INTRODUCTION

Introduction

Contents

- Human cognitive processes
- Models
- Structure of the book
Abstraction and human mind

• The human mind continuously re-works reality by applying cognitive processes

• **Abstraction**: capability of finding the commonality in many different observations:
  • generalize specific features of real objects (generalization)
  • classify the objects into coherent clusters (classification)
  • aggregate objects into more complex ones (aggregation)

• **Model**: a simplified or partial representation of reality, defined in order to accomplish a task or to reach an agreement
Models

What is a model?

![Diagram showing System and Model with a mapping relationship]

**Mapping Feature**
A model is based on an original (=system)

**Reduction Feature**
A model only reflects a (relevant) selection of the original's properties

**Pragmatic Feature**
A model needs to be usable in place of an original with respect to some purpose

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**Purposes:**
- descriptive purposes
- prescriptive purposes
Motivation
What is Model Engineering?

- Model as the **central artifact** of software development

![Diagram of Model Engineering with arrows pointing to Static analysis, Rapid prototyping, Code generation, Automated testing, Documentation, Refactoring/Transformation.]

[Illustration by Bernhard Rumpe]

The MD* Jungle of Acronyms

- **Model-Driven Development (MDD)** is a development paradigm that uses models as the primary artifact of the development process.
- **Model-driven Architecture (MDA)** is the particular vision of MDD proposed by the Object Management Group (OMG)
- **Model-Driven Engineering (MDE)** is a superset of MDD because it goes beyond of the pure development
- **Model-Based Engineering** (or “model-based development”) (MBE) is a softer version of ME, where models do not “drive” the process.
Motivation
Why Model Engineering?

- **Traditional** usage of models in software development
  - **Communication** with customers and users (requirement specification, prototypes)
  - Support for software design, capturing of the intention
  - **Task specification** for programming
  - **Code visualization**, for example in TogetherJ

- What is the **difference** to Model Engineering?
Motivation

Usage of models

- Do not apply models as long as you have not checked the underlying simplifications and evaluated its practicability.

- Never mistake the model for the reality.
  - Attention: abstraction, abbreviation, approximation, visualization, …
Motivation
Constructive models (Example: Electrical Engineering)

[Slide by Bernhard Rumpe]
Motivation
Declarative models (Example: Astronomy)

- Heliocentric model by Kopernikus
Motivation
Application area of modeling

- **Models as drafts**
  - Communication of ideas and alternatives
  - Objective: modeling per se

- **Models as guidelines**
  - Design decisions are documented
  - Objective: instructions for implementation

- **Models as programs**
  - Applications are generated automatically
  - Objective: models are source code and vice versa
Motivation

Increasing abstraction in software development

- The **used artifacts of software development** slowly converge to the concepts of the **application area**

  - Business objects (course, account, customer)
  - Components (provided/required interface)
  - Libraries (GUI, lists)
  - Procedural constructs (while, case, if)
  - Assembler and mnemonic abbreviations (MV, ADD, GET)
  - Assembler (001001)

[Illustration by Volker Gruhn]
Structure of the book
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Chapter #2

MDSE PRINCIPLES

Teaching material for the book
Model-Driven Software Engineering in Practice
by Marco Brambilla, Jordi Cabot, Manuel Wimmer.
MDSE Principles

Contents

- Concepts
- Approaches
- Adoption
MDSE aim at large

- MDSE considers models as first-class citizens in software engineering
- The way in which models are defined and managed is based on the actual needs that they will address.
- MDSE defines sound engineering approaches to the definition of
  - models
  - transformations
  - development process.
Concepts
Principles and objectives

- **Abstraction** from specific realization technologies
  - Requires modeling languages, which do not hold specific concepts of realization technologies (e.g., Java EJB)
  - Improved **portability** of software to new/changing technologies – model once, build everywhere
  - **Interoperability** between different technologies can be automated (so called Technology Bridges)

