Model-Based Software Engineering

Lecture 01 – Introduction

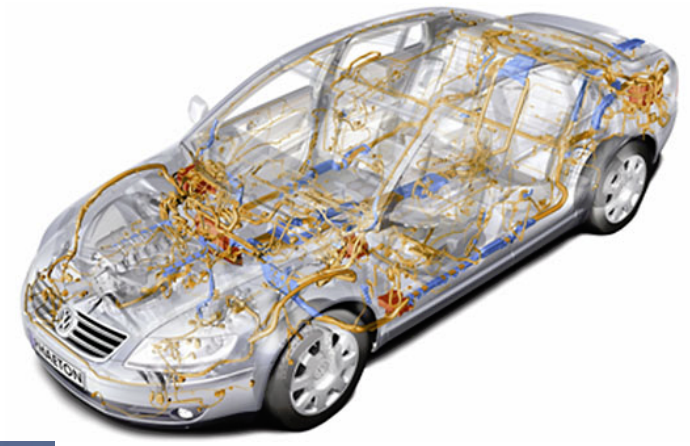
Prof. Dr. Joel Greenyer

April 5, 2015

Discussion

- What do **you** associate with the term "Model-Based Software Engineering?"

Critical Software-Intensive Systems



SOFTWARE ENGINEERING

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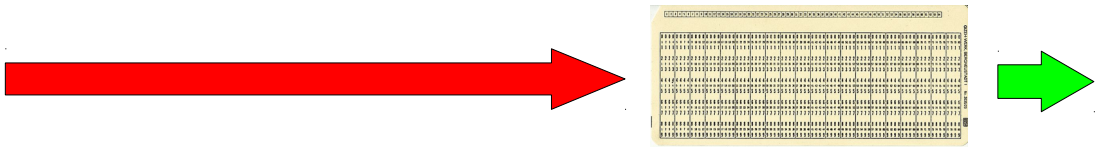
      Communications of the ACM, **1972**
      (http://www.cs.utexas.edu/users/EWD/ewd03xx/EWD340.PDF)

Historical Perspective

- in the early days of computers: punch cards

Requirements  **Hardware**

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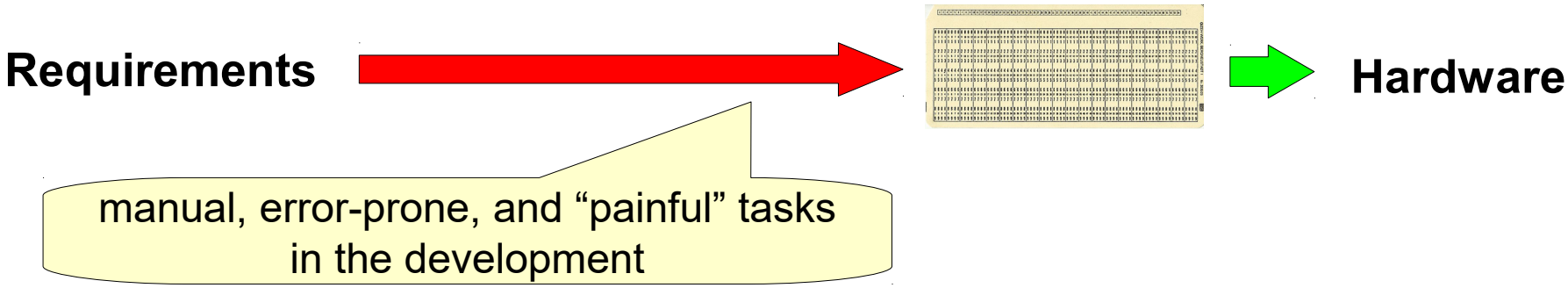

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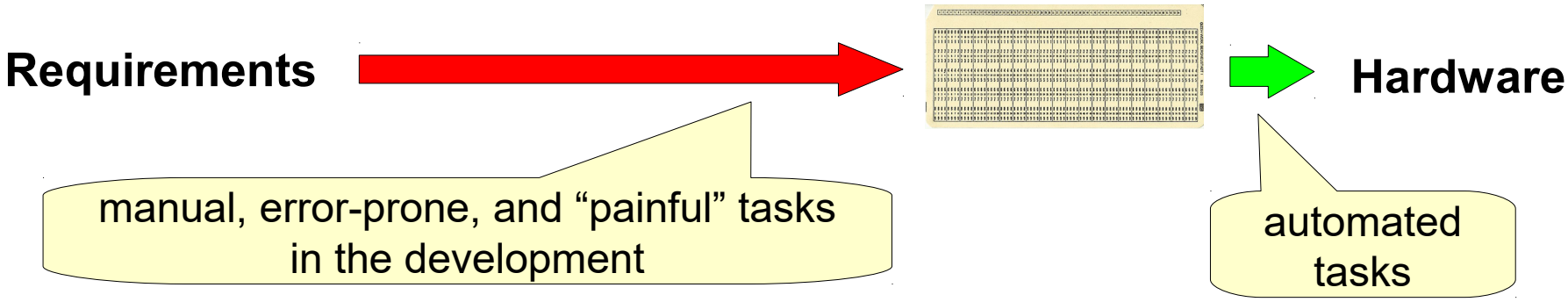

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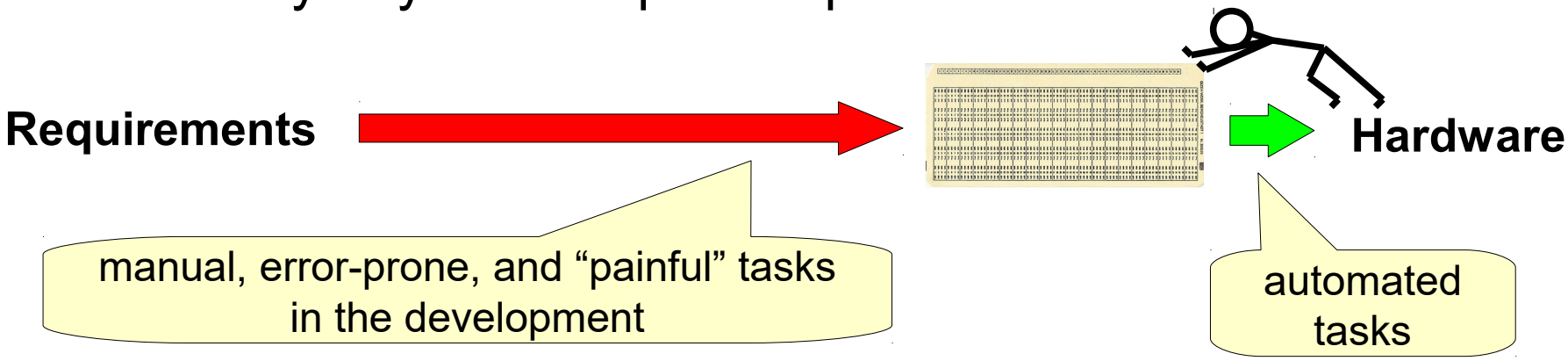

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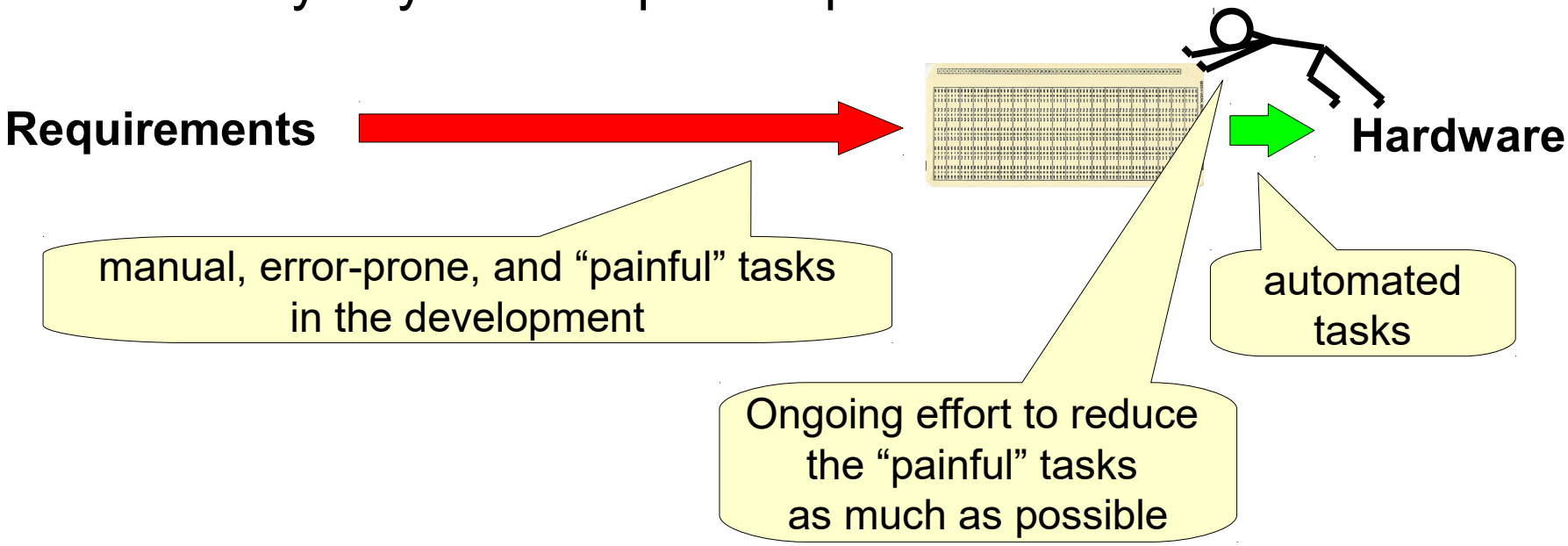

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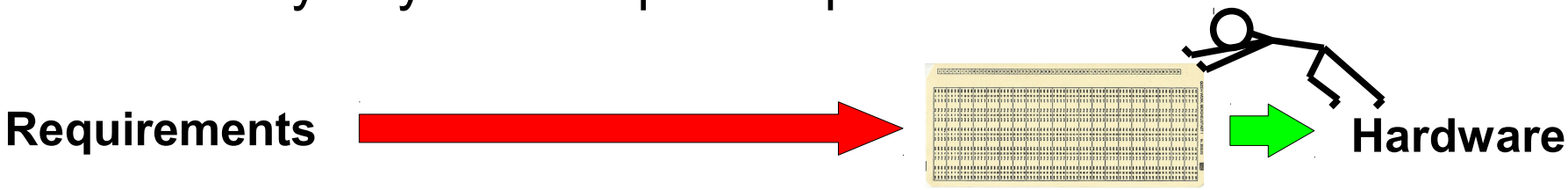

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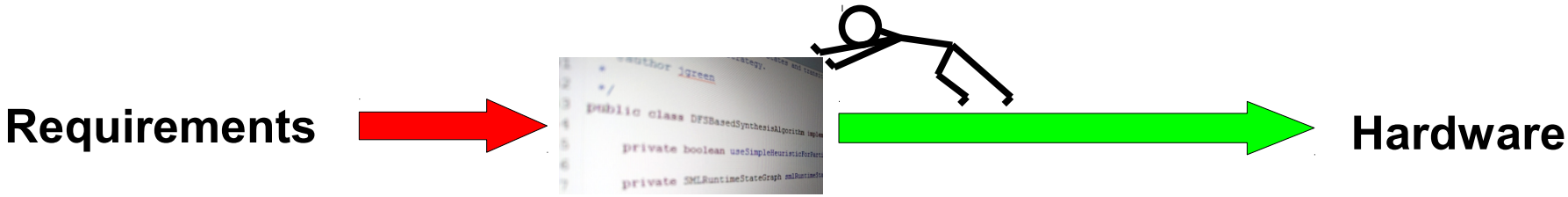

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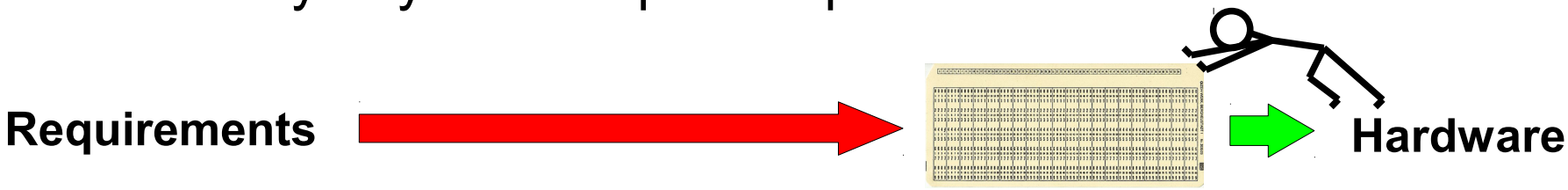

