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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


**Model-Driven Development and Product Lines, Leipzig 2006**


**Generators - More than a Necessary Evil?**

Rüdiger Schilling  
Cord Giese

Delta Software Technology GmbH

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«The Generator Company»

Do Generators Really Pay Off?


Model-based Generator Development

«Pattern By Example»

A Windshield Wiper in Action

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## The Generator Company

- 30 Years of Generator-based Tools
  - Software development, maintenance and modernization
  - Hundreds of installations
  - Hundreds of thousands of generated programs
- User Experiences
  - Frequently already "product lines" by generators
  - Rather common: "abuse" of standard generators for in-house development of generators
- From 1997: New Generator Technology
  - E.g. for developing product-specific generators

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## Generators – a Necessary Evil?

- Scenario:  
A software system family (*product line, product family*) is to be developed – two situations:
  - A) „Everything is considered: Models, DSL, Design etc. – Hey, we figured out we need some generators – No problem, who’s got nothing to do right now?“
  - B) „Generators, the last thing we need to develop in-house! – For heavens sake, let’s keep our hands off this and let us use the good old CPA method\* “

\* CPA – still the most commonly used software development method:  
*copy, paste, adapt*

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## Abstraction Gap


The diagram illustrates the Abstraction Gap with a vertical axis labeled 'Abstraction Level'. It shows four levels of abstraction, each represented by a horizontal line with a double underline:

- Domain Specific Language (top)
- UML Diagrams
- High Level Language (Java)
- Low Level Language (C, Assembler) (bottom)

Green double-headed arrows indicate relationships between adjacent levels: a small arrow between UML Diagrams and High Level Language (Java), and larger arrows between UML Diagrams and Domain Specific Language, and between High Level Language (Java) and Low Level Language (C, Assembler).

- Generator is not on par with generator
- From simple syntax transformers...
  - universal
  - ... to extensive software-assembling machines
  - specialized
  - optimizing
  - domain specific (DSG)


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## Do Generators Pay Off?

- Greater Abstraction Gap =
  - More benefits
    - More efficiency (Automation), simple usage (e.g. DSL)
  - More efforts
- More Benefits through Duplication (*Economy of Scope*)
  - E.g. system families, product lines
- Higher Specialization Limits Duplication
- Challenge:
  - More efficient development and maintenance of generators


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## Do Generators Pay Off?

- Quality Improvement Through Less Manual Processes
  - Reproducibility
  - Traceability
- Fulfilling Quality Standards
  - SPICE – Software Process Improvement and Capability Determination
    - Process Maturity Level
  - (A)SIL - (Automotive) Safety Integrity Level
    - Level of Reliability; Threat Assessment
- Condition:
  - Methodical Construction of Generators

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## Generators and Automation

*Thomas J. Watson, the founder of IBM, is reported to have said in 1943:*

*"I think there is a world market for about five computers"*

- Didn't IBM's founder have a clue of computers?
- Surely he had – he was only a realist
- Computers were extremely expensive, huge and unwieldy and tough
- There was only a limited market for them
- Hardly imaginable in 1943 :
  - Cheap and small computers for everyone... e.g.
  - For existential things like web blogs or Spider Solitaire ☺

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## A Vision


- What has this got to do with generators?
- If you can decrease the costs for the development and usage of generators dramatically
  - Then generators will even pay off in smaller but highly specialized projects

*The Automation Assumption*

*"If you can compose components manually, you can also automate this process"*

*Czarnecki, Eisenecker, 2000*


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## Generators as a Domain

- Reaching the efficiency and quality goals requires ...
  - ... the acceptance that the construction of generators is an individual domain
    - And not as the fall-out of something else
- This means, we need ...
  - ... a specific methodology
  - ... adequate modeling and realization concepts
  - ... extensive tool support


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## Methodology

- Theoretical Background: *Generative Programming*
  - The goal of generative programming is to replace manual search, adaptation, and assembly of components with the automatic generation of needed components on demand*  
*[GP2002 at ICSR7]*
- Model-based Development
  - **WITH** Generators
  - **FOR** Generators