- **Automated code generation** from abstract models
  - e.g., generation of Java-APIs, XML Schemas, etc. from UML
  - Requires expressive and precise models
  - Increased **productivity** and **efficiency** (models stay up-to-date)

- **Separate development** of application and infrastructure
  - Separation of application-code and infrastructure-code (e.g. Application Framework) increases **reusability**
  - **Flexible** development cycles as well as **different development roles** possible
MDSE methodology ingredients

- **Concepts**: The components that build up the methodology
- **Notations**: The way in which concepts are represented
- **Process and rules**: The activities that lead to the production of the final product
- **Tools**: Applications that ease the execution of activities or their coordination
MDSE Equation

Models + Transformations = Software
Target of MDSE

- **The Problem Domain** is defined as the field or area of expertise that needs to be examined to solve a problem.
- **The Domain Model** is the conceptual model of the problem domain.
- **Technical Spaces** represent specific working contexts for the specification, implementation, and deployment of applications.
Modeling Languages

- **Domain-Specific Languages (DSLs):** languages that are designed specifically for a certain domain or context.
- DSLs have been largely used in computer science. Examples: HTML, Logo, VHDL, Mathematica, SQL.

- **General Purpose Modeling Languages (GPMLs, GMLs, or GPLs):** languages that can be applied to any sector or domain for (software) modeling purposes.
- The typical examples are: UML, Petri-nets, or state machines.
Metamodeling

- To represent the models themselves as “instances” of some more abstract models.
- **Metamodel** = yet another abstraction, highlighting properties of the model itself

- Metamodels can be used for:
  - defining new languages
  - defining new properties or features of existing information (metadata)
Model Transformations

- Transforming items
- MDSE provides appropriate languages for defining model transformation rules
- Rules can be written manually from scratch by a developer, or can be defined as a refined specification of an existing one.
- Alternatively, transformations themselves can be produced automatically out of some higher level mapping rules between models
  - defining a mapping between elements of a model to elements to another one (model mapping or model weaving)
  - automating the generation of the actual transformation rules through a system that receives as input the two model definitions and the mapping
- Transformations themselves can be seen as models!!
Concepts
Model Engineering basic architecture

Application

Modeling
Model

Automation
Transformation / Code generation
Reuse

Abstraction (bottom-up)

Transformation / Code generation

Realization
Artifacts (e.g. code)

Construction (top-down)

Application domain

Modeling language

Transformation definition

Transformation language

Meta-Level

Meta-modeling language

Defined using

Defined by

Uses
Modelware vs. Grammarware

- Two technical spaces

![Diagram showing Modelware and Grammarware]

Model Transformations

MOF and transformation setting
Types of models

- **Static models**: Focus on the static aspects of the system in terms of managed data and of structural shape and architecture of the system.
- **Dynamic models**: Emphasize the dynamic behavior of the system by showing the execution.

Just think about UML!
Approaches

CASE

- **Historic** approach (end of 20\textsuperscript{th} century)
- **Example**: Computer Associates’ AllFusion Gen
  - Supports the Information Engineering Method by James Martin by a series of diagram types (incl. user interface)
  - Fully automated code generation for one architecture (3-Tier) and plenty of execution platforms (Mainframe, Unix, .NET, J2EE, different databases, …)
  - Advantage/Disadvantage: no handling with the target platform required/possible
- **Different implementation versions of the basic architecture**
  - Meta-Level often not supported / not accessible
  - Modeling language often fixed, tool specific versions
  - Execution platform often not considered or fixed
- **Advantages**
  - Productivity, development and maintenance costs, quality, documentation
- **Disadvantages**
  - Proprietary (version of a) modeling language
  - Tool interoperability nonexistent
  - Strongly dependent on the tool vendor regarding execution platforms, further development
  - Tools are highly complex
Approaches
Executable UML