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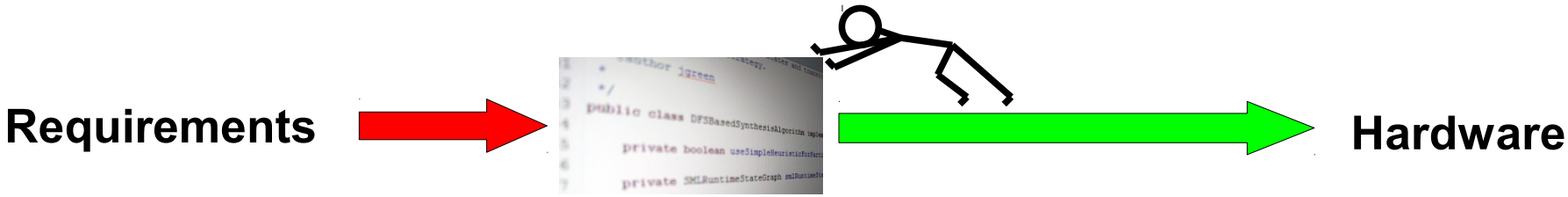
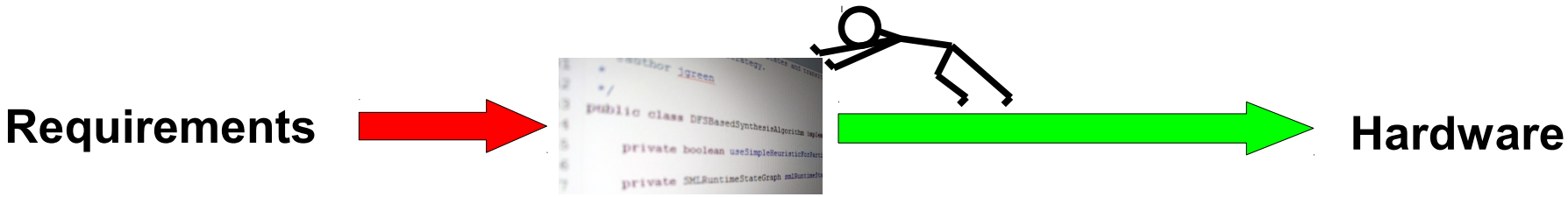


Goal:
1. Describe software on **adequate abstraction** level
2. **Automate** (code) generation as much as possible
3. **Automate analysis** as much as possible

Model-Based Software Engineering

- Model-based software engineering is about continuing the trend towards more adequate ways of describing software, and automating as much of the development as possible



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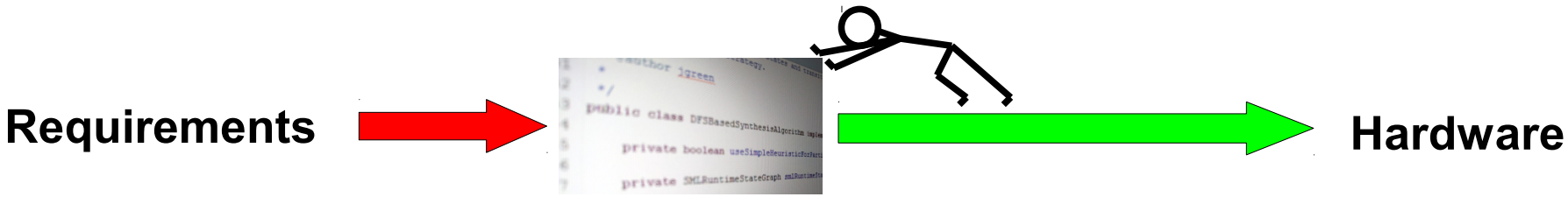

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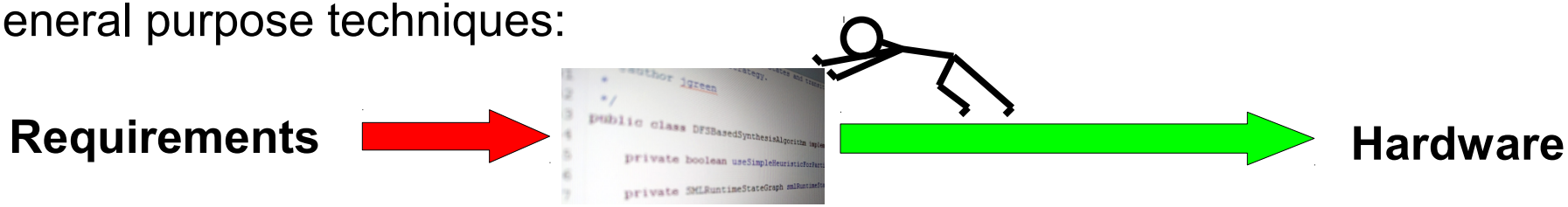

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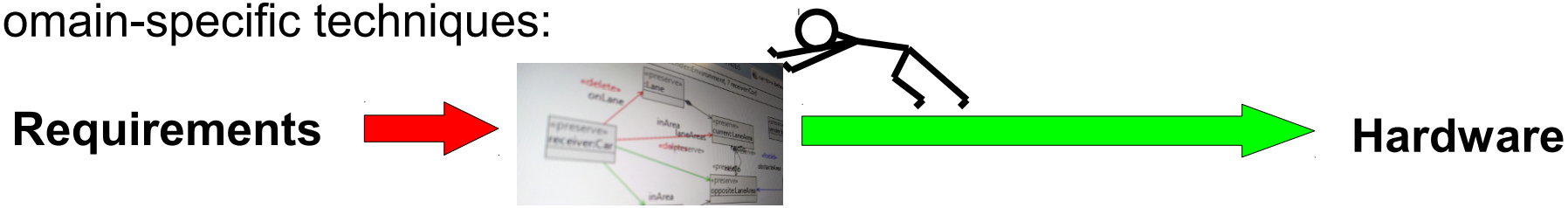

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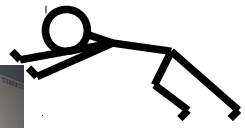
Requirements     **Hardware**

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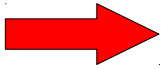
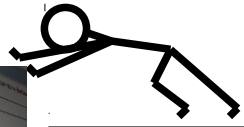
Requirements     **Hardware**

"The last push" is only possible when languages and tools are tailored for a specific domain.

Agenda

1. Motivation ✓
2. What you will learn in this lecture
   - Learning Objectives
   - Topics
   - Literature
3. Organizational Issues
4. Introduction:
   - What is a model?
   - What is model-based software engineering (MBSE)?
   - What are reasons for doing MBSE?

SOFTWARE ENGINEERING

1.2 What you will learn in this lecture

Leibniz Universität Hannover

SOFTWARE ENGINEERING

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- Students have deepened their understanding of modeling and abstraction and of modern software engineering technologies.

SOFTWARE ENGINEERING

Topics

- Introduction and Overview

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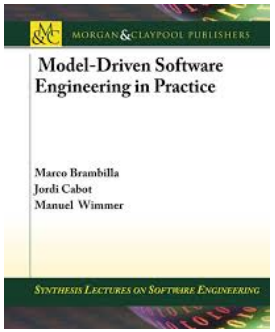
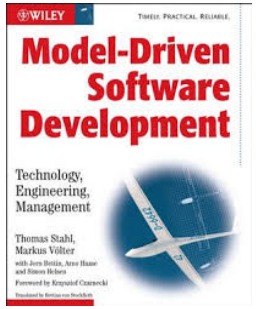
- Further Topics (TBD)

Literature

- Brambilla, Cabot, Wimmer: Model-Driven Software Engineering in Practice, Morgan & Claypool Publishers, 2012.
- Stahl, Völter, Efftinge, Haase: Modellgetriebene Softwareentwicklung: Techniken, Engineering, Management, dpunkt, 2. Auflage, 2007.
- Völter: DSL Engineering: Designing, Implementing and Using Domain-Specific Languages, CreateSpace Independent Publishing Platform, 2013
  (http://voelter.de/data/books/markusvoelter-dslengineering-1.0.pdf)
- Stahl, Völter: Model-Driven Software Development: Technology, Engineering, Management, Wiley, 2006.
  (http://www.voelter.de/data/books/mdsd-en.pdf)





SOFTWARE ENGINEERING

1.3 Organizational Issues

Leibniz Universität Hannover

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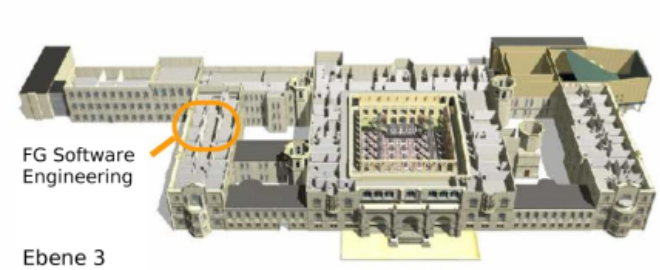

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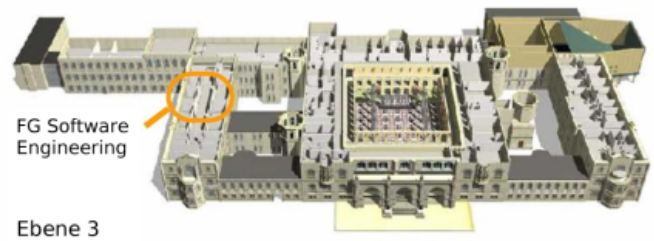
    - Formal analysis and synthesis



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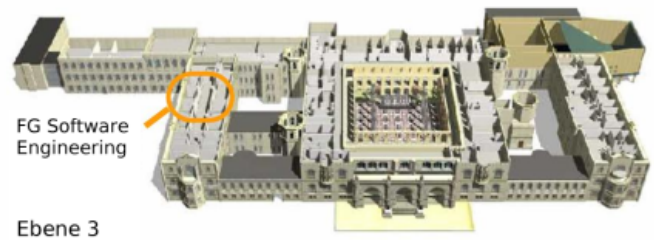
- Contact
  - Email: greenyer@uni-hannover.de
  - Office G322
  - You can make appointments via email