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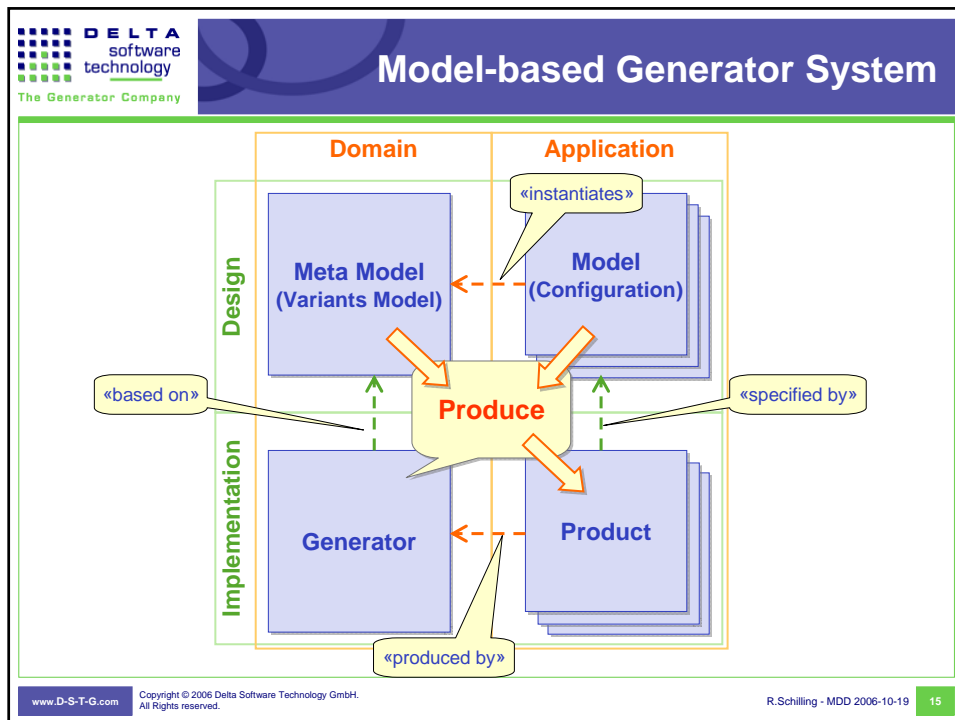
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## Model-based Generator System

- Four „Headstones“
  - Variants Model
    - Model of variability and variants
  - Generator
    - To be developed
  - Configuration
    - Selection of the variant, product specification
  - Product
    - To be generated (in variants)

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**The Meta Model (Variant Model)**

- Model of Variability and Variants
  - What is the distinction between the members of a system family?
- The Model Might be Very Simple
  - See Windshield Wiper
- A Variant Model can be Derived From:
  - Feature Model, DSM, UML ...
- ... or Modeled Independently Like
  - HyperSenses™ Meta Model

The slide includes a screenshot of a UML class diagram showing a hierarchy of classes like 'Order\_Process' and 'Wiper'. Below it is a screenshot of a 'MetaModel' window showing class details for 'Wiper' with features like 'wiper\_size' and 'wiper\_color'.



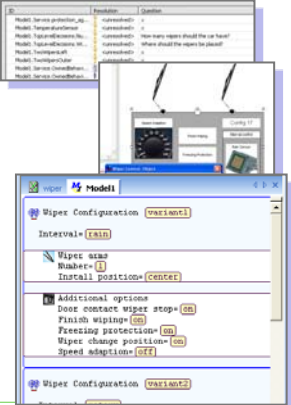


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## The Model (Configuration)

- Selection of the Variant, Product Specification
  - Selection, parameterization and composition of attributes
- DSL-Application
  - Specification on domain level instead of programming on technical level
- Different User Interfaces
  - Tabularly, textual or XML format
  - graphical or semi-graphical DSL
  - HyperSenses™ (configuration) model




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## The Model (Configuration)



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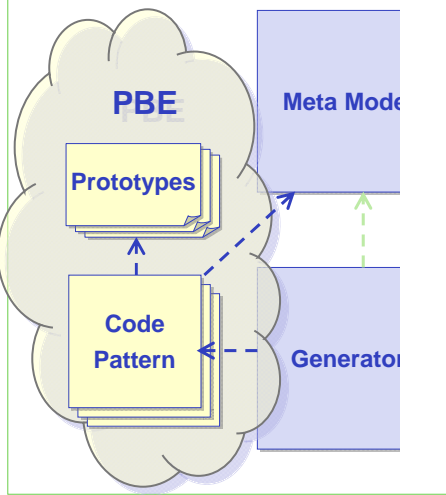
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## Model-based Generator Construction




