Product Line Software Engineering in Europe –
Fundamental Concepts and Case Study

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Outline

• Product Line Concepts
  - Definition
  - Approaching Reuse
  - Life cycle

• Case Study: Testo
  - Adoption
  - Quality Measurement at Architecture Level
  - Experience and Next Steps
Definition: Product Line

- Definitions: Product Lines
  - A product line is “a set of systems sharing a common set of features that satisfy the specific needs of a particular market segment” [Clements, Northrop]
  - A product line is “a family of products designed to take advantage of their common aspects and predicted variabilities” [Weiss, Lai]
Ad hoc Reuse

- Product Requirements → Application Engineering → Product
- Reuse Repository (Archive) → Application Engineering → Product
- Reuse Repository (Archive) → Product Requirements → Application Engineering → Product
- Reuse Repository (Archive) → Product

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Domain Engineering

Successes
- GUI Libraries
- Databases
- Middleware
- Operating Systems
- ...

Domain

Domain Artifact Base

Product Requirements

Application Engineering

Product

Feedback
Series of Application Engineering Projects

- Specification ➔ Design ➔ Implementation ➔ System Test ➔ Maintenance

Share maintenance effort

Coordinate (concurrent) projects
Organizational Life Cycle

Application Engineering

Family Engineering

Presentation slide from the ISE/IEIT joint workshop in Tokyo, Japan on July 3, 2007.
Product Line Life Cycle

Product Line Infrastructure

Domain

Family Engineering

Product Line Artifacts Base

Evaluation
Adaptation
Integration
Coordination
Evolution
Classification
Documentation
Identification

Scoping

Application Engineering

Product Requirements

Product Requirements

Product Requirements

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Testo – Product Family

- Subject: climate and flue gas measurement devices
  - Domain: Embedded system
  - Programming Language: C
  - Product Line: ~ 100 – 600 KLOC per system

- Sample products:
Testo – Product Line Adoption

Organizational Issues
Incremental introduction of product line concepts due to
- Limited resources
- Tight deadlines
- Learning process of engineers due to changed development paradigm

Establishment of a special team for maintenance and evolution of the framework

History – Product line adoption
2002 – Scoping
2003 – Architecture development
2004 – Development of first 3 commercial products as product line instances
2005 – Update of product line architecture based on measured feedback from product developments
2005/06 – Development of additional 7 products as product line instances
2006/07 – Monitoring and analysis of product line performance
-2009 – 2nd release of PL infrastructure
Testo – Product Line Methodology and Technology [Fraunhofer PuLSE™]

Applied research since 1997
(= 3-4 innovation cycles)

Industry Partners (selection)

BOSCH

HITACHI
Inspire the Next

MARKET

testo

BLAUPUNKT

Deployment Phases

PuLSE Initialization

Product Line Infrastructure Construction

Product Line Infrastructure Usage

Product Line Infrastructure Evolution

Technical Components
(Product Line Practices)

Customizing
Scoping
Modeling
Architecting
Designing
Coding
Testing and Inspection
Evolving and Managing
Instantiating

Support Components

Project Entry Points
Organizational Issues
Maturity Scale

Slide 12
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Testo – Product Line Architecture and Framework

- All product line instances comply to a single product line architecture
- 1st Release of framework components cover ~ 40% of product implementation
Fraunhofer SAVE – **Software Architecture Visualization and Evaluation**

- Collection of eclipse plug-ins
  - Supported languages: Java, C/C++, Delphi
  - Computations of
    - Architectural compliance (implemented as specified)
    - Model transformations (lifting, manipulation)
  - Visualization
    - Graphical modeling of architectures
      - UML-based notation (extensible)
    - Exploration of extracted architectures

- Awarded the Innovation Price 2005 of Rhineland-Palatinate
  - Ministry of Economics, Transportation, Agriculture and Viniculture
Fraunhofer SAVE – Features

- Additional Features
  - Ownership computation
  - Rule-based evaluation
  - Visualization of deltas between two system states
  - Generic interface for multiple metrics
  - System environment analysis

- Application Purposes
  - Evolution control
  - Comprehension
  - Re-documentation
  - What-if scenarios

⇒ Instrument to support, control and evolve the architecture of a system or product line
⇒ Hard connection between architecture definition and implementation!
Testo – Quality Measurement at Architecture Level (refined level)

For illustration only!
Testo – Improvement Recommendations

• Decomposition structure
  - Reference architecture in place (with exceptions)
  - Improvements to framework to support the derivation of future products
    • Adaptation of either the framework or the product implementation
    • Refactoring of obsolete dependencies (e.g., includes, but no included element is used), as well as to encapsulate global variables.

• Documentation consistency
  - Documentation has not fully reflected implemented architecture
Testo – Currently Addressed Product Line Issues

- Maintainability in a product line context
  - Balancing of variability in components
  - Decision criteria for suitable framework component candidates
- Testability of new products reusing framework components
  - Reduction of test effort
- Monitoring the component quality for the identification of
  - Inspection candidates
  - Subsystem interface refinements
- Measuring the efficiency and impact of applied actions
Thank you for your attention!

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