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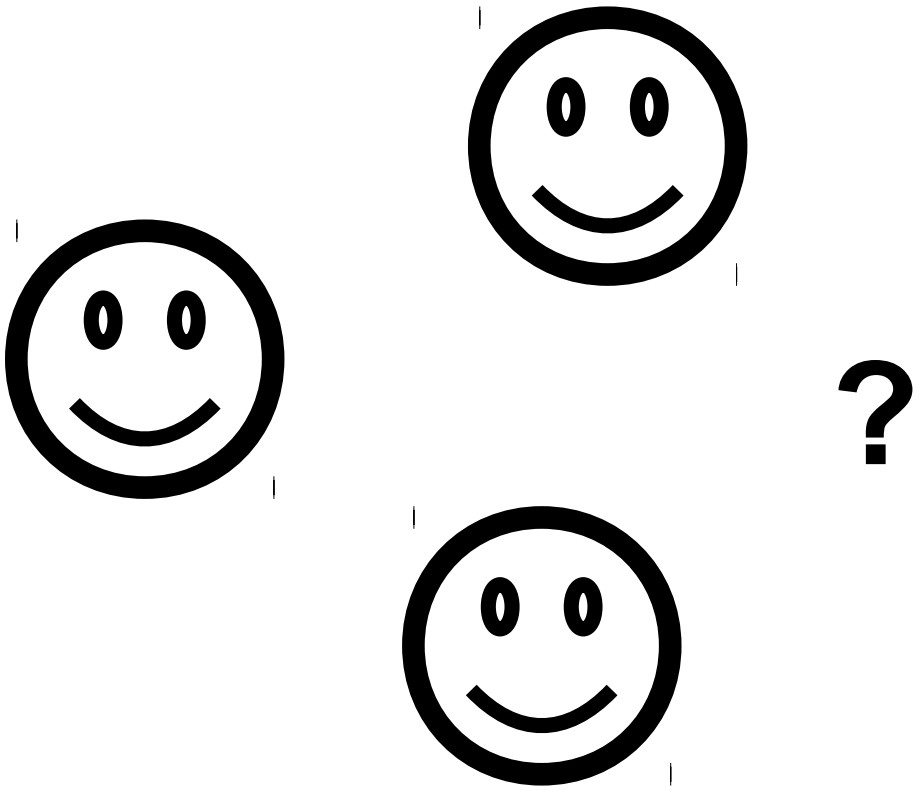
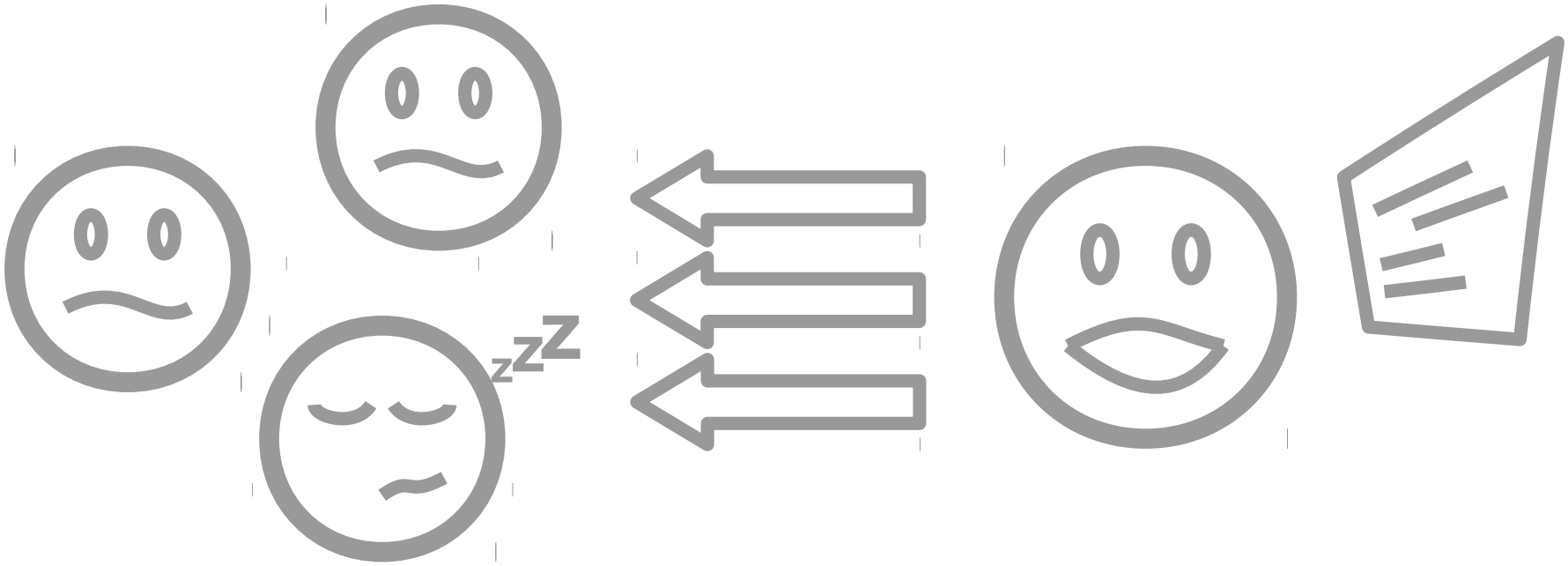


Interaction in the lecture



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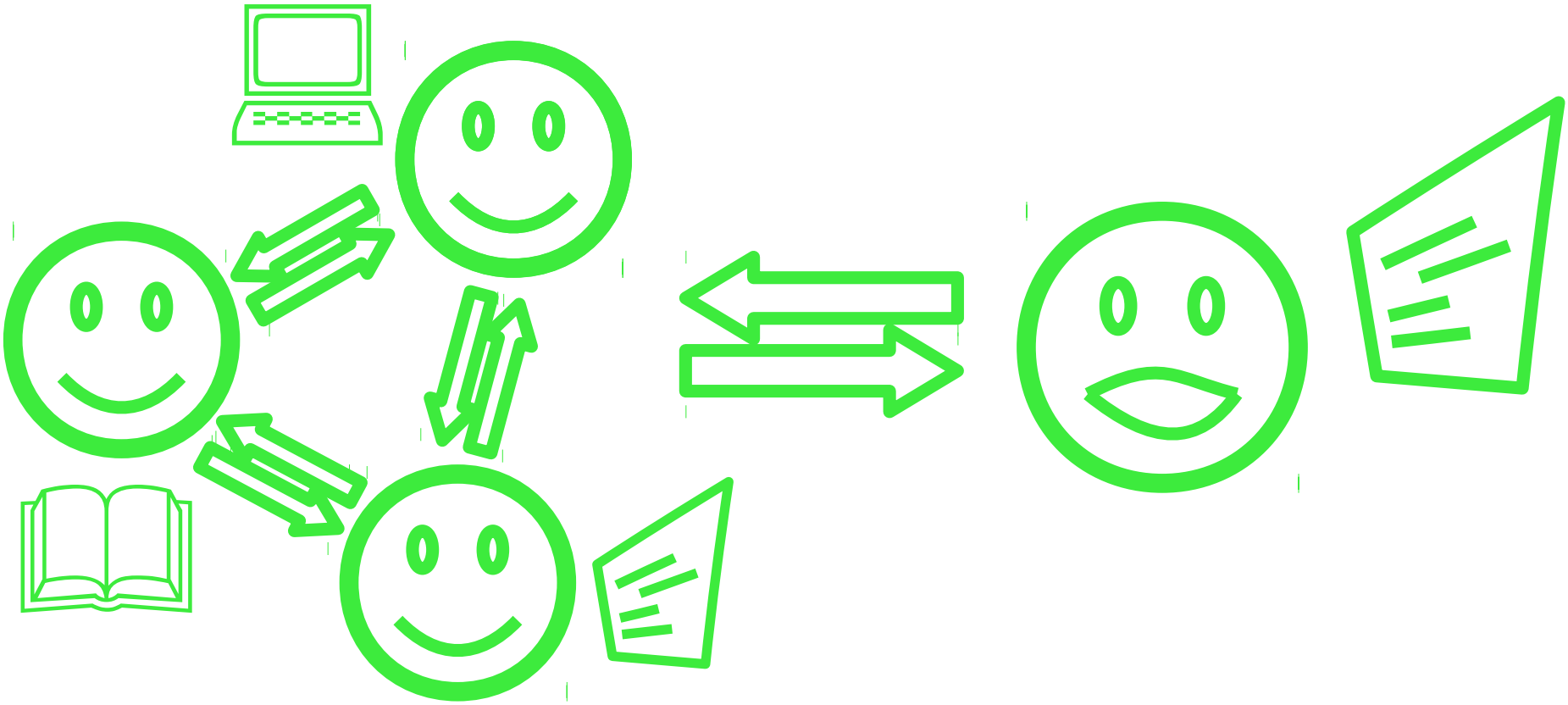

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  - Use the Stud.IP forum if you are still looking to join a group

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  - Otherwise, you can use the tutorials to work on your mini projects

Organizational Issues

- Date and time of the **lecture**:
  - Tuesdays 14.15-15.45 PM, A310
- Date and time of the **tutorial**:
  - Tuesdays, 16:00-16:45, B302 (per request: 16:05 – 16:50)

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- **Tutorials start next week**

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  - Tuesdays 14.15-15.45 PM, A310
- Date and time of the **tutorial**:
  - Tuesdays, 16:00-16:45, B302 (per request: 16:05 – 16:50)
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  - date (preliminary): 30 August, 15.15-16.45

ITIS Students

- This course is also offered to ITIS students under the name **Model-Driven Software Development**

- Because the course is worth **6 ECTS points** for ITIS students (instead of 4 ECTS points for non-ITIS students), the ITIS students will have to work on and present an additional mini project towards the end of the lecture period
  - details will be announced later

Lecture Dates

- 05.04.2016 – today
- 12.04.2016
- 19.04.2016
- 26.04.2016
- 03.05.2016
- 10.05.2016 – **no lecture**
- 17.05.2016 – no lecture (lecture-free week)
- 24.05.2016
- 31.05.2016
- 07.06.2016
- 14.06.2016 – **no lecture**
- 21.06.2016
- 28.06.2016
- 05.07.2016
- 12.07.2016

SOFTWARE ENGINEERING

1.4 Introduction

Leibniz Universität Hannover

SOFTWARE ENGINEERING

What is a Model?

What is a Model?

- popular models:

Quelle: http://de.wikipedia.org/wiki/Heidi_Klum

What is a Model?

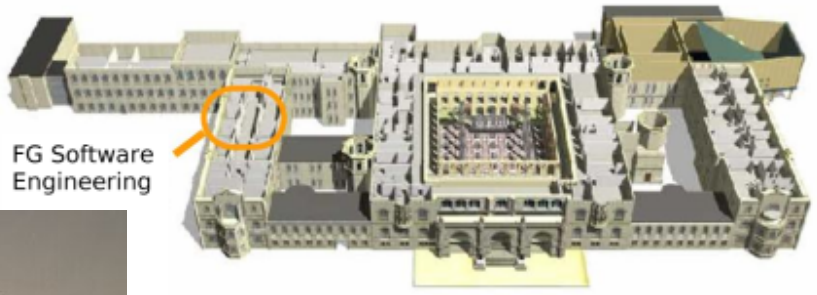
- Models of boats:

http://de.wikipedia.org/wiki/Modellboot

Portrevel shiphandling school
http://www.portrevel.com/

What is a Model?

- Architecture models:



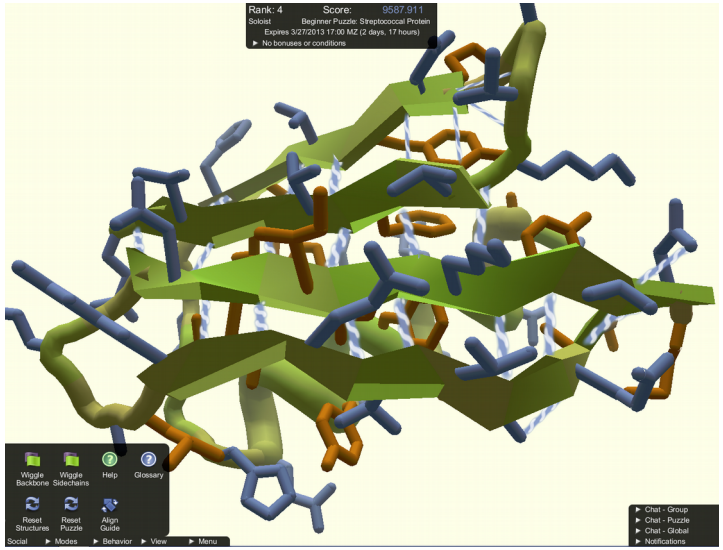
(this was already the first model in the lecture)

Model of the Opéra Garnier, Paris

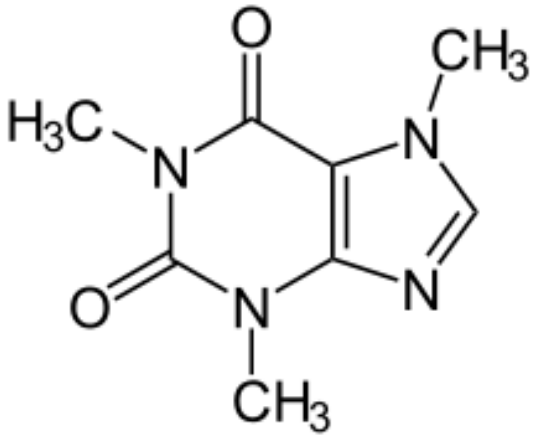
http://de.wikipedia.org/wiki/Op%C3%A9ra_Garnier

Neues Rathaus in Hannover

What is a Model?