### Pattern By Example™ (PBE)

- Solution examples as samples for code pattern
  - With variation points, conditional blocks and calculations
- The code patterns are being coupled to the variant model
- Code patterns and variant model are the source for the  
**Generation of Generators!**

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## From Prototype to Code Pattern

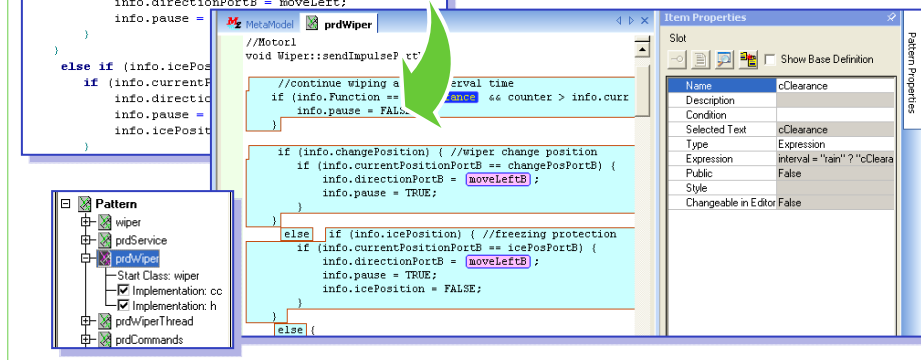
```

//Motor1
void Wiper::sendImpulsePortB() {
    //continue wiping after interval time
    if (info.Function == cClearanceRainSensor && counter
        info.pause = FALSE;
    }

    if (info.changePosition) { //wiper change position
        if (info.currentPositionPortB == changePosPortB)
            info.directionPortB = moveLeft;
        info.pause = TRUE;
    }
    else if (info.icePosition)
        if (info.currentPositionPortB == icePosPortB)
            info.directionPortB = moveLeft;
            info.pause = TRUE;
            info.icePosition = FALSE;
        }
    }
}

```

### Pattern By Example™



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Leipzig, 20.10.2006

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## Pattern By Example

- There can be various implementations of a pattern
  - E.g. for different languages
- Hierarchies of patterns for complex applications
- Implementations can be inherited and overloaded
  - „Similar but not equal“
- «Rendering» = 1 «tree» with 1 implementation type

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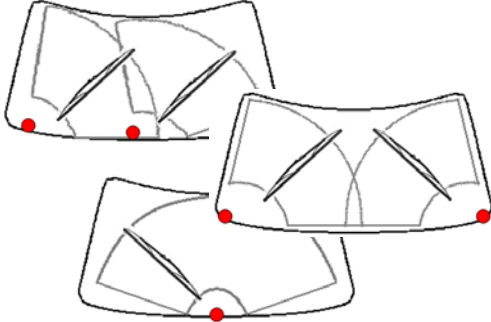
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## Example: Windshield Wiper




- Example: Windshield Wiper control
  - Microcontroller
    - 8-Bit RISC Processor
  - Operating system PURE
  - Software in C++
  - **Generation of different variants**
- Example from the PESOA Project ...

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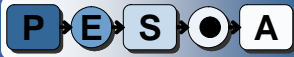
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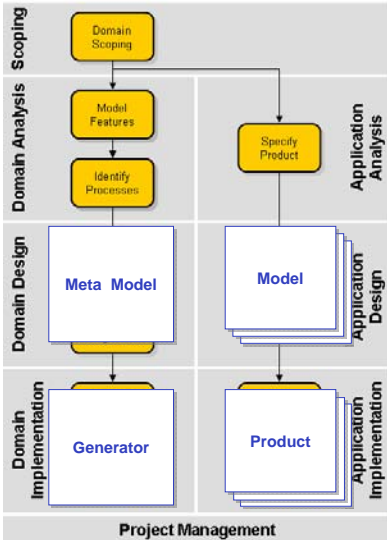
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## Research Project:






- Process Family Engineering in Service-Oriented Applications
  - Product line architecture for variant-rich processes
  - Application areas **e-Business** and **Automotive**
    - Tool chains
  - [www.PESOA.org](http://www.PESOA.org)
- Delta Software Technology:
  - Generator concepts and techniques
  - HyperSenses™

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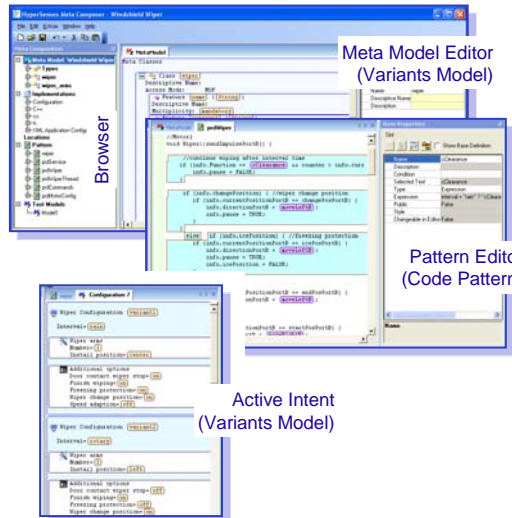
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## HyperSenses Tools



Meta Model Editor  
(Variants Model)

Browser

Pattern Editor  
(Code Pattern)

Active Intent  
(Variants Model)


- HyperSenses Meta Composer™
  - Design and Implementation of a Generator
- HyperSenses Active Intent™
  - Product Configuration
  - Generator-(Test)Application
- Generators can be integrated into other products
  - «Generator as Service»

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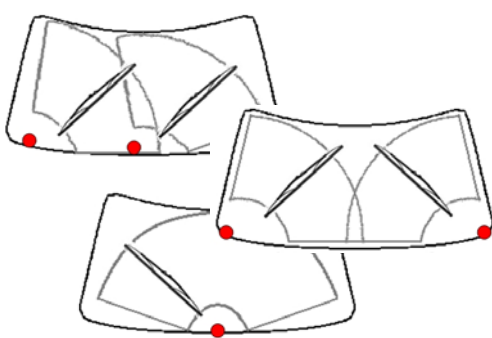
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## Windshield Wiper Options



- 1 or 2 wiper arms
- Install positions
  - Left or outer side
- Fixed or adaptable intervals
- Rain sensor
- Freezing protection
- Automatic wiper stop when opening the front doors

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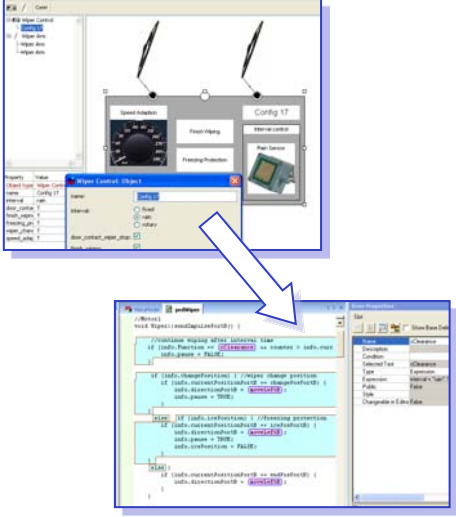
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## A Tool Chain



The screenshot shows a graphical user interface for a tool chain. At the top, there are several windows: 'Speed Selection', 'Power Rating', 'Config 1?', and 'Power Sensor'. Below these is a 'HyperSenses' window with various checkboxes and labels. A large blue arrow points from this window to a code editor window below it. The code editor displays a list of configuration items with their values, such as '18 (Info.Power) = 0.000000', '19 (Info.Speed) = 0.000000', and '20 (Info.Power) = 0.000000'. To the right of the code editor is a 'Properties' window with various settings.

- Particularly for this event, differing from the research project
- Tool Coupling:
  - MetaEdit+ 4.5 beta
  - HyperSenses 2.0
- 2-stages Import:
  - Type data → meta model (variant model)
  - Graph data → model (configuration)

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## The Windshield Wiper in Action

*Live Demonstration*

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