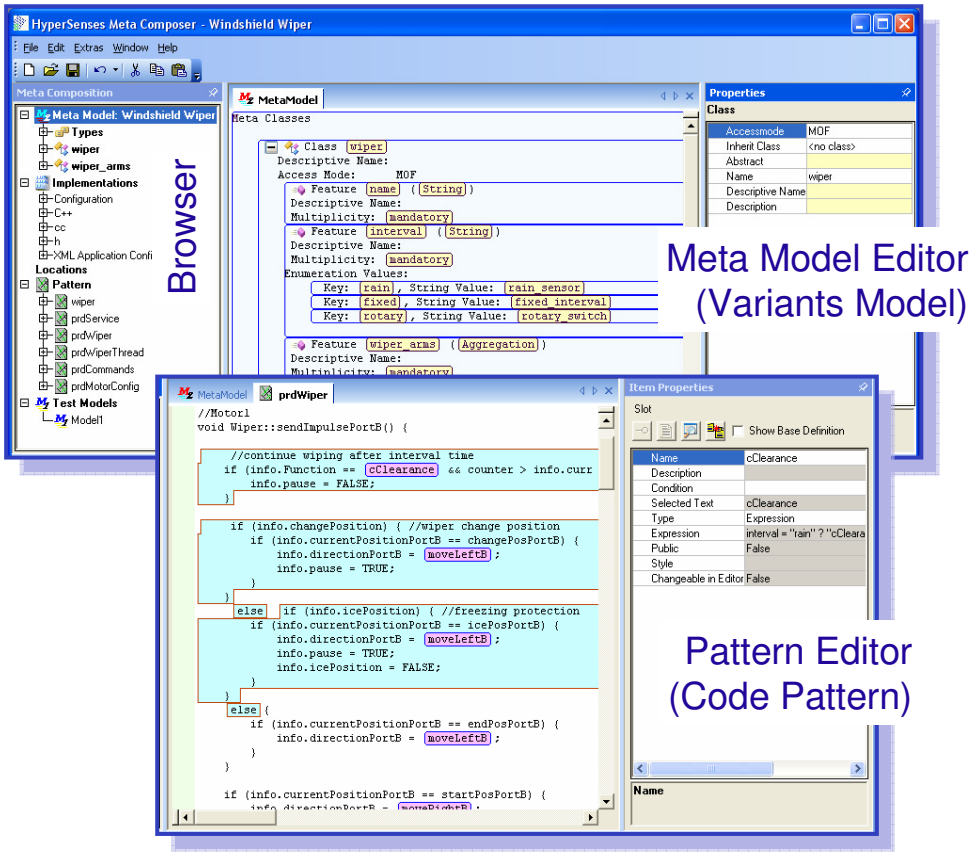
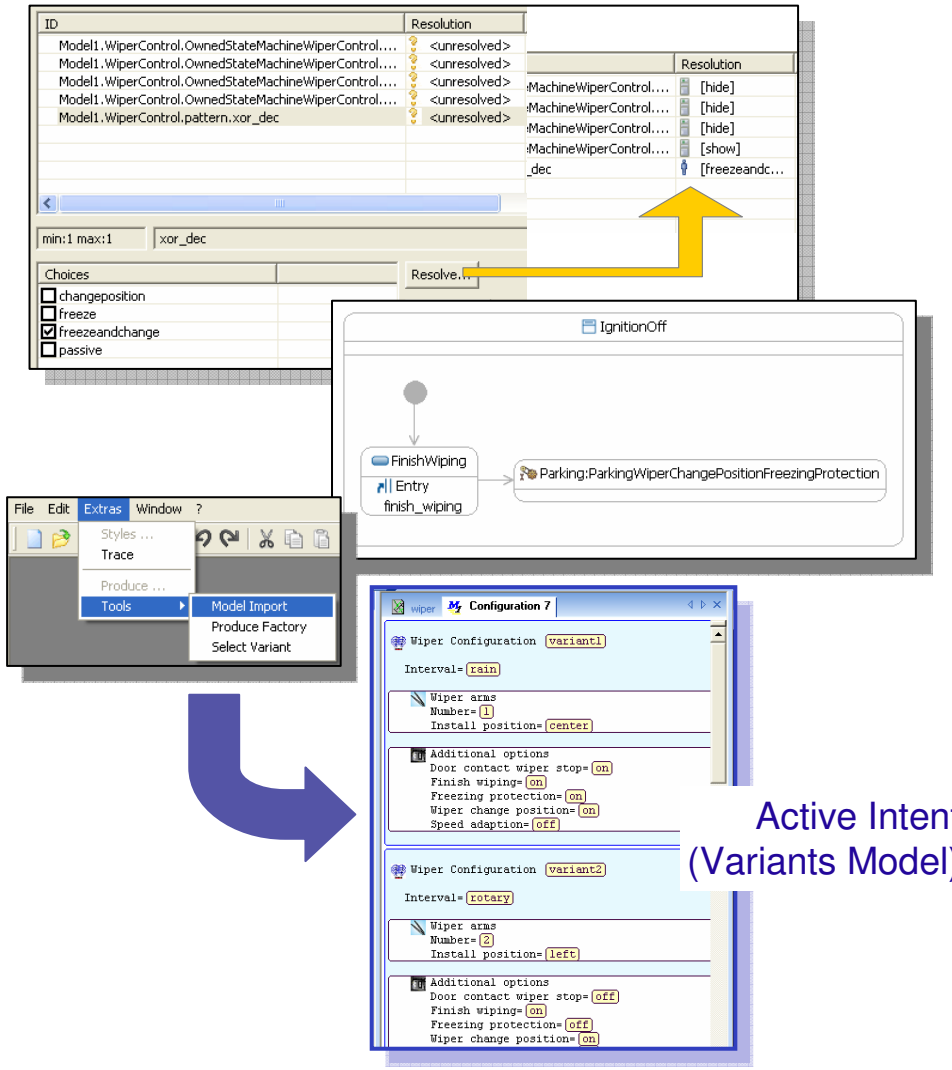
Domain Implementation