model of a protein molecule



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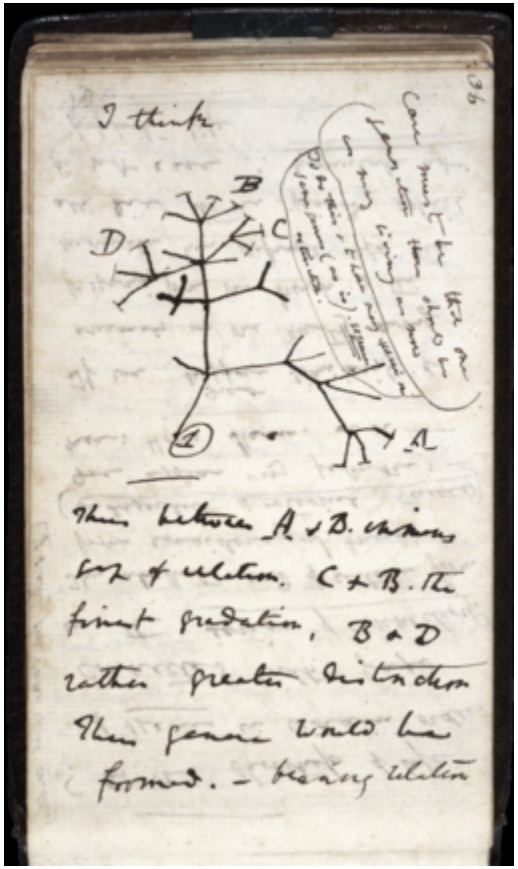
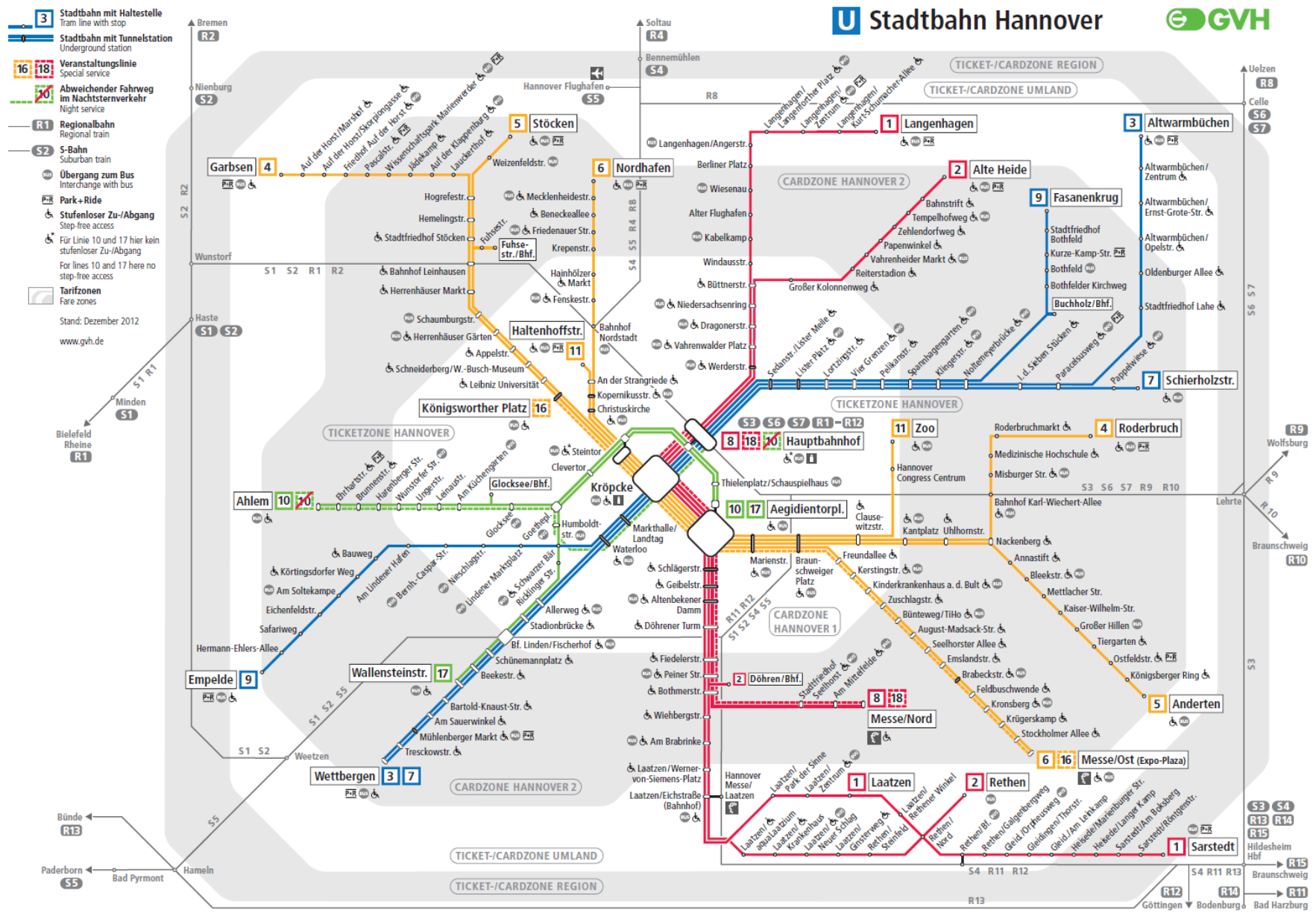


page from Darwin's notebook around July 1837 showing his first sketch of an evolutionary tree

https://en.wikipedia.org/wiki/Tree_of_life_%28biology%29

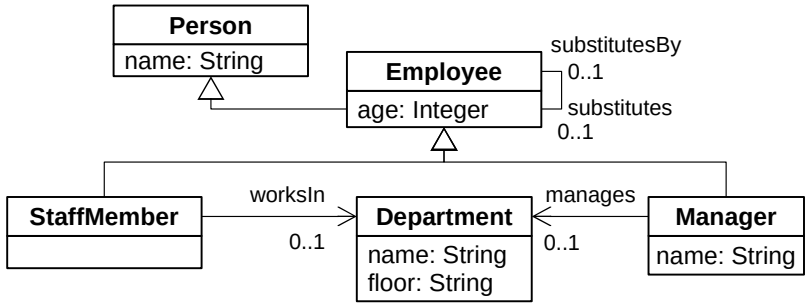
SOFTWARE ENGINEERING

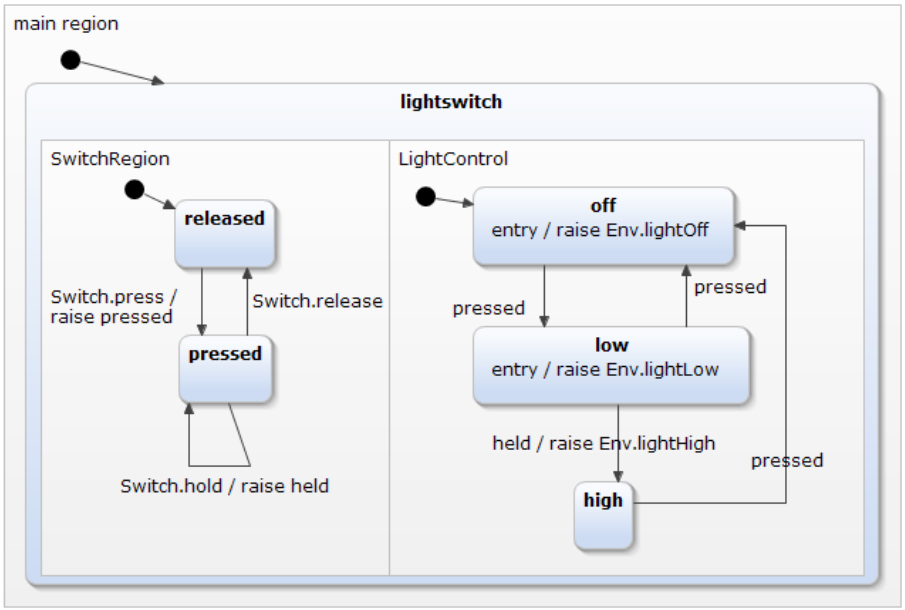
What is a Model?

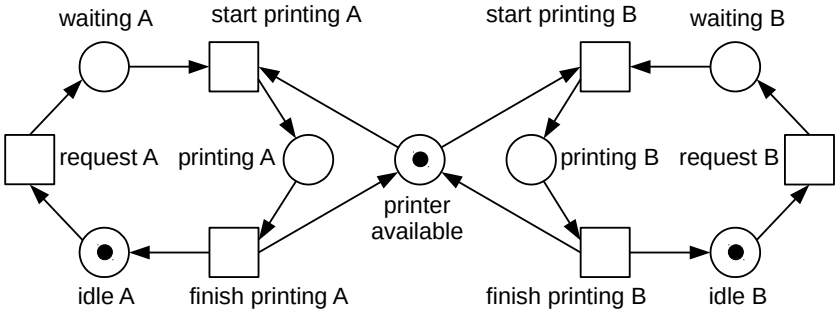


What is a Model?

- Models in computer science:








```
1 procedure DFS(G,v):
2   label v as discovered
3   for all edges from v to w in
          G.adjacentEdges(v) do
4     if vertex w is not labeled as
          discovered then
5       call DFS(G,w)
```

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  - Operations on the model allow the modeler to deduce information about the original (**interpretation**)

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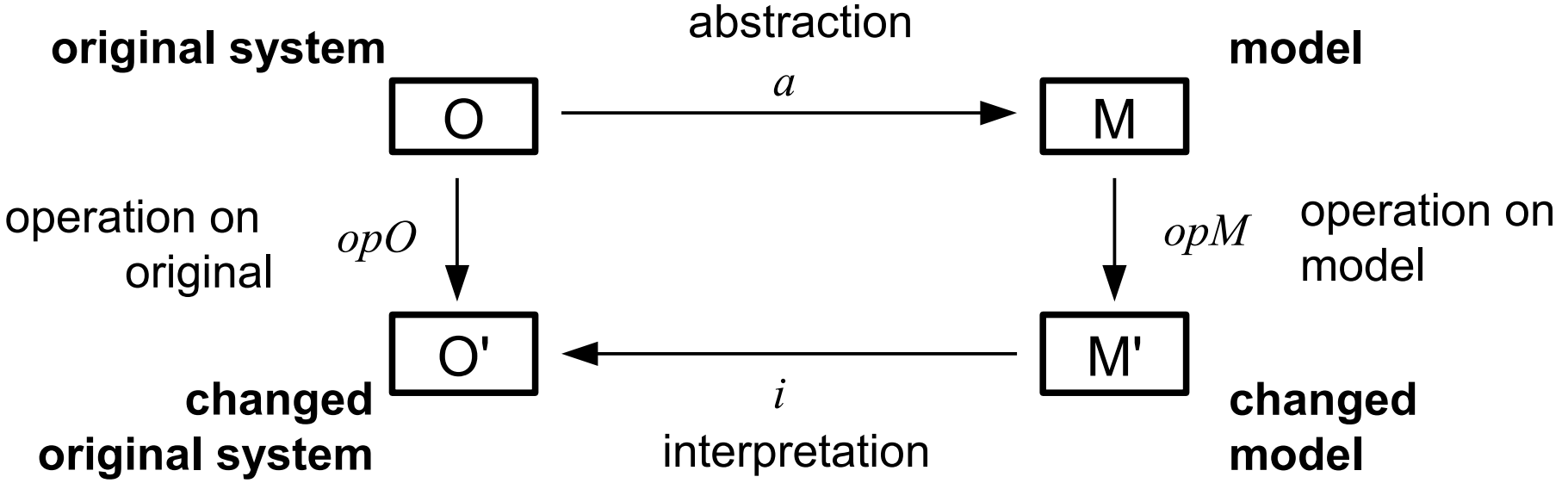
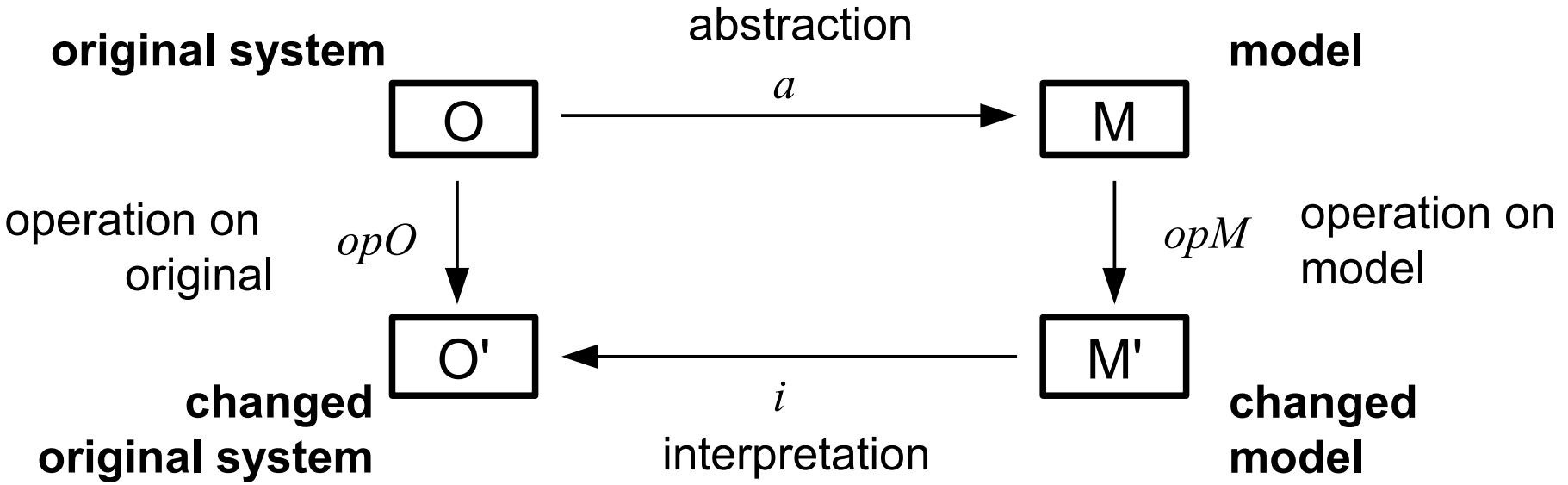


What is a Model?

