Web Engineering

Development Processes for Web Applications

Prof. Dr. Alexander Knapp
Dr. Nora Koch

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Ludwig-Maximilians-Universität München

Definition

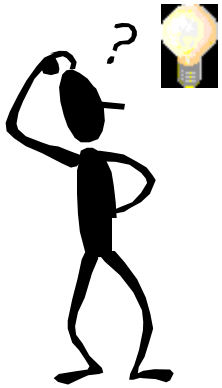
- Web engineering is the application of a systematic and quantifiable approach to cost-effective requirements analysis, design, implementation, testing, operation, and maintenance of high-quality Web software.
- Web engineering is also the scientific discipline concerned with the study of these approaches.

Gerti Kappel, Birgit Pröll, Siegfried Reich,
Werner Retschitzegger: Web Engineering, (2006)

- Web software is created via a development process, not a manufacturing process. It means that software creation is always engineering.

Victor Basili et al. (2006)

From the Idea to the Software Product



- The roadmap to building high quality software products is the software process
- A software process provides a framework for managing activities that can very easily get out of control
- Project management supports and controls the development

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<li><a href="blatt-01.pdf">Übungsblatt 1</a></li>
<li><a href="blatt-02.pdf">Übungsblatt 2</a></li>
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<a href="http://www.pst.informatik.uni-muenchen.
de/projekte/uwe/argouwe.shtml"></a><br />
<ul><li>Lösungsvorschläge zu Blatt 1 (Aufgabe
1a und 1c) und Blatt 4 als <a title="Lösungen
Blatt 1 und 4" href="Web-FilmDB.zip">ArgoUWE
Modell</a></li><li><a title="loesungsvorschlag-02.zip"
href="loesungsvorschlag-02.zip">Lösungsvorschläge
zu Blatt 2</a></li>
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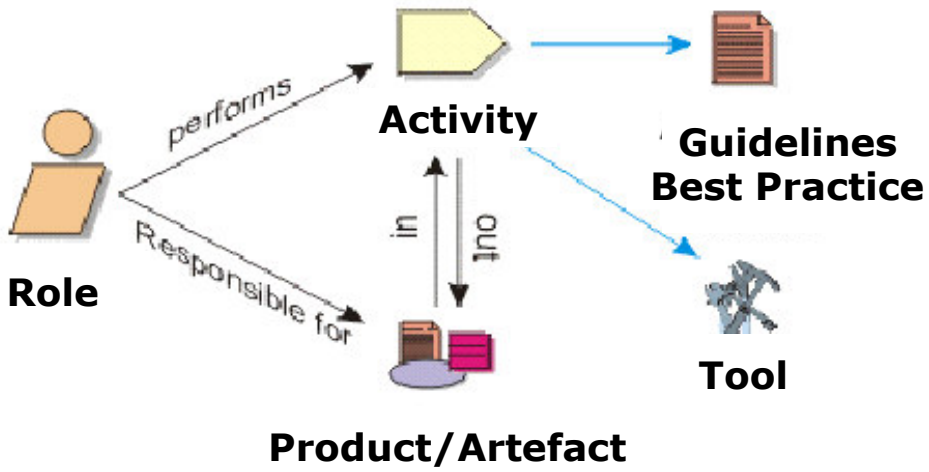
Phases in Development Processes for Web Applications

- Feasibility study
  - analysis of technologies
  - availability of resources
- Requirements analysis
  - elicitation
  - specification
  - validation
- Design
  - modelling
  - Web pages style design
  - selection of Web architecture
- Implementation
  - coding
  - content creation or import
  - testing
  - documentation
- Quality assurance
  - verification
  - performance evaluation
- Deployment
  - distribution
  - configuration
  - training
- Maintenance
  - changes
  - documentation
- Project management
  - planning
  - cost estimation
  - risk management

Development Process Basics

- Resources to be used in the project
  - budget, time, team (role, actor), tools, best practice (guidelines)...
- Activities to be performed to achieve the project goal
  - tasks
- Products to be delivered
  - results, artefacts, deliverables, milestones



Waterfall vs. Iterative Development Processes

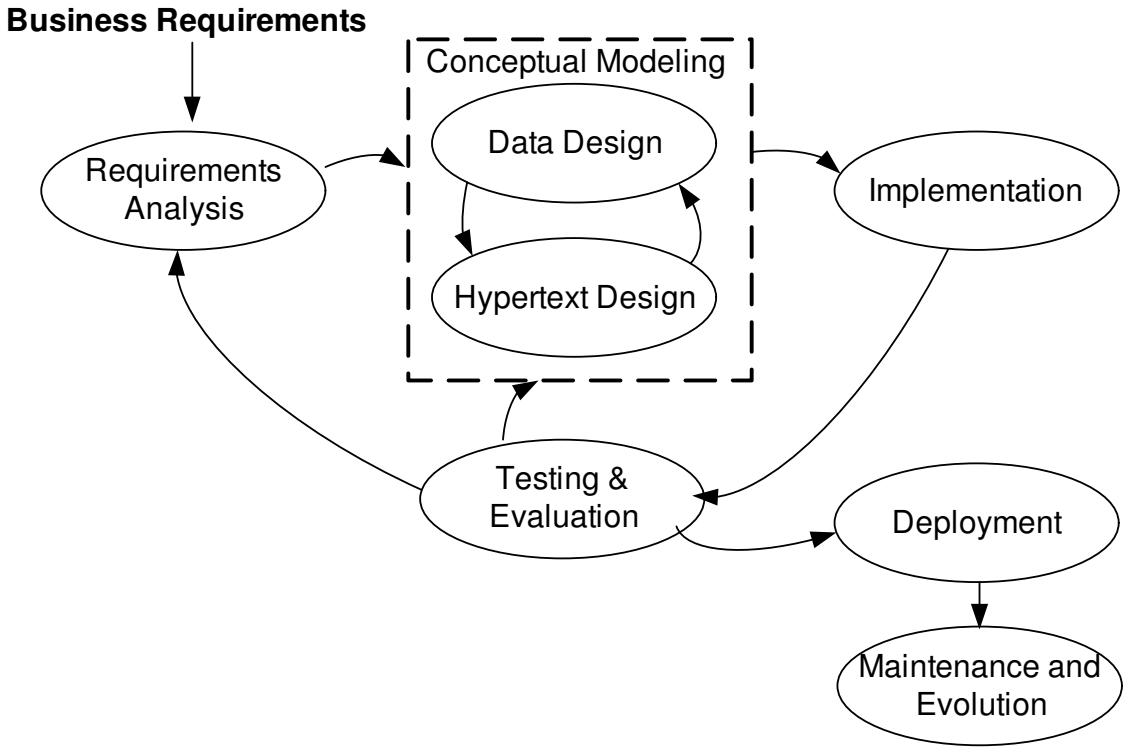
- Waterfall
  - first step is the capture all requirements followed by estimation of costs and scheduling, then design, implementation and deployment
  - not appropriate if requirements change or are unreliable
  - examples in the Web Domain
    - RMM: Relationship Management Methodology
    - WSDM: Web-System Design Method

- Iterative
  - approach to build software in several iterations in sequence
  - each iteration is a self-contained mini-project (requirements, analysis, design, programming, testing, …)
  - goal: production of an executable iteration release (integration and testing of all software)
  - examples in the Web Domain
    - WebML methodology

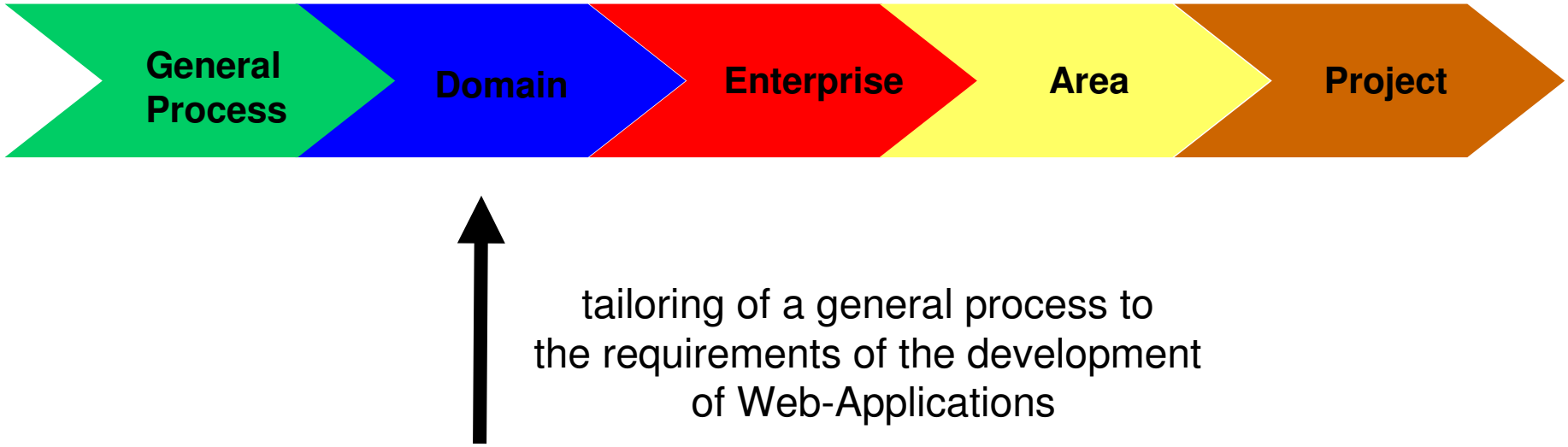
WebML

- WebML is a visual language for specifying the content structure of a Web application and the organization and presentation of such content in a hypertext