- Separation of generic and variant implementation parts
  - Domain-specific components
    - Hardware abstraction layer
  - Domain-specific generator (DSG)
- HyperSenses Meta Composer™
  - **Design** and
  - **Implementation** of a DSG

Application Engineering



Active Intent (Variants Model)

- Interactive, guided configuration → Resolution Model
- Instantiation of variant-rich UML model
- HyperSenses Active Intent™
  - In general: product configuration - here:
    - **Model Import**
    - (Data verification)
    - **Produce Factory**

Automotive Product Lines

- Typical for the "automotive" area:
  - High number of product variants → necessity of product lines
- Fulfillment of quality standards
  - SPICE – *Software Process Improvement and Capability Determination*
    - Measure of the "stage of maturation" of the process
- **Quality gains by omitting manual processes**
  - Reproducibility
  - Traceability

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QoS Requirements – Performance

- Performance requirements
  - Primarily caused by storage limitations
    - Windshield wiper controller: 4KB SRAM
  - Belongs to typical characteristics of all "embedded" areas

- Variant-specific code generation by domain-specific code generators (DSGs) generally leads to better results than an "all-in-one" solution.

  - … better than "generic" code generation as performed by e.g. Matlab/Simulink (or any UML-based code generator)

QoS Requirements – Reliability (I)

- Reliability requirements
  - Certification necessities, as typical for leading "embedded" areas, e.g. medical control systems
  - (A)SIL - *(Automotive) Safety Integrity Level*
    - According quality standard
    - Measure of reliability; hazard rating

- Re-use of assets, modeling, and automated application production generally leads to a higher software quality.

  - … because of a less amount of bugs (that are additionally easier to detect)

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QoS Requirements – Reliability (II)

- Moreover: special reliability features
  - e.g. if connection µC – sensor is interrupted an emergency program providing a fixed interval could be started
  - semantical (domain) abstraction level
    - GP: problem space

- Reliability requirements partially are to be considered already at domain analysis.

  - … and implemented like non-QoS features (i.e. they are not "across" other requirements)

QoS Requirements – Real-time (I)

- Real-time requirements
  - Automotive: timeliness more important than speediness
  - Decisive: **sample rate**
    - Cycle time for measurement of sensor signals by control function (incl. refreshing function variables)
  - Example: windshield wiper rain sensor
    - Sufficient if human eye recognizes response time as "immediate" (> 60 Hz)
    - → Sensor response time (incl. control function!) < 1/60 s
  - Example: engine control
    - Ignition time + injection time have fixed timing

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QoS Requirements – Real-time (II)

- Analysis work
  - **Concurrency analysis**
    - Parallel execution of tasks on several processors
  - **Schedulability analysis** for all tasks
    - Number of tasks executable if each task keeps its deadline
- Implementation tasks
  - Adapt control function implementations
  - Use of real-time operating system → number and priority of tasks to be configured

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QoS Requirements – Real-time (III)

- Handling within product line architecture
  - Are generated routines affected?
  - If yes, then …
  - **1. Solution space variability**
    - → Configuration in HyperSenses Active Intent
  - **2. Problem space variability**
    - → Modeling UML timing diagrams
  - Domain-specific modeling on a high abstraction level tends to case 1.
  - Modeling by experts/engineers on a technical level tends to case 2.

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The End

- **Many thanks!**
- Are there any more questions?
- You will find more information on
- www.D-S-T-G.com/OOPSLA2006