- *a*: abstraction, projection, reduction, formalization



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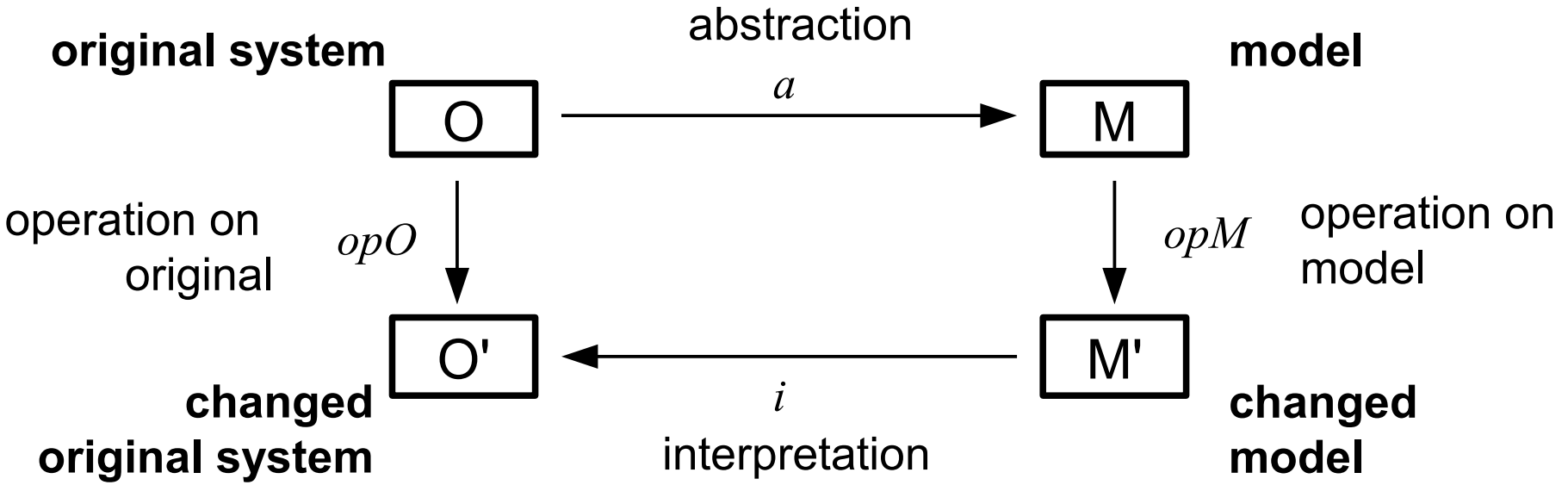

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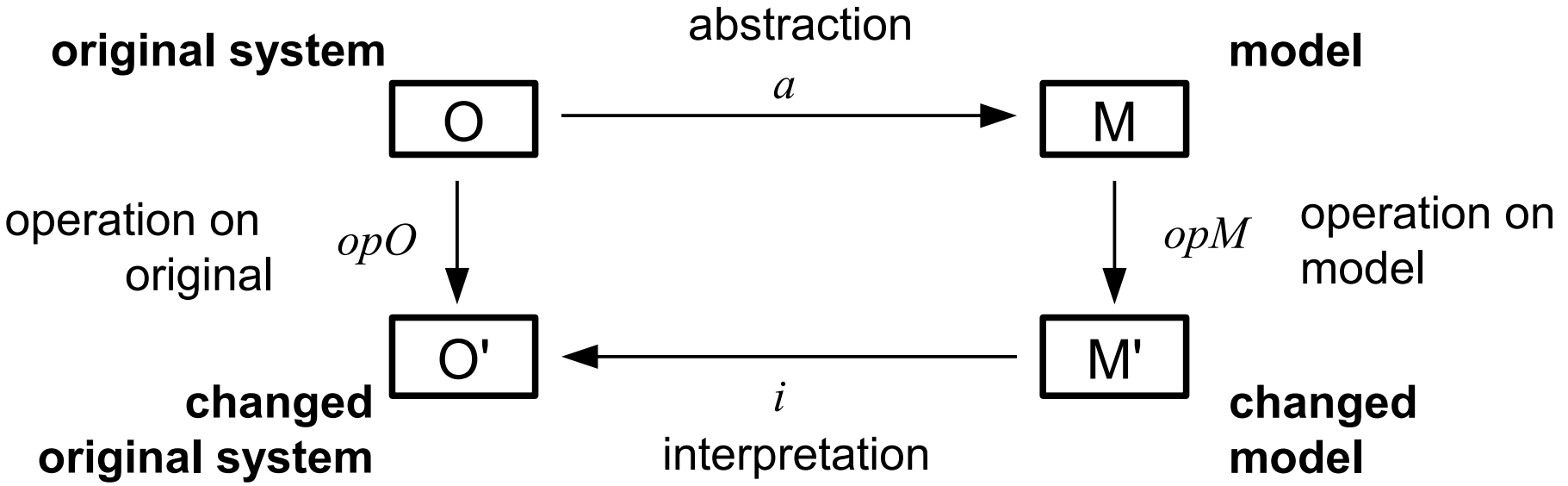

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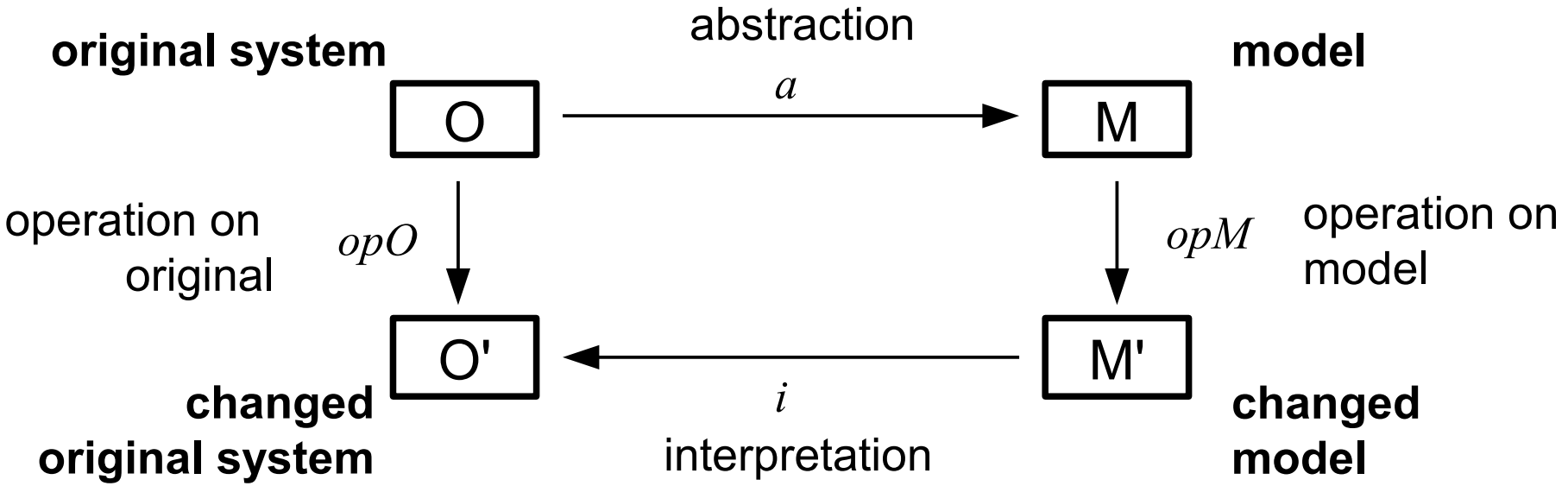
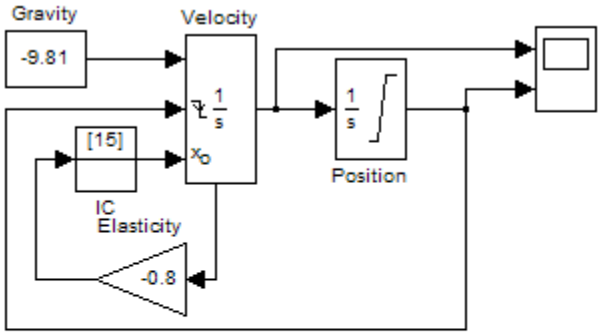
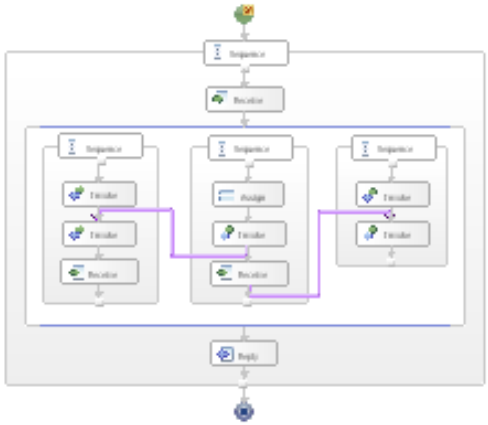
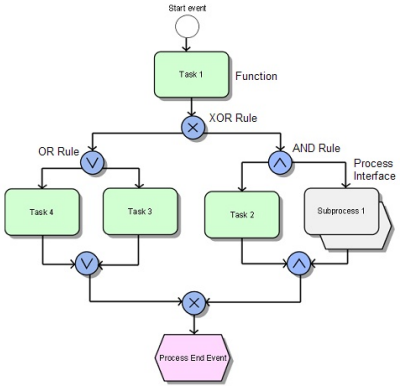


What is Model-Based Software Engineering?







UNIFIED MODELING LANGUAGE™

OMG SYSTEMS MODELING LANGUAGE™

AADL

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  Techniques that rely on the use of specific formal models for automatically generating executable code

- or **Model-Driven Engineering (MDE)**:

  Techniques that create and use (domain) specific models for solving specific (software) engineering problems

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  A standardized software development methodology by the Object Management Group (OMG) for developing software by using the modeling languages defined by the OMG (like UML)

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- **Computer-Aided Software Engineering (CASE):**

  Software development tools that use (often graphical) models, inspired by Computer-Aided Design (CAD)

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- **Round-Trip Engineering:**

  A software development methodology that aims to support changes in the model as well as in the generated code. Not only can code be generated from models, but changes in the code can also be translated back into the model (reverse engineering)

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- **Domain-Driven Design (DDD):**

  Principles and patterns for creating models for a particular domain

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- Models can be used for other analysis tasks (for example formal verification)

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- Better ways to handle new challenges
  - for example multi-platform software, (software-) production lines, etc.

