Domain-specific IDEs in embedded automotive software

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Michael Rudorfer
Paul Hoser, Tilmann Ochs, Christian Salzmann, Martin Thiede

BMW Car IT

Markus Völter *

* völter ingeniurbüro für softwaretechnologie
Domain-specific IDEs in embedded automotive software.

Overview.

Background / Challenge

BMW Car IT AUTOSAR prototype

Domain-specific IDE with Eclipse
IDE Step 1: Projects, XML, Generator
IDE Step 2: Model Explorers
IDE Step 3: Graphical Editors

Graphical Editing Framework GEF
Working with GEF
Generating GEF editors

Summary
Domain-specific IDEs in embedded automotive software.
Today’s Situation I.

- Embedded operating systems do not provide full hardware abstraction
- Many different hardware platforms are used
- Limited modularity, little reuse: if hardware (processor type...) changes, the software is often re-developed from scratch
- Lifecycle gap: the lifetime of cars are usually much longer than those of ECUs
- Changing hardware requires
  - compatible re-development of software on the new hardware, or
  - available stocks of old hardware
- Unit based cost structure drives car manufacturer to use cheapest possible hardware → limited resources
Domain-specific IDEs in embedded automotive software.
Today’s Situation II.

The increasing amount and complexity of software in cars requires new methods and tools.

A component-based approach is aspired to master challenges in future automotive software development.
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Solution Approach I.

• An architecture-centric programming model will be used in the future to realize component-based development for ECUs

• The goal is a separation of concerns:
  • **Software components** only deal with application logic and can be developed independently of the underlying hardware and bus systems
  • **Middleware-layer** handles aspects of remote communication, component lifecycle, scheduling and timing as well as OS abstraction
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Related Technologies: What’s different in AUTOSAR?

- Middleware technologies like J2EE or Corba are not suitable for various reasons:
  - Resource limitations in the automotive domain prevent us from using heavyweight application servers or ORBs

- AUTOSAR is an upcoming automotive industry standard that implements comparable concepts using a different approach
  - As the desired system is static after system design, the middleware-layer can be tailored for the special requirements of the scenario (omit features not needed)
  - A code-generator uses information from a system model to generate a highly optimized, lean middleware-layer
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Why a prototype?

- BMW Car IT is building a proof of concept prototype of the AUTOSAR standard
- Standard based on committee discussions
- Early prototypes are vital for validating “paperware” concepts
- Provide timely feedback to the committee from an implementer’s perspective
- Give future users an early impression of the upcoming development paradigm and tooling
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IDE Support – Why?

- Since the prototype is intended to give developers a „feeling“ of what AUTOSAR is going to be, and to convince them of the idea, developer acceptance is a major concern for the prototype.

- As a consequence, an IDE had to be developed.

- We decided to use Eclipse as a basis for the IDE.
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Models.

- Models describe various aspects of the system, such as
  - Components and Interfaces
  - Component Instances and Connectors
  - Hardware characteristics, topology and networks
  - Deployment of instances on hardware topologies
  - Timing

- Format and content (metamodel and concrete syntax) is defined by the AUTOSAR committee

- In the prototype, a code-generator (openArchitecture Ware) verifies these models for consistency and correctness before code generation starts.

- Code generation templates define the RTE code generated for each model element
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IDE I: Projects, XML, Generator.

• The first iteration of the IDE has the following features:
  
  • AUTOSAR-specific projects
  • Code generator integration
  • Generator messages displayed in IDE
  • Model editing based on manual editing of XML files (models are in XML)
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IDE 1: Projects, XML, Generator.

Generator Access and Log
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IDE II: Model Explorers.

- Models are getting larger and more complex
- In order to provide a better picture of the XML-based models, we started developing tree-based model viewers.
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IDE II: Model Explorers.

Various Model Browsers in the IDE
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IDE III: Graphical Editors.

- “Real” developers started using the prototype → Read-Only Browsers were not sufficient anymore
- AUTOSAR defines a graphical notation for the various kinds of models. This notation of AUTOSAR is not UML-based (although it does use boxes and lines).
- We use GEF to build graphical editors for the AUTOSAR specific notations.
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IDE III: Graphical Editors.

Editing Components and Interfaces
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IDE III: Graphical Editors.

Networks, ECUs and Deployments
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Working with GEF.

- GEF is a very powerful framework for building graphical editors for graph-like structures on the Eclipse Platform.

- However, it is not easy to use:
  - Documentation is improvable
  - A specific „intent“ is scattered through many classes (models, parts, policies, ...); i.e. many artifacts have to be adapted to realize a new feature
  - We needed to stay in sync with the evolving metamodel we use for the AUTOSAR generator development; frequent changes!
Domain-specific IDEs in embedded automotive software.
Generating GEF editors.

- As a consequence, we now generate most of the GEF editors from our domain metamodel.
- Relations between meta-classes are defined in an instantiator
- Behaviour of the editors is “configured” by the instantiator
- Approach gives us serveral hooks to implement sophisticated domain model-specific behaviour
- Only figures have to be coded by hand
- Editors are always in sync with the metamodel, changes become simpler, and GEF development in general is a pleasure now 😊
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Generator infrastructure II.
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Example – setting up the editor.

```java
EditorDesc editor = new EditorDesc();
metamodel.addEditor(editor);
editor.setName("CompositionEditor");

MetaClassDesc prototype = new MetaClassDesc( ... );
editor.addItem(prototype);

OneToOneAssociationDesc assocCompositionP2P =
    new OneToOneAssociationDesc ( ... );
editor.addConnectionItem(assocCompositionP2P);

OneToManyContainmentDesc editor2prototype =
    new OneToManyContainmentDesc(editor, prototype,
    "ASComponentPrototype");
editor.configure();
```
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Example – relations between metaclasses.

// define class description from "ComponentPrototype"
private MetaclassDesc prototype = new MetaclassDesc(
    new RClass(metamodel, ASComponentPrototype.class),
    MetaclassDesc.NO_ASSOCIATIONTYPE, true);

prototype.setTitle("Prototype");
prototype.addStringProperty("name").setVisibleInDiagram(true);
prototype.addStringProperty("module", ASModule.class,
    "QualifiedName").setVisibleInDiagram(true);

metamodel.addMetaclass(prototype);

MetaclassDesc portPrototype = new MetaclassDesc(... // port prototype

// define containment of port and component prototype
new OneToManyContainmentDesc(prototype, portPrototype,
    "PortPrototype");

Generator Run

XYEditor.java
XYEditorPart.java
XYEditorModel.java
XYEditPolicy.java
... +XYFigure.java
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Some numbers:

From
• less than 100 LOC editor description
• plus a few hundred LOC for the figures

We generate
• 50+ GEF Source-Files
• containing serveral thousand LOC of GEF Code

Generating GEF editors simplyfies development drastically!
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- The increasing amount and complexity of software in cars will in future require new methods and tools for software development - Model-driven software development is a promising approach.

- Early prototyping is a major contribution to a stable, reliable infrastructure.

- Eclipse is a very good basis for developing custom, domain-specific IDEs.

- The combination of GEF and code generation yields a very productive environment for building graphical editors.

- The approach taken here in the automotive domain could be suitable for other domains as well.
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References and Acknowledgements.

Acknowledgements:

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References:

AUTOSAR
http://www.autosar.org

BMW Car IT
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