- Inspired by Boehm's spiral model (Boehm, 1988)
- iterative and incremental
- prototype or partial version of the application in each iteration
- tested and evaluated and extended
- support WebRatio tool

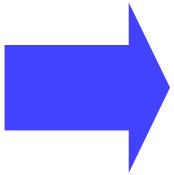


Development Process Adaptation



Requirements for Web Development Processes

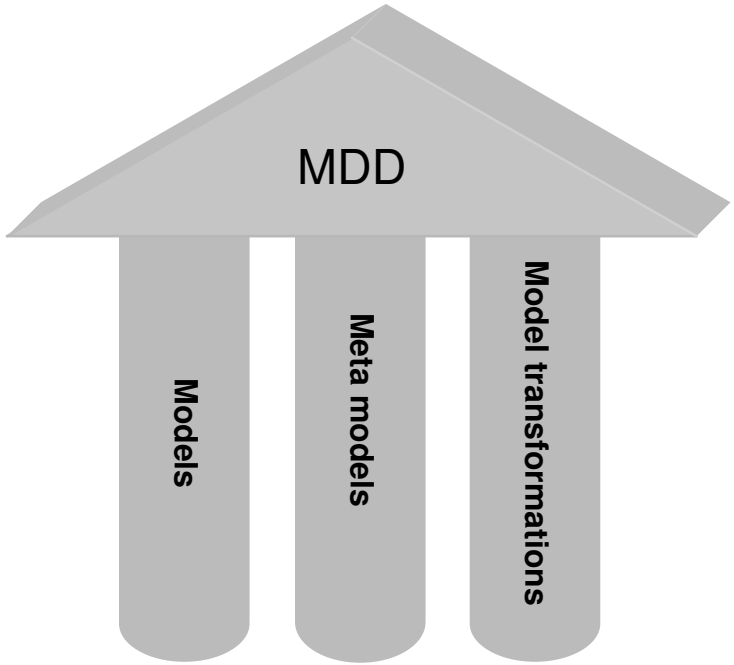
- Appropriate for short software life-cycles
  - average 3 to 6 months
  - time-to-market pressure
  - co-existence of releases
- Separation of concerns
  - content, structure, presentation, …
- Change management
  - continuous update of content
  - changes in structure
  - changes and improvements in layout and user interface functionality
  - adaptation to new technologies and standards



Model-Driven Development (MDD)
seems to be a promising approach in the Web Domain

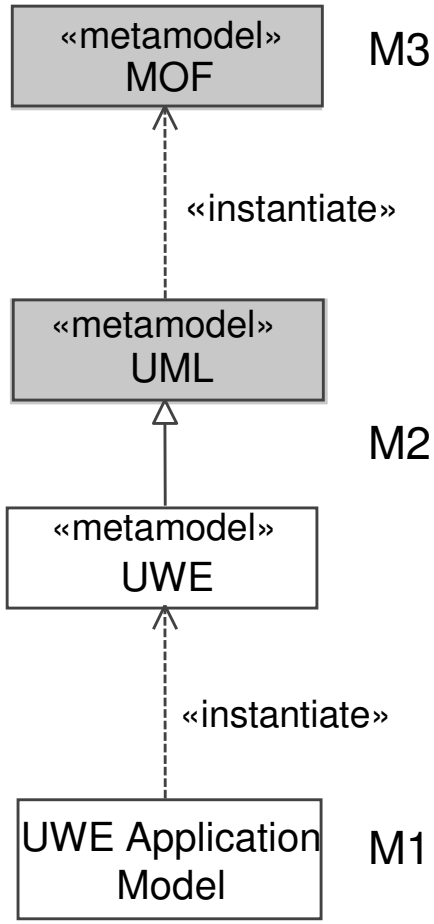
Model-Driven Development Approaches

- MDD approaches based on
  - models and model transformations
- MDD approaches require languages for
  - specification of models
  - description of metamodels
  - definition of model transformations
- MDD in the Web Domain
  - several methods propose modelling
    - OOHDM, OO-H, UWE, WebML, Hera,…
    - separation of concerns
    - similar Web specific modelling elements
    - different notations
  - some methods define metamodel for modelling languages
    - OO-H, UWE, W2000, WebML, …
  - few approaches address model transformations
    - OOWS, UWE, WebSA, …



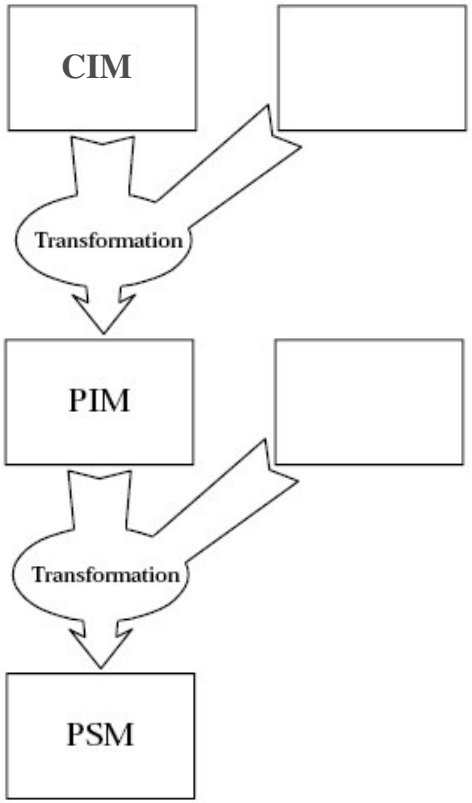
MDD Principles: Models and Metamodels

- Models
  - computational independent model (CIM)
  - platform independent model (PIM)
  - platform specific model (PSM)
- Metamodels
  - definition of concepts and relationships among concepts
  - compatibility with the OMG metamodelling architecture
  - MOF meta-metamodel
    - XMI interchange format → tool compatibility (theoretically)
  - static semantics given by OCL constraints (well-formedness rules)
  - basis for tool support