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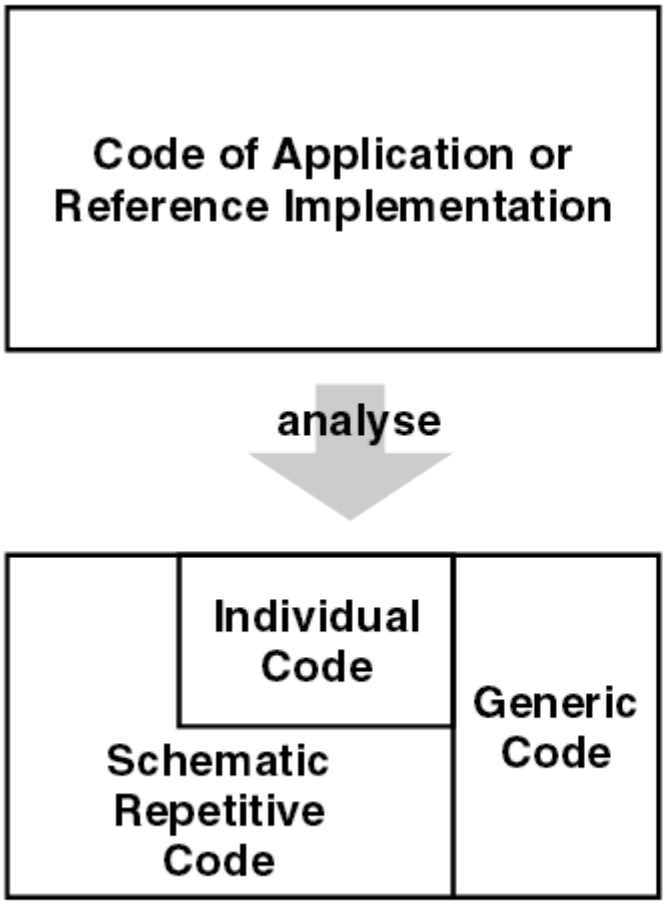
  - Event-Driven Process Chain (EPCs) used to describe business processes in SAP systems
  - BPEL and other languages for describing processes in Service-Oriented Architectures

The idea of MBSE/MDSD in a bit more detail



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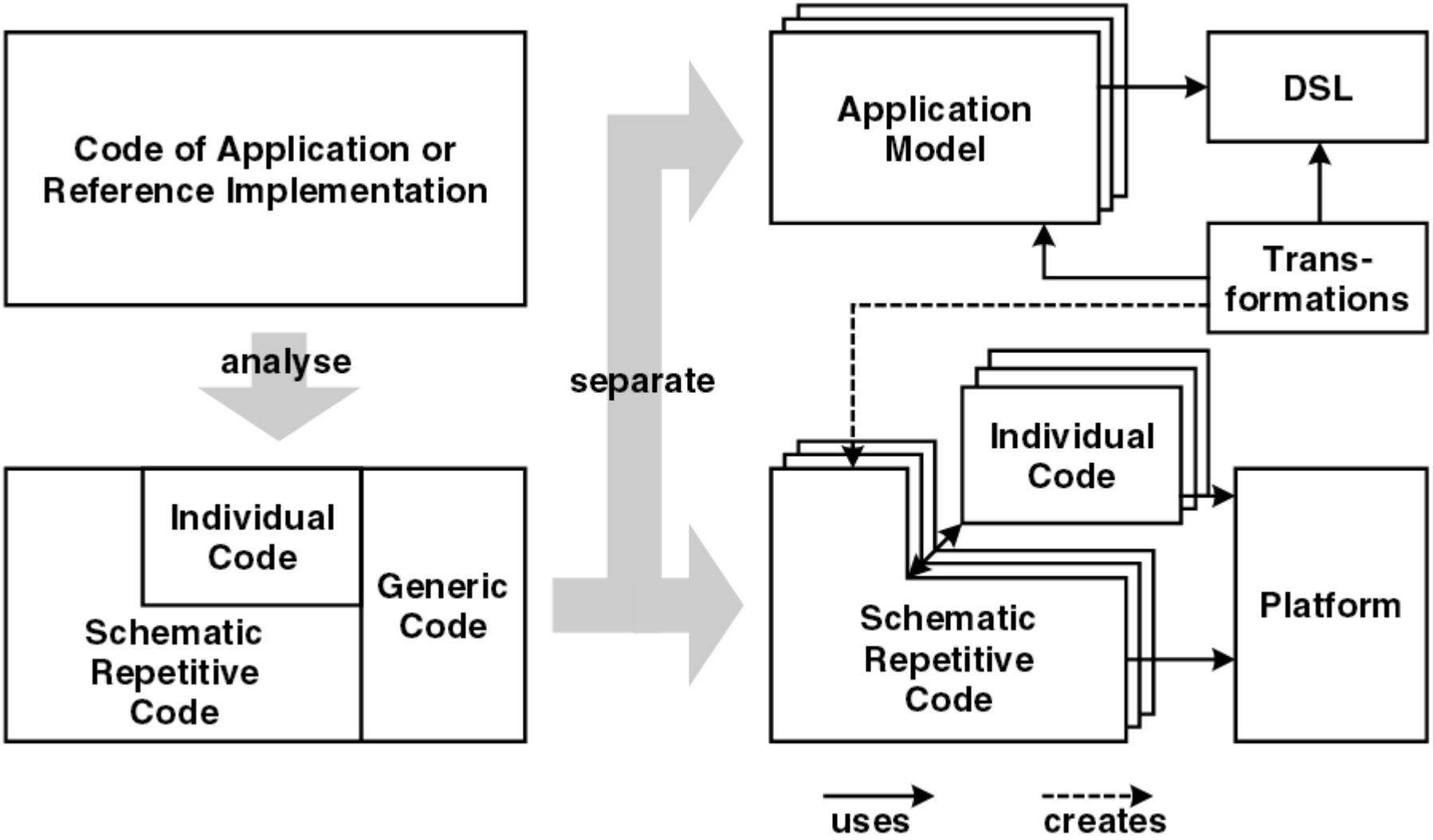

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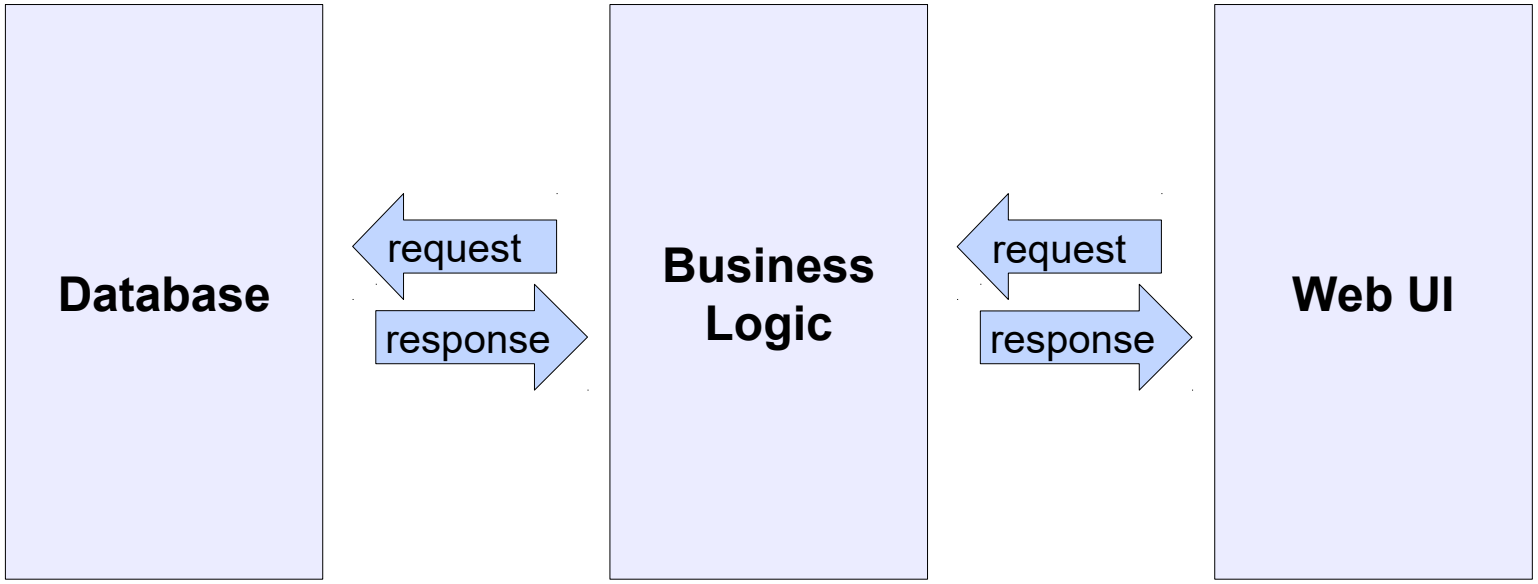
Example: MDSD for a Three-Tier Web Application



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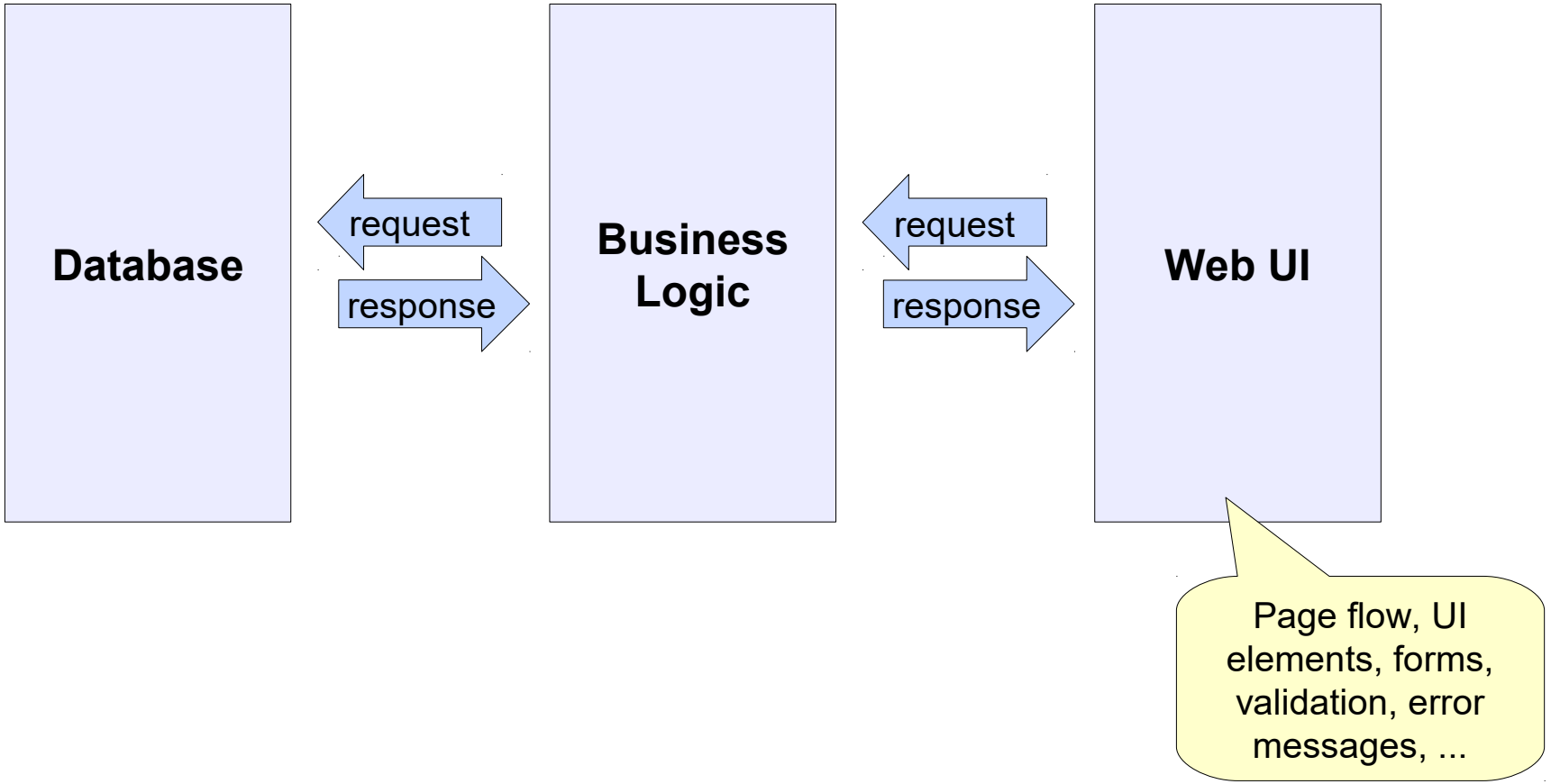

