A Model-driven Product Line Approach For HMI Development

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ikv and DENSO – who we are

problem analysis

our tools
- gmf
- metamodeler
- emf
- eclipse
- medini core

our know-how
- meta-modeling
- domain knowledge
- process transformation
- desi-design

medini solution™

global supplier of automotive technology, systems and components

DENSO Europe
motivation

car infotainment software belongs to those products with relatively large common behavior but different look and feel

OEMs (car manufacturers) want a high quality, time and cost saving infotainment system satisfying their individual functional and non-functional requirements

OEM suppliers like DENSO cannot therefore deliver same looking software to all customer

DENSO therefore has the challenge of combining the following aspects:
- mass production to reduce cost
- high degree of software re-use to increase productivity and quality
- customize software easily to fulfill OEM’s individual requirements

roadmap

- motivation
- HMI development process at DENSO
- model-driven HMI development
  - HMI screen flow modeling
  - HMI screen flow simulation
- variant management with software product line approach
  - family models : feature and variation modeling
  - variant models : generated from family models
- tool demonstration
model-driven product line development process

- feature-wise stable core navigation software
- separate screen flow from look and feel (skin) design
  - screen flow and skin models have clear semantics
- consistency checks can be applied to models in order to validate them
- HMI model can be simulated in order to detect errors at an early stage
- system features are modeled and connected to HMI models
  - allows fast feature based configuration and generation of customer specific variants
- HMI code can be generated from the models

model-driven HMI development – screen flow modeling

- developed screen flow modeling domain specific language (specialization of UML activities) and graphical editor
- abstract screen model specifies the structure of HMI screens and possible actions that can be triggered from a screen
- a screen flow model specifies the transitions between screens. Transitions are activated by triggering actions
- a task model specifies the tasks expected to be executed by the navigation core
model-driven HMI development – screen flow simulation

- Skin is modeled using TiGRiX
- Screen flow can be simulated without concrete skin
- Connect skin to abstract screens and then simulate flow with skin
- Different skins conforming to the same flow can be simulated simultaneously
- Skins designed with other technologies like Flash could also be connected and simulated

SPL based HMI development process - overview

Define functions and dependencies
Product line goal model to identify main goals to be supported by the product
Product line model contains all possible flows and features for all customers

Capture requirements relevant for all potential applications
Product line development (the whole product)

Develop the functions in the product line model

Product line feature model

Define the features for a product (a variant)
Application feature model

Generate the variant model based on the application model

Variant model

Product development (a variant for a customer)
**SPL based development process**

**main goals of product line development**
- development of reusable artifacts
- identification of commonalities within a family of products
- identification of variations in a family of products

**main goals of product development**
- development of selected product (variant)
- maximize reuse of existing artifacts
- identification of new common features

**feature models**

**feature**
- a characteristic of a system relevant for some stakeholder
- examples:
  - a requirement
  - a technical function or function group
  - a non-functional (quality) characteristic

features are related to each other
- a feature may have optional or mandatory subfeatures
- features may exclude or require each other

features are related to other artifacts of the product line
- a component may implement a feature
- a feature may fulfill a goal or requirement
- a feature may control the flow of activities in a use case
HMI variant management with product line approach

**family models**
- variation points are explicitly modelled in family screen flow
- family features are applied to screen flow model elements for expressing:
  - **optional flows**: a feature exits or not in a variant
  - **alternative flows**: a feature is realized in different variants differently

**variant models**
- feature decision is made in family model for a specific variant and used to derive variant feature model
- variant flow model is derived from family flow based on the variant feature model
- QVT engine is used for the transformation
  - flexible adaptation of generation rules without redeployment
  - bidirectional transformation possible

HMI variant management - family models

![Diagram showing variation point for settings depending on market with 'Telephone is optional' note]
from family to variant models

QVT Transformation

conclusion

- model driven development provides semantically rich and consistent models which separate flow and skin design but allows connecting them to check conformance and enhance communication

- product line approach increases reuse while allowing easy customization to specific customer requirements

- reduction of the average development time for a new product

- reduced time-to-market and time-to-revenue for a new product

- better product quality and improved company reputation for quality

- increased agility to react on market requirements

- reduction in the average engineering cost per product