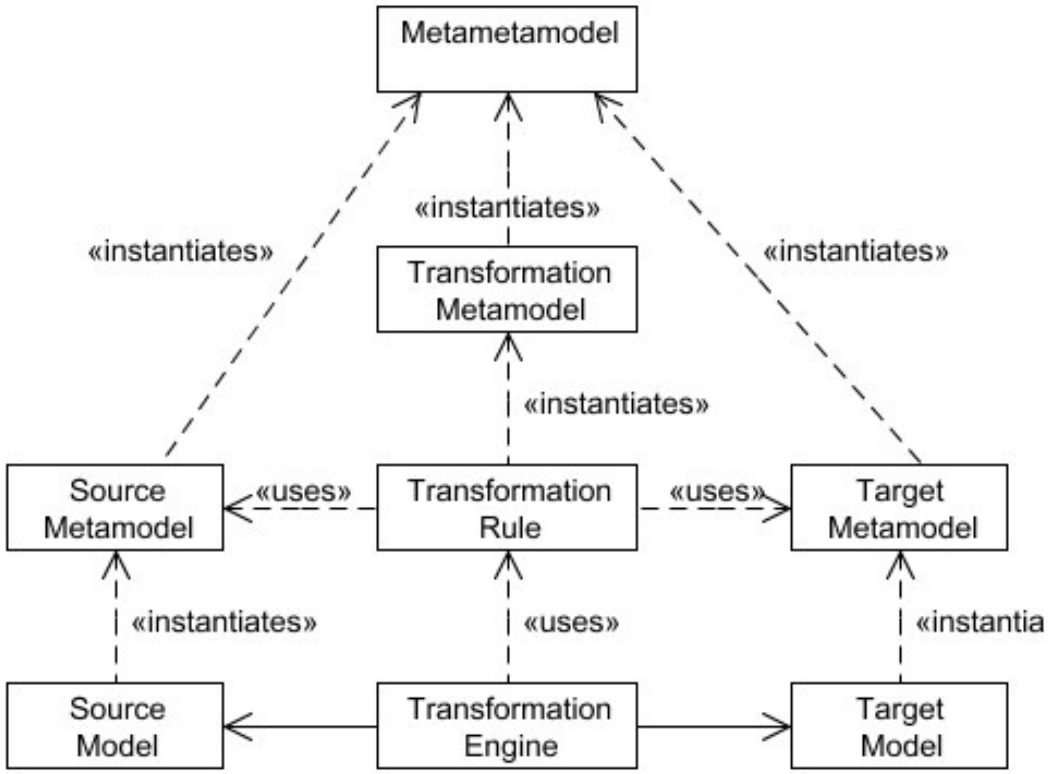
MDD Principles: Model Transformations

- Model transformations
  - CIM→PIM, PIM→PIM, PIM→PSM
- Model transformation languages
  - general programming languages
    - Java
  - graph transformation languages
    - Attribute Graph Grammar (AGG)
  - query/view/transformation languages
    - QVT
    - ATLAS Transformation Language (ATL)
- OMG standards
  - MOF, UML, OCL, XMI, QVT



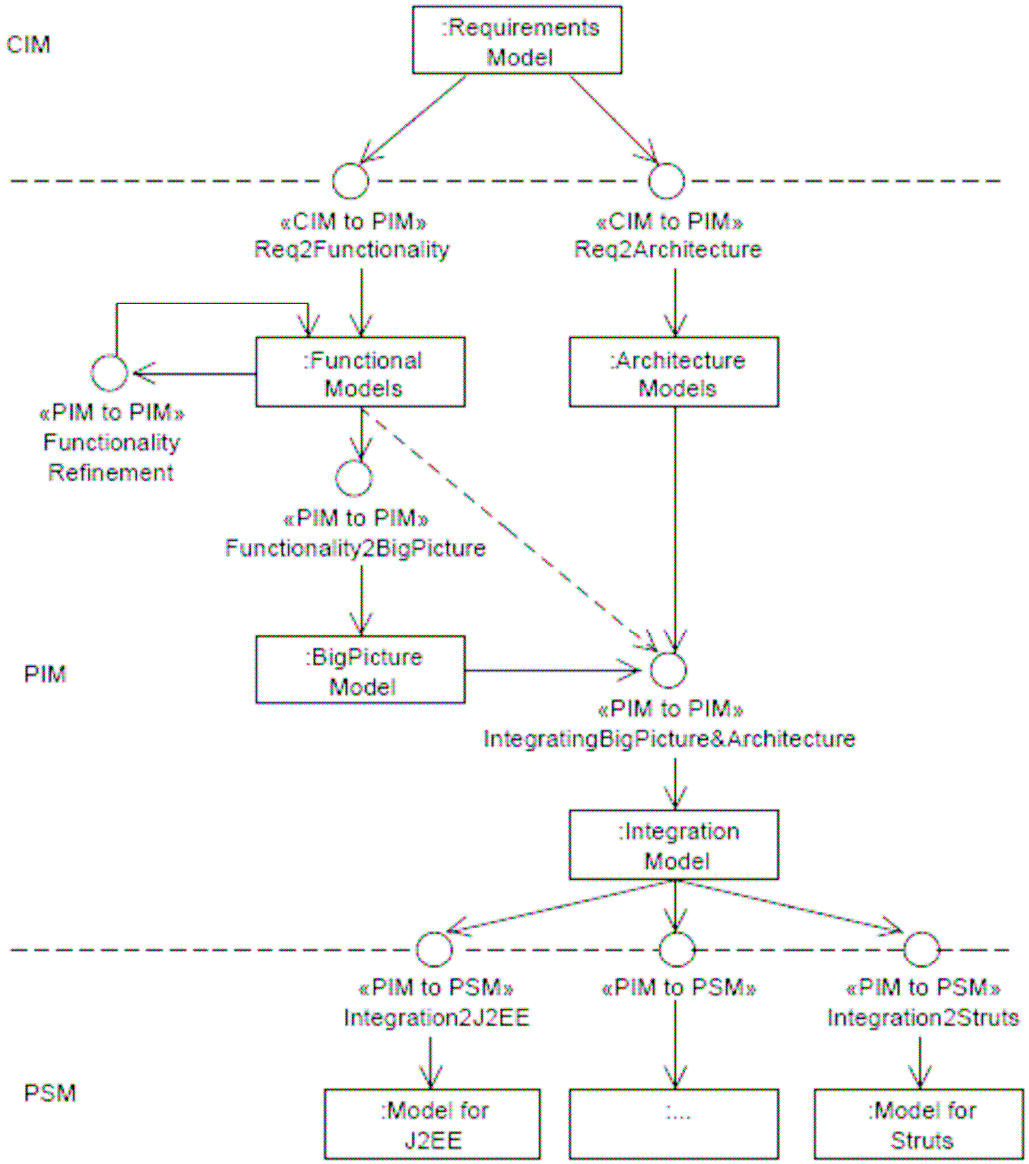
Model Transformations

- Translate between source and target models
  - instances of same or different metamodel
- Translation performed by a transformation engine
- Transformation engine executes rules
- Transformation rules are
  - defined at metamodel level
  - applied at model level
- Set of rules
  - seen as a model
  - with a metamodel
- Metamodels are based on a metametamodel



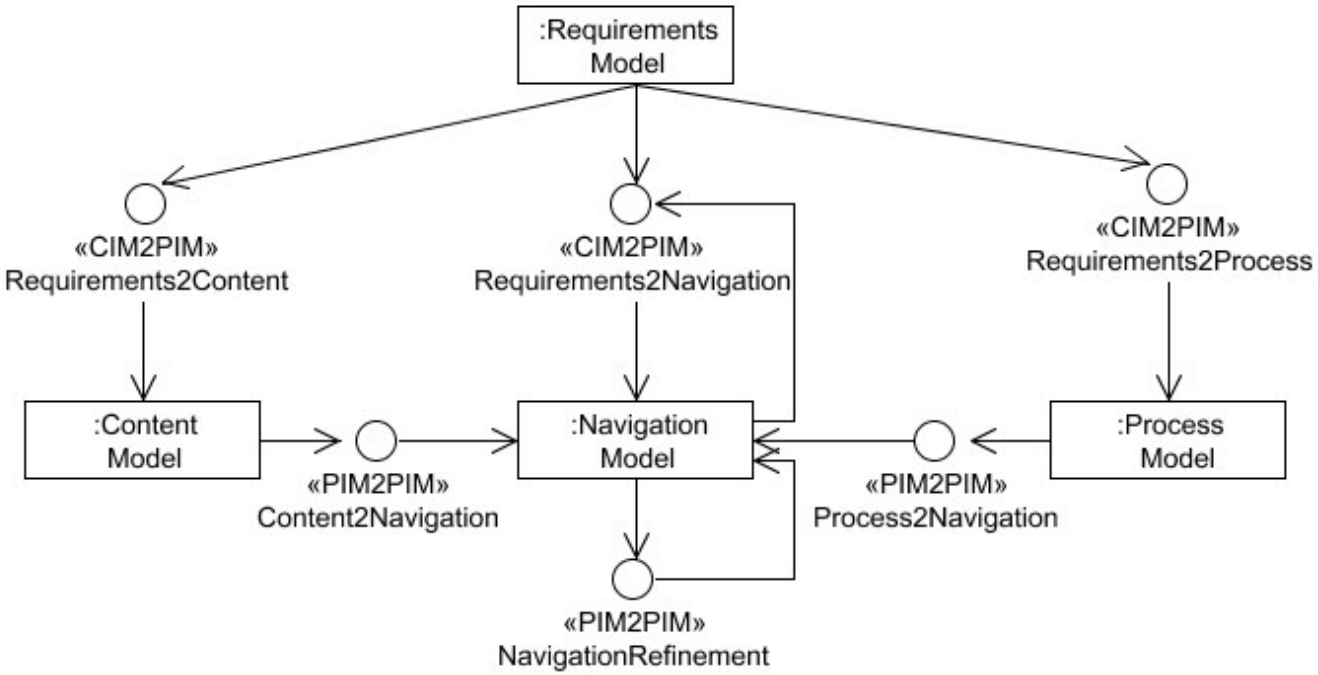
Model transformation pattern (J. Bézivin, 2004)

Model-Driven Process of UWE



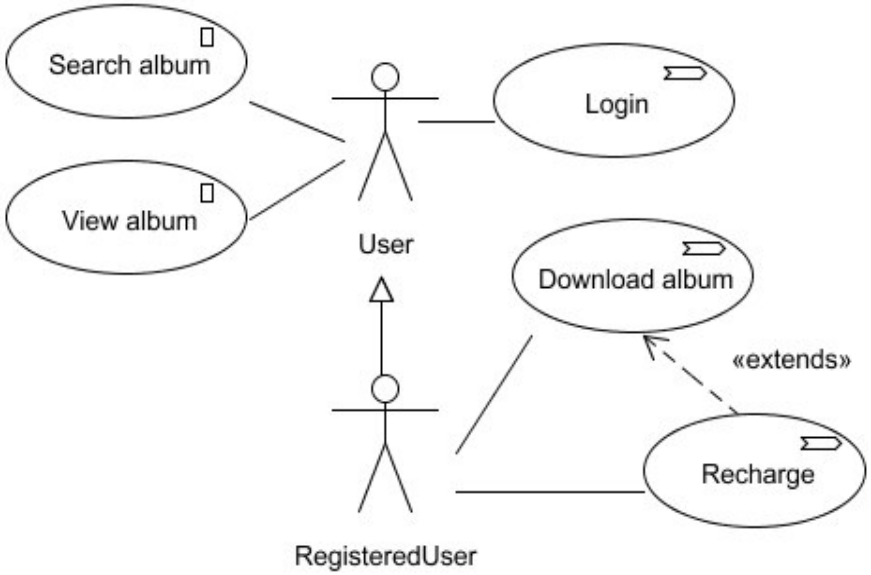
- Graphical representation of the process
  - process as UML activity diagram
  - model transformations as stereotyped UML actions
  - models as UML object flow states
  - implicit initial and final state
- Types of models in UWE
  - requirements model (CIM)
  - functional models (PIM)
    - content model
    - navigation model
    - ...
  - architecture models (PIM)
  - integration models (PIM)
  - models for J2EE, .Struts (PSM)

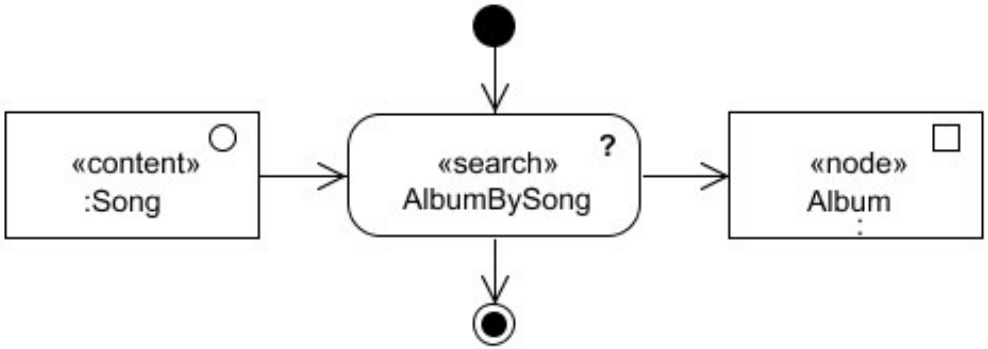
UWE Development Process
Requirements to Functional Models



Music Portal Example (excerpt)

- Requirements model
  - UML use case diagrams
  - UML activity diagrams
- Web requirements engineering profile (WebRE)
  - WebUser,
  - navigation, WebProcess
  - browse, search, …
  - content, node, …

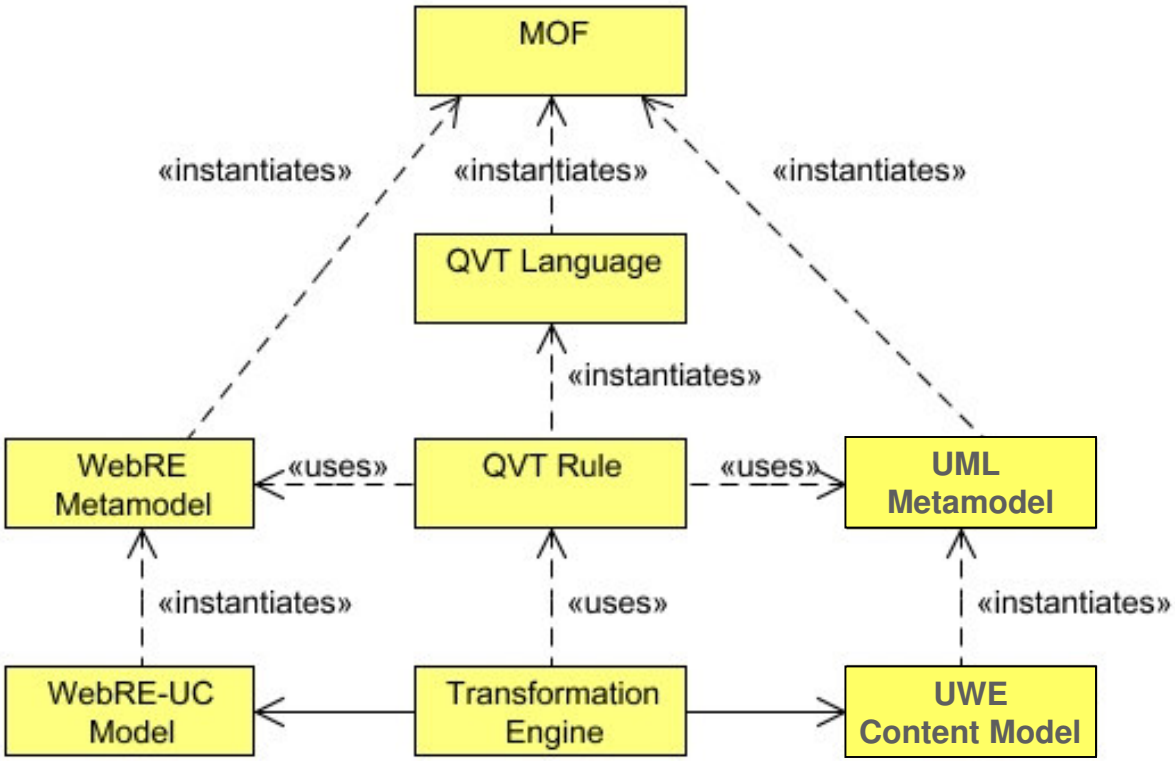




Query View Transformation Language (QVT)

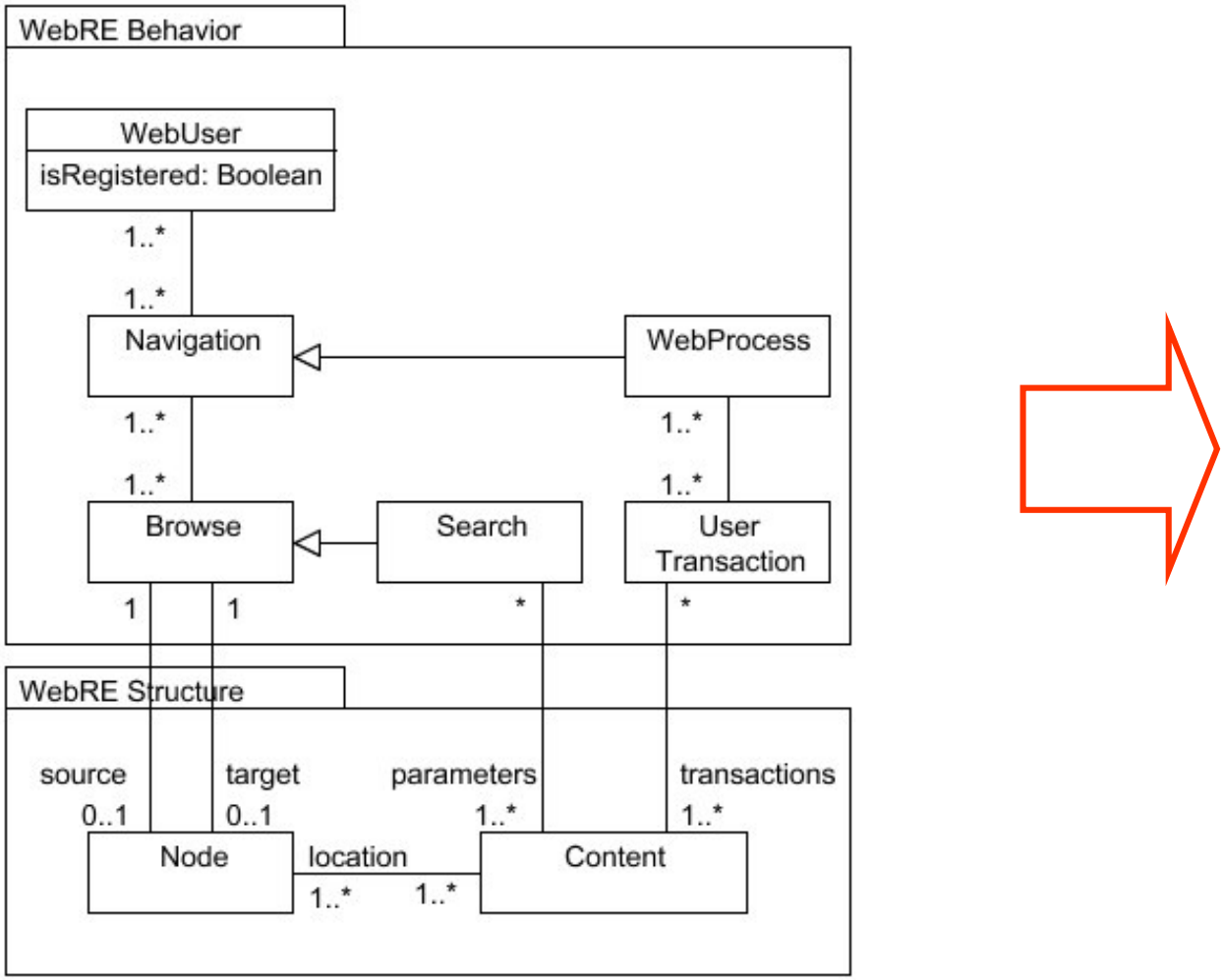
- Request for proposal launched by OMG
  - to define a standard way to transform source models into target models
  - compatible with the MDA recommendation suite: UML, MOF, OCL, etc.
- Ideas in this proposal
  - source and target models may conform to arbitrary MOF metamodels
  - transformation program is considered itself as a model, and as a consequence also conforms to a MOF metamodel
- QVT comprises three languages
  - relations, core and operational mappings
- QVT relations and core are declarative languages
  - relations language has a graphical concrete syntax
- QVT operational mapping language is an imperative language
  - that extends both QVT relations and QVT core
  - syntax of the QVT operational mappings language provides constructs commonly found in imperative languages (loops, conditions, etc.)
- Partial QVT implementations
  - SmartQVT (op), OptimalJ (core), ATL (QVT-like)

Model Transformations Pattern

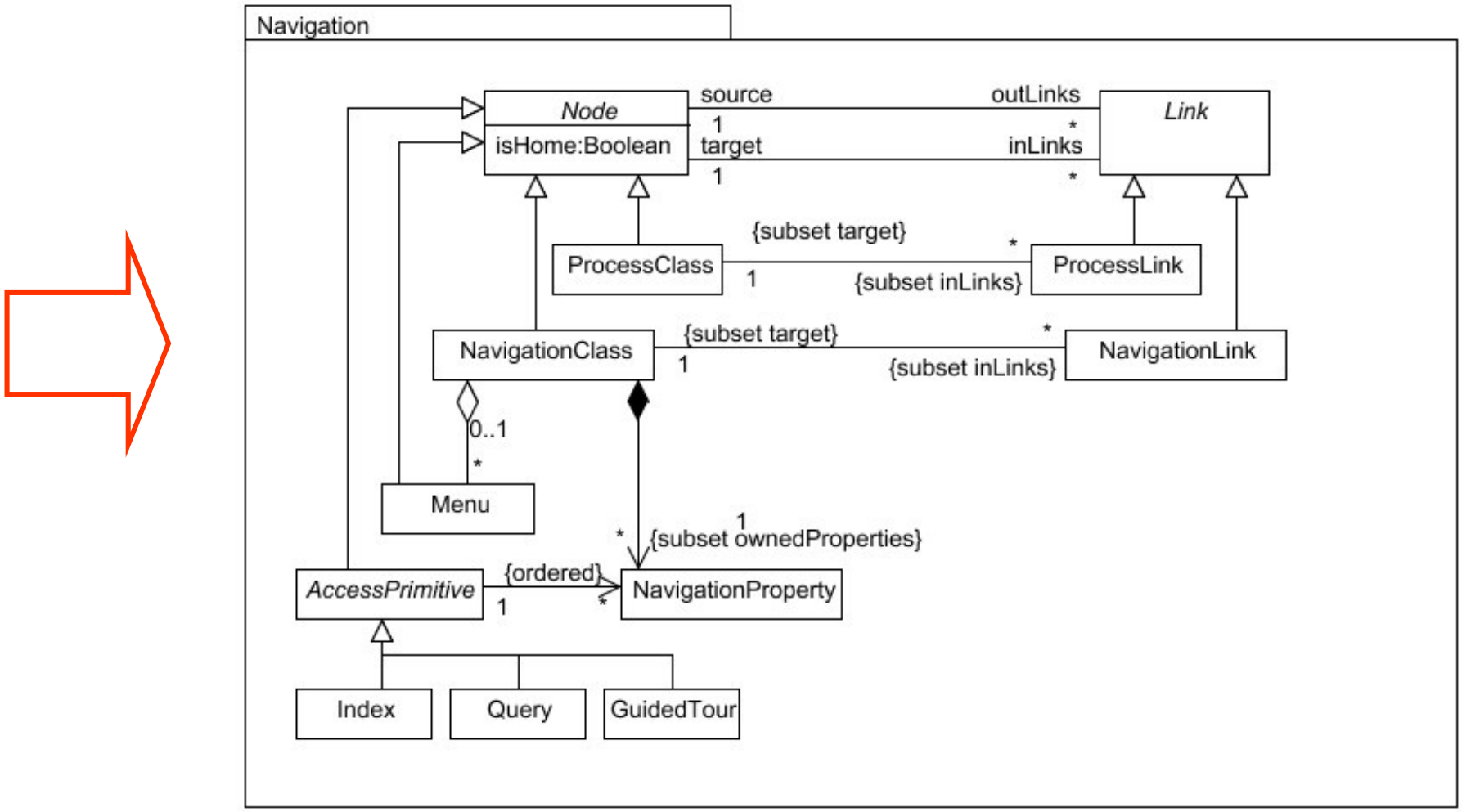


Model transformation pattern (J. Bézivin, 2004)

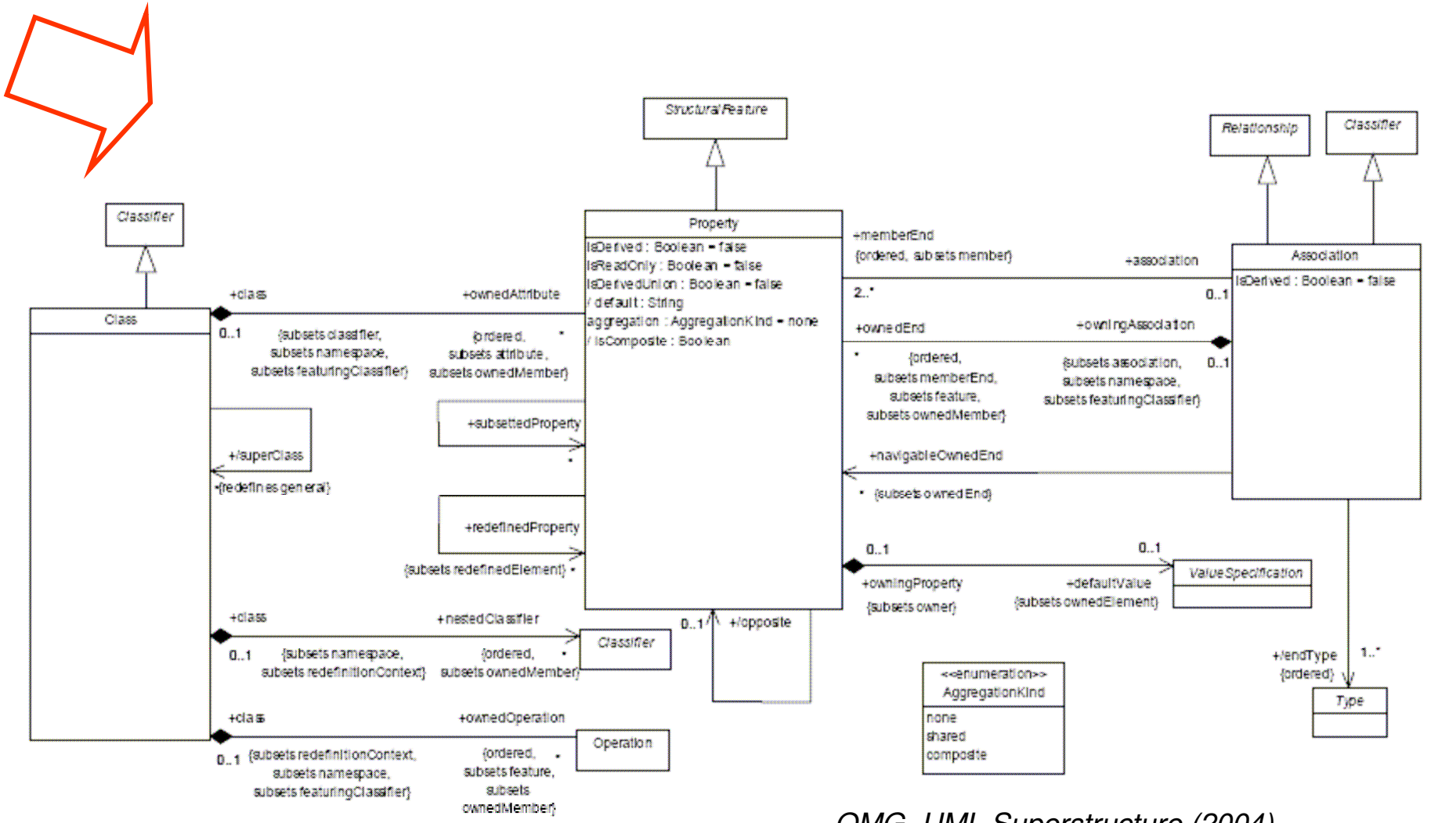
WebRE Metamodel



UWE Metamodel: Navigation Package



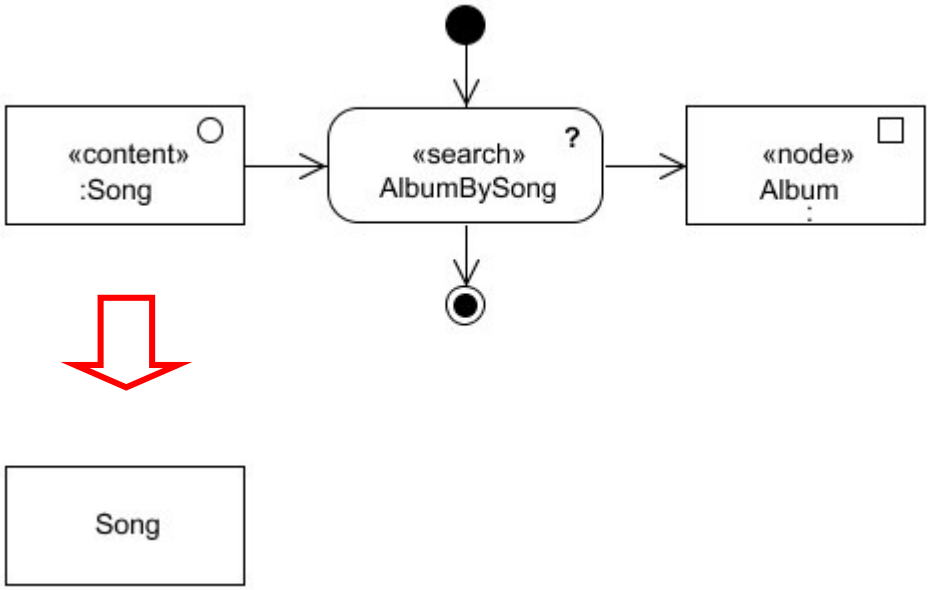
UML Metamodel



OMG, UML Superstructure (2004)

Transforming Requirements to Content (1)

- Source: requirements model (UML activity diagram)
  - objects input for Web actions
  - objects result of Web actions
- Target: content model
  - classes of the content model
- Profile-based transformation



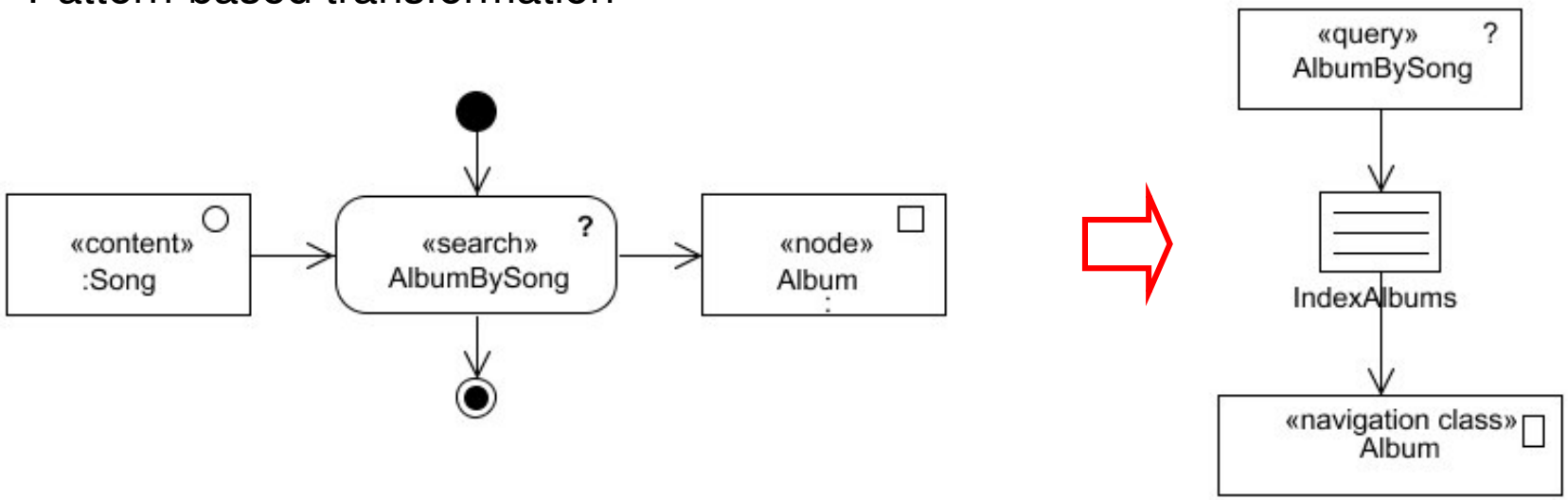
Transforming Requirements to Content (2)

- Model transformation language
  - Query View Transformation (QVT)
  - textual notation
- Transformation rule

```
transformation ReqContent2ContentClass (webre:WebRE,uwe:UWE) {
     top relation R1 {
         checkonly domain webre  c: Content {name = n};
         enforce   domain uwe    cc: Class {name = n}; }
     top relation R2 {cn: String;
         checkonly domain webre  p: Property {namespace=c:
                                 Content{}, name =  cn};
         enforce domain uwe  p1: Property {namespace = cc: Class{};
                                 name = cn }
         when {R1 (c,cc);}
      }
}
```

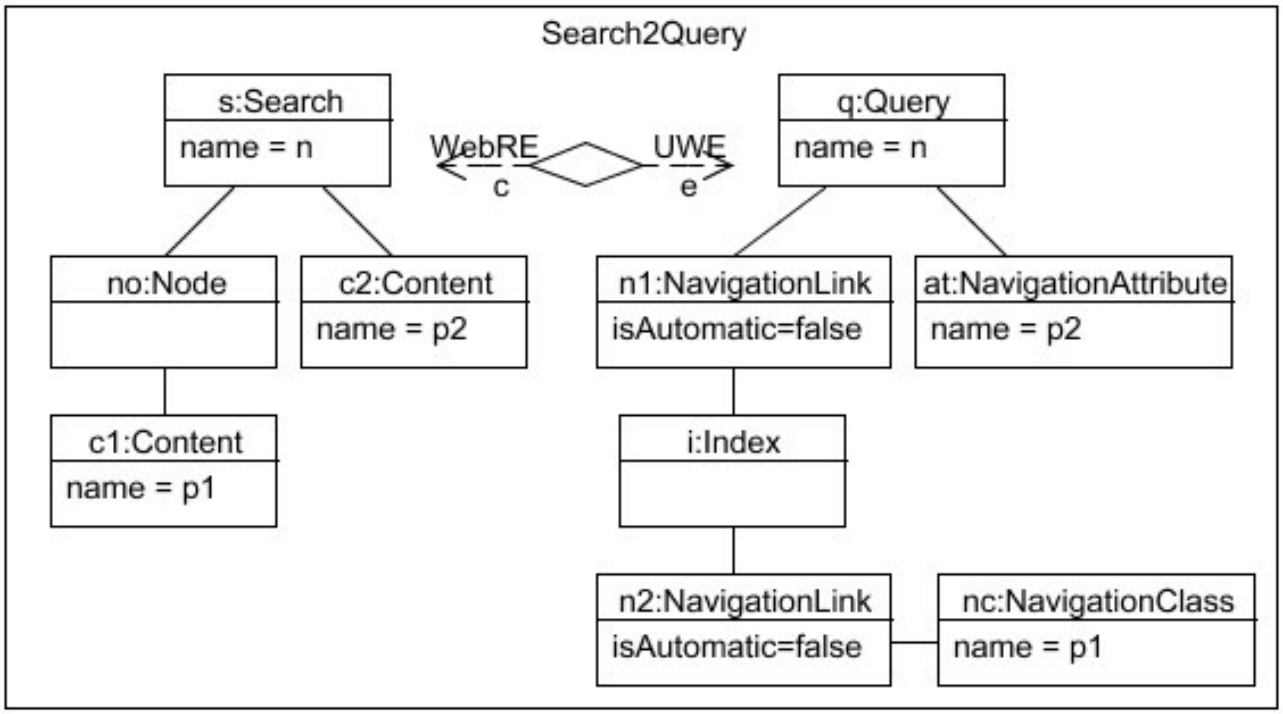
Transforming Requirements to Navigation Elements (1)

- Source: requirements model (UML activity diagram)
  - search action
  - content and node object flow states
- Target: navigation model
  - query and index class
  - navigation class
  - navigation link
- Pattern-based transformation

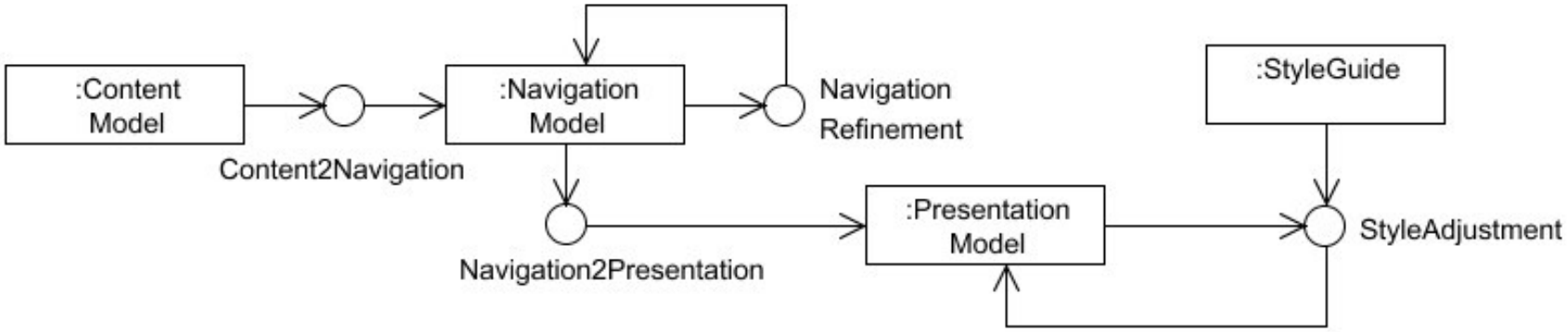


Transforming Requirements to Navigation Elements (2)

- Model transformation language
  - QVT
  - graphical notation
- Transformation rule



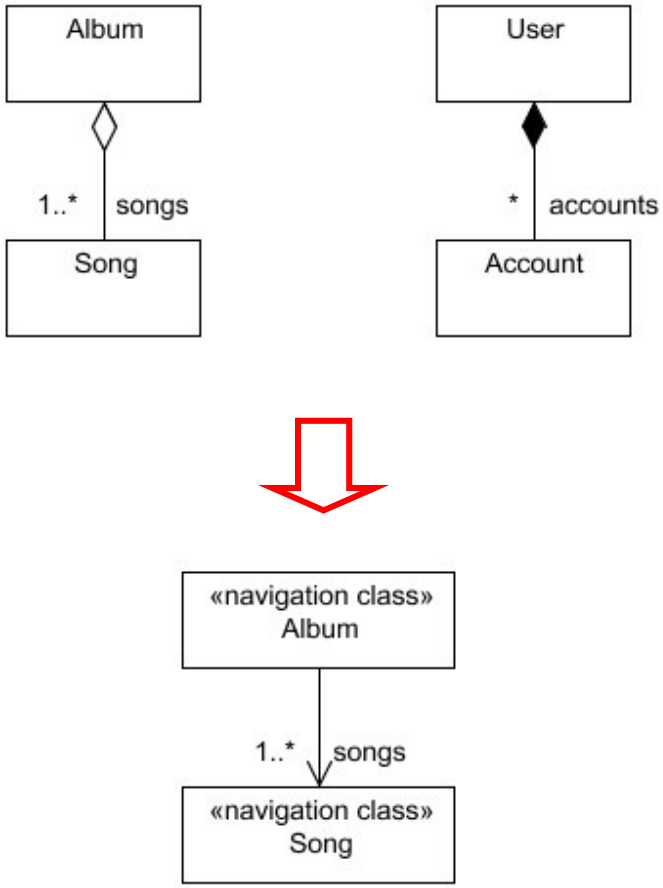
Construction of Functional Models



- UWE metamodel and UWE profile
  - navigation elements: *navigation class, navigation link, index*, …
  - presentation elements: *presentation class, anchor, image*, …
- Case tool ArgoUWE
  - extension of ArgoUML
  - provides stereotypes
  - supports (semi-)automatic execution of transformations

Transforming Content to Navigation (1)

- Content2Navigation
  - generates navigation classes from content classes
  - adds a navigation links based on associations of the content model
- Marking elements
  - identification of classes of the content model that are relevant for the navigation view
  - task performed by designer
- Semi-automatic transformation



ATLAS Transformation Language (ATL)

- ATL is a model transformation language
  - developed at INRIA to answer the QVT Request for Proposal
- ATL can be used for syntactic or semantic translation.
  - It is built on top of a model transformation Virtual Machine
- ATL development toolkit
  - plugin available in open source from the GMT Eclipse Modeling Project (EMP)
  - implements the MOF Query/View/Transformation language QVT

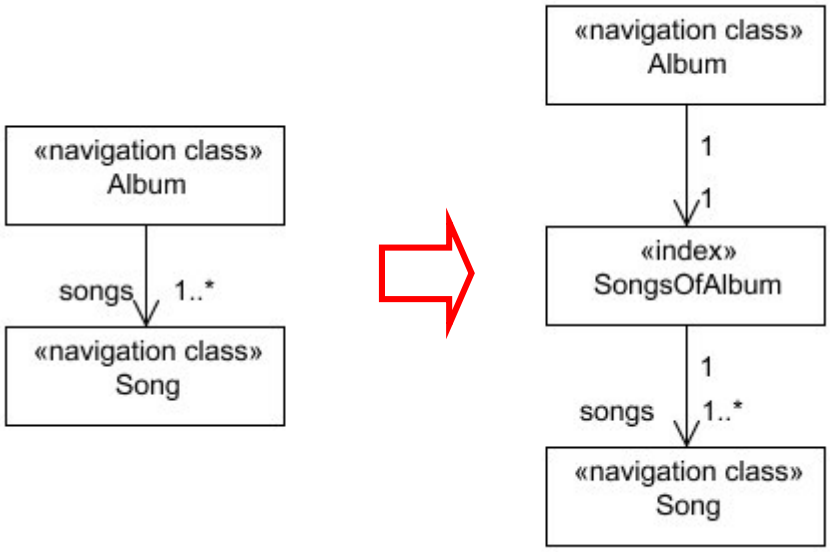
Transforming Content to Navigation (2)

- Implementation
  - Java within CASE tool ArgoUWE
  - ATL (ATLAS Transformation Language)
- ATL transformation rule

```
rule Class2NavigationClass {
   from c : UML!Class ( c.oclIsTypeOf( UML!Class ) )
   to  nc : UWE!NavigationClass (
            name <- c.name,
            ownedAttribute <- c.ownedAttribute->select( p |
                   p.association.oclIsUndefined() ) )
}
```

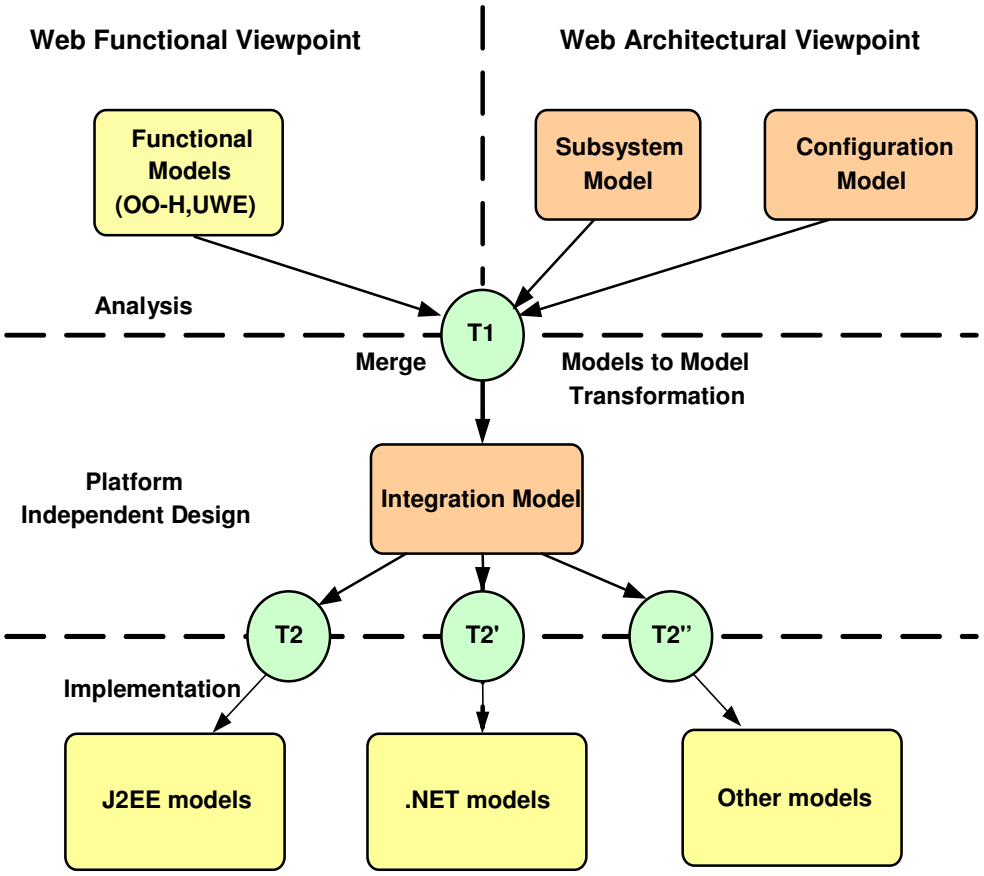
Refinement of Navigation Model

- Improvement based on patterns
  - index for associations with multiplicity greater than one at the directed association end
  - menu for navigation classes with multiple outgoing associations
- Implementation
  - Java in ArgoUWE
  - ATL



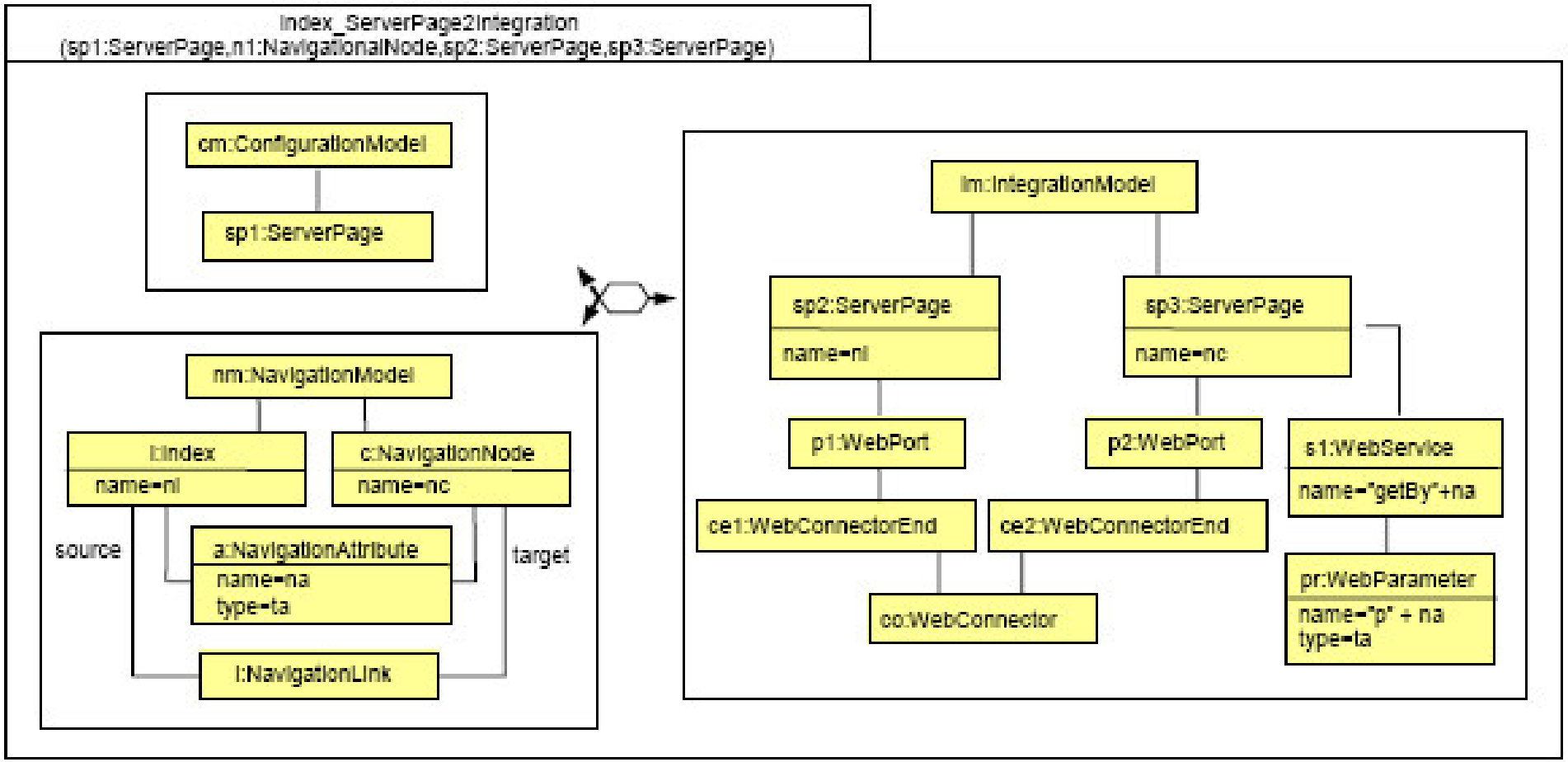
Integration with Architecture Models

- Web Software Architecture (WebSA) approach*
  - domain specific language for modelling architectural views of Web applications
    - subsystem model
    - configuration model
    - integration model
  - UML profile of architectural modelling elements
    - Web component
    - Web port
    - Web connector
    - server page,
    - etc.
  - QVT-like transformations



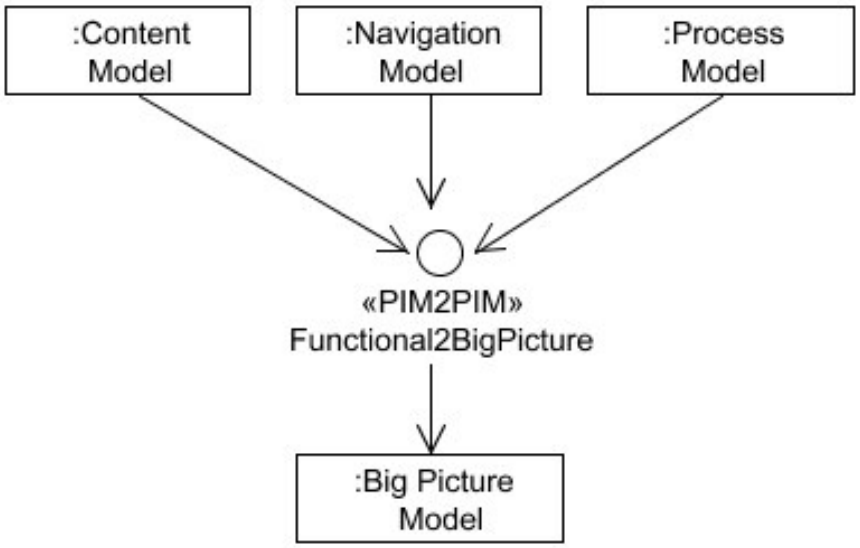
Santiago Melía, University of Alicante, PhD Thesis (2007)

Example WebSA