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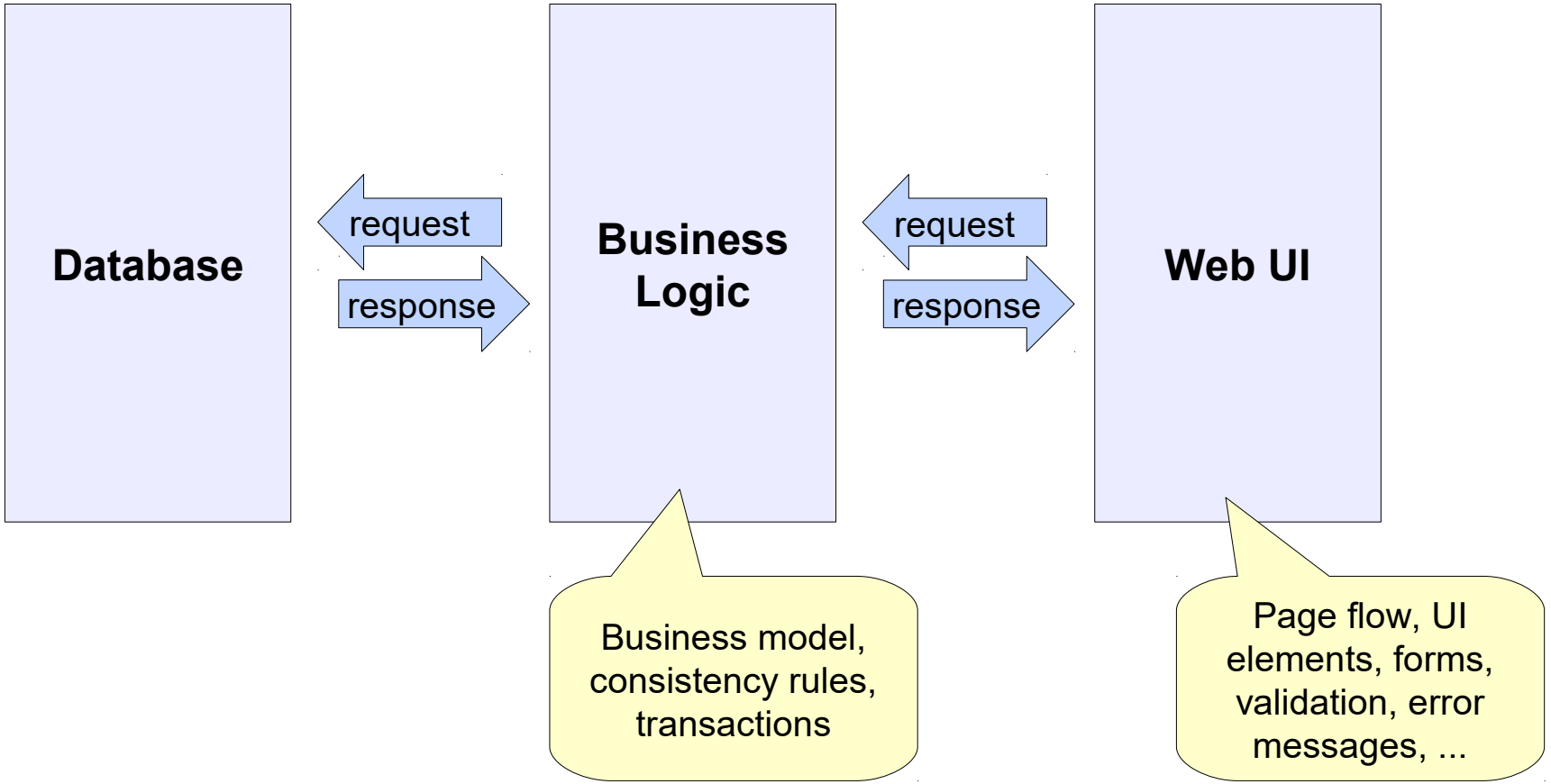

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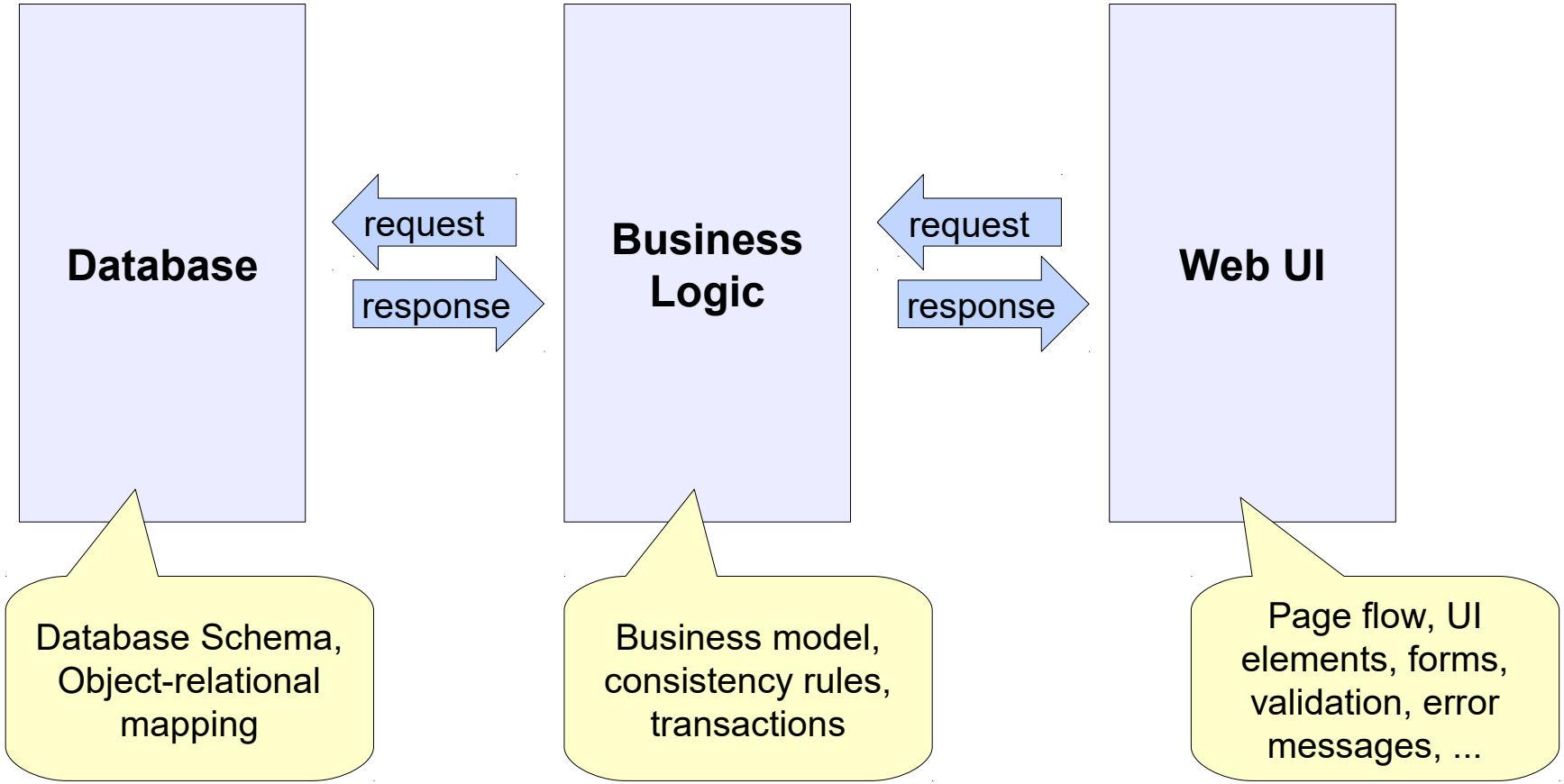

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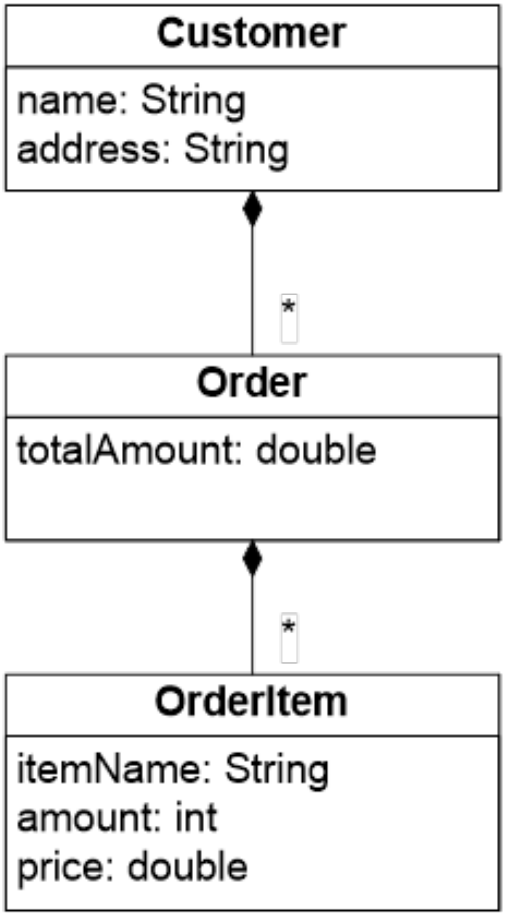
- The business model:



Example: MDSD for a Three-Tier Web Application

- Frontend
  - Apache Tomcat Web Application (WAR)
  - Java Script UI & Validation
  - Struts UI Framework
- Business Logic
  - Java EE Session Beans
  - Entity Beans
  - Pricing rules
- Database
  - Hibernate OR Mapping
  - MySQL Database

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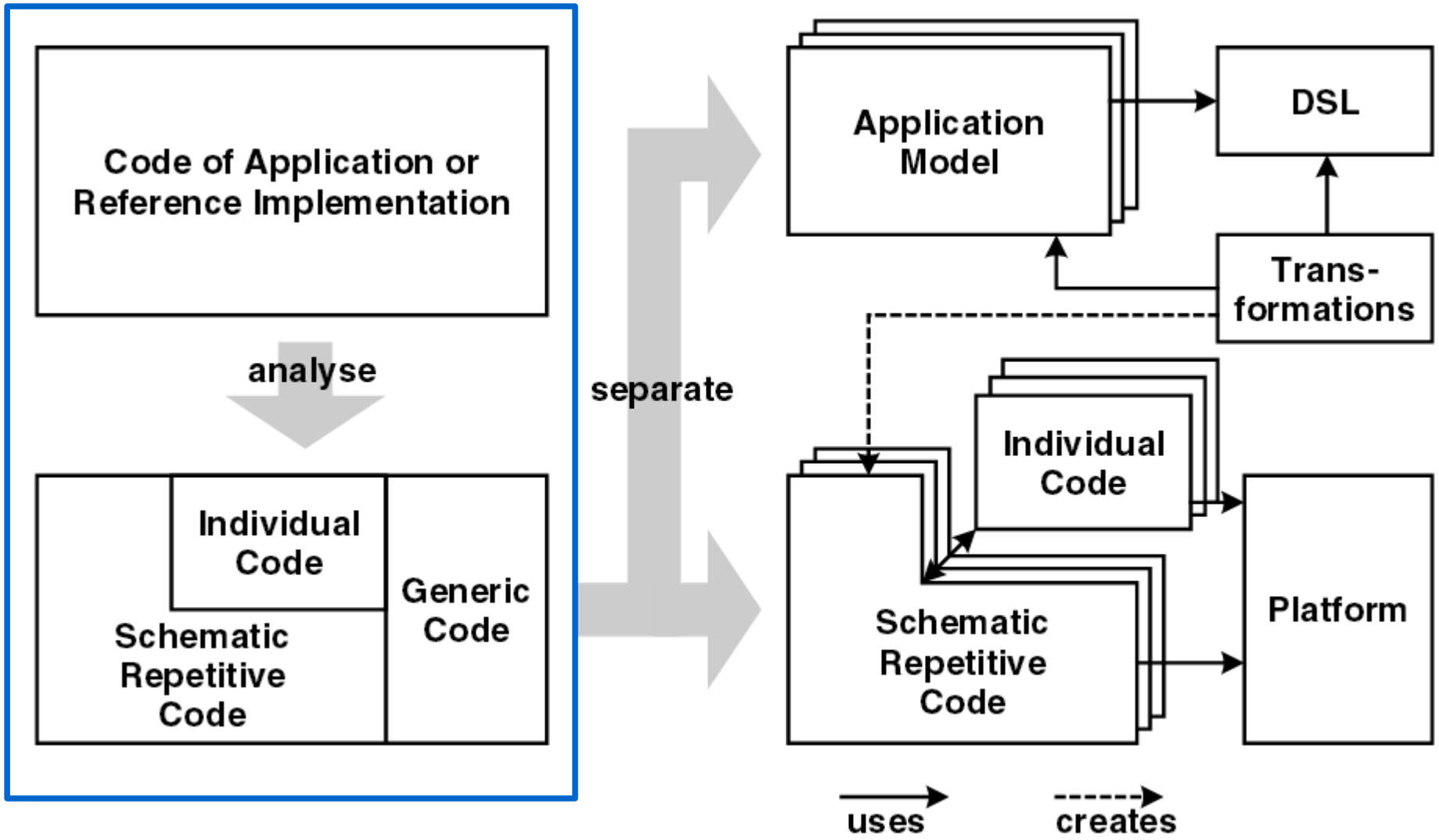