- **“CASE with UML”**
  - **UML-Subset**: Class Diagram, State Machine, Package/Component Diagram, as well as
  - UML Action Semantic Language (ASL) as programming language

- **Niche product**
  - Several specialized vendors like Kennedy/Carter
  - Mainly used for the development of Embedded Systems

- **One part of the basic architecture** implemented
  - Modeling language is predetermined (xUML)
  - Transformation definitions can be adapted or can be established by the user (via ASL)

- **Advantages** compared to CASE
  - Standardized modeling language based on the UML

- **Disadvantages** compared to CASE
  - Limited extent of the modeling language

Approaches

MDA

- **Interoperability** through platform independent models
  - Standardization initiative of the Object Management Group (OMG), based on OMG Standards, particularly **UML**
  - Counterpart to CORBA on the modeling level: interoperability between different platforms
  - Applications which can be installed on different platforms → portability, no problems with changing technologies, integration of different platforms, etc.

- **Modifications to the basic architecture**
  - Segmentation of the model level
    - **Platform Independent** Models (PIM): valid for a set of (similar) platforms
    - **Platform Specific** Models (PSM): special adjustments for one specific platform
  - Requires model-to-model transformation (PIM-PSM; compare QVT) and model-to-code transformation (PSM-Code)
  - Platform development is not taken into consideration – in general industry standards like J2EE, .NET, CORBA are considered as platforms

[www.omg.org/mda/]
Modeling Levels
CIM, PIM, PSM

- Computation independent (CIM): describe requirements and needs at a very abstract level, without any reference to implementation aspects (e.g., description of user requirements or business objectives);
- Platform independent (PIM): define the behavior of the systems in terms of stored data and performed algorithms, without any technical or technological details;
- Platform-specific (PSM): define all the technological aspects in detail.
Modeling levels

CIM

- Eg., business process

New customer arrives to counter → Check customer identity → Retrieve account number → Ask customer about operation to perform → Execute operation on account
Modeling levels
MDA Platform Independent Model (PIM)

- specification of structure and behaviour of a system, abstracted from technological details

- Using the UML (optional)

- Abstraction of structure and behaviour of a system with the PIM simplifies the following:
  - Validation for correctness of the model
  - Create implementations on different platforms
  - Tool support during implementation
Modeling levels
MDA Platform Specific Model (PSM)

- Specifies how the functionality described in the PIM is realized on a certain platform
- Using a UML-Profile for the selected platform, e.g., EJB
Approaches
MDA Reverse Engineering / Roundtrip Engineering

- Re-integration onto new platforms via Reverse Engineering of an existing application into a PIM and subsequent code generation

- MDA tools for Reverse Engineering automate the model construction from existing code
MDSE in Industry
Adoption and acceptance (hype)

- Not yet mainstream in all industries
- Strong in core industry (defense, avionics, …)
MDSE Industry (2)

Adoption

“The Chasm”

Area under the curve represents number of customers
Tool support

- Drawing vs. modeling

Diagram: Venn diagram showing the overlap between Modeling Tools and Drawing Tools.
Eclipse and EMF

- EMF (Eclipse Modeling Framework) is the core methodology in Eclipse to support MDE.
- Full support for metamodeling and language design
- Fully MD (vs. programming-based tools)
- Used in this course!
Conclusion
Modeling in the new millennium – Much has changed!

- »When it comes down to it, the real point of software development is cutting code«
  - To model or to program, that is not the question!
  - Instead: Talk about the right abstraction level

- »Diagrams are, after all, just pretty pictures«
  - Models are not just notation!
  - Instead: Models have a well-defined syntax in terms of metamodels

- »No user is going to thank you for pretty pictures; what a user wants is software that executes«
  - Models and code are not competitors!
  - Instead: Bridge the gap between design and implementation by model transformations

MODEL-DRIVEN SOFTWARE ENGINEERING IN PRACTICE


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or buy it on www.amazon.com