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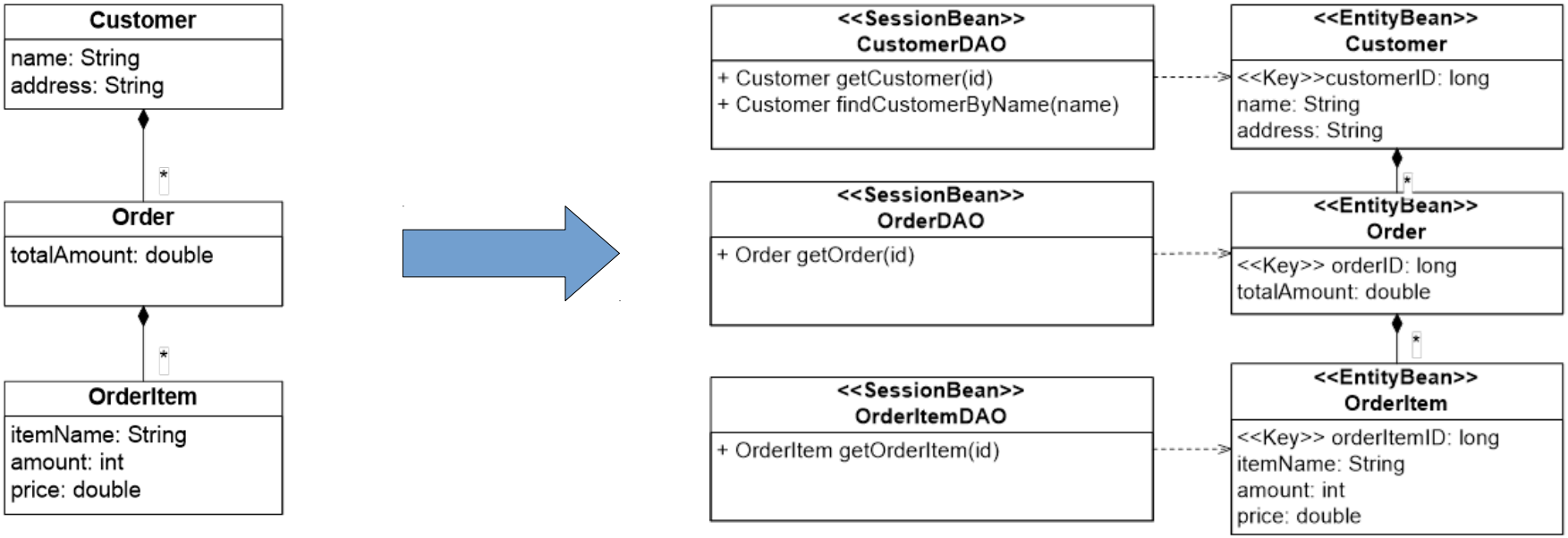
Example: MDSD for a Three-Tier Web Application

- Approach: Transform the platform-independent business model into different platform-specific models,
- For example: Generating a Bean model



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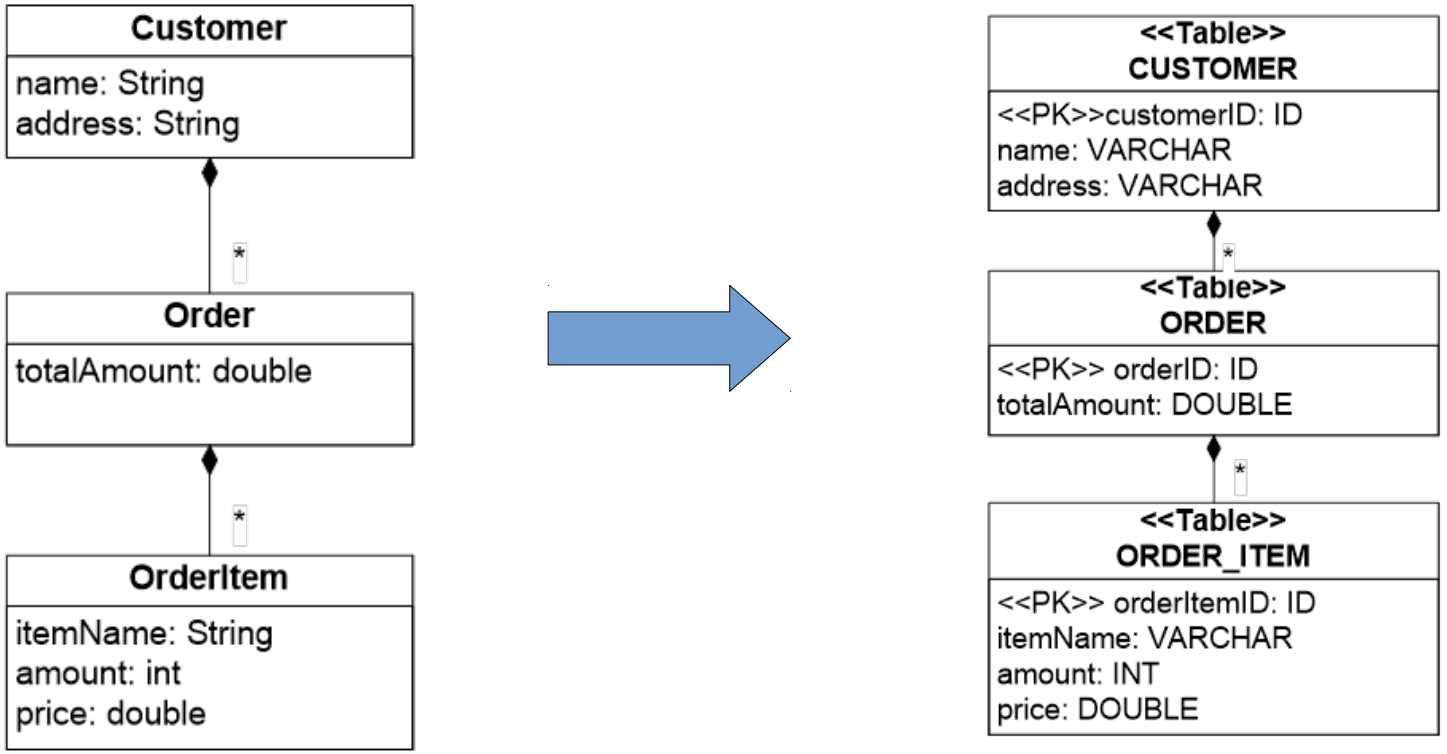
Example: MDSD for a Three-Tier Web Application

- Also generate the database schema:



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- Furthermore, generate forms, validation rules, error messages, object-relational mapping rules, configuration files, ...

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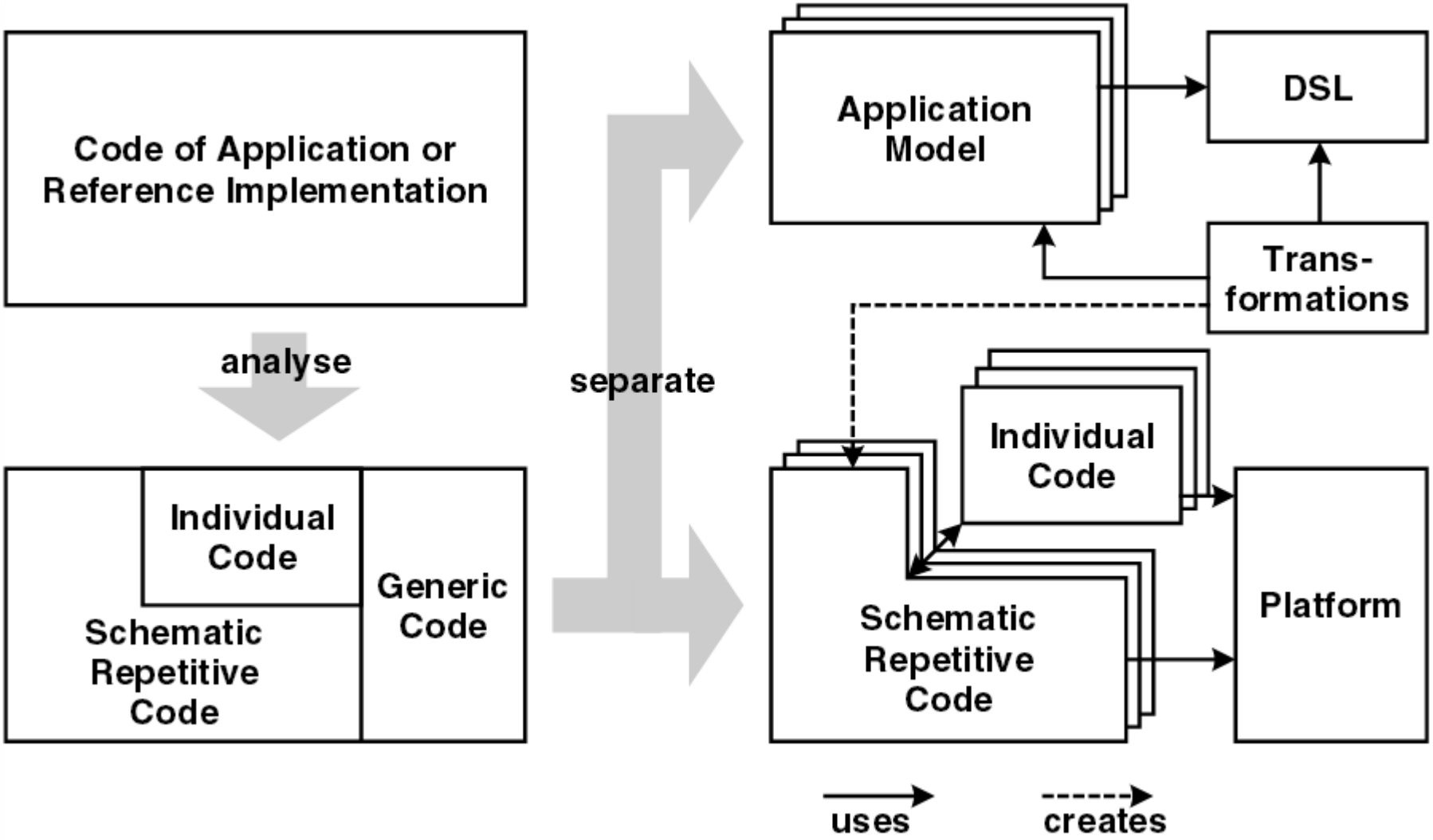
The idea of MBSE/MDSD in a bit more detail



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Agenda / Summary and Outlook

1. Motivation ✓
2. What you will learn in this lecture ✓
   - Learning Objectives
   - Topics
   - Literature
3. Organizational Issues ✓
4. Introduction: ✓
   - What is a model?
   - What is model-based software engineering (MBSE)?
   - What are reasons for doing MBSE?

What's next: Meta-modeling – defining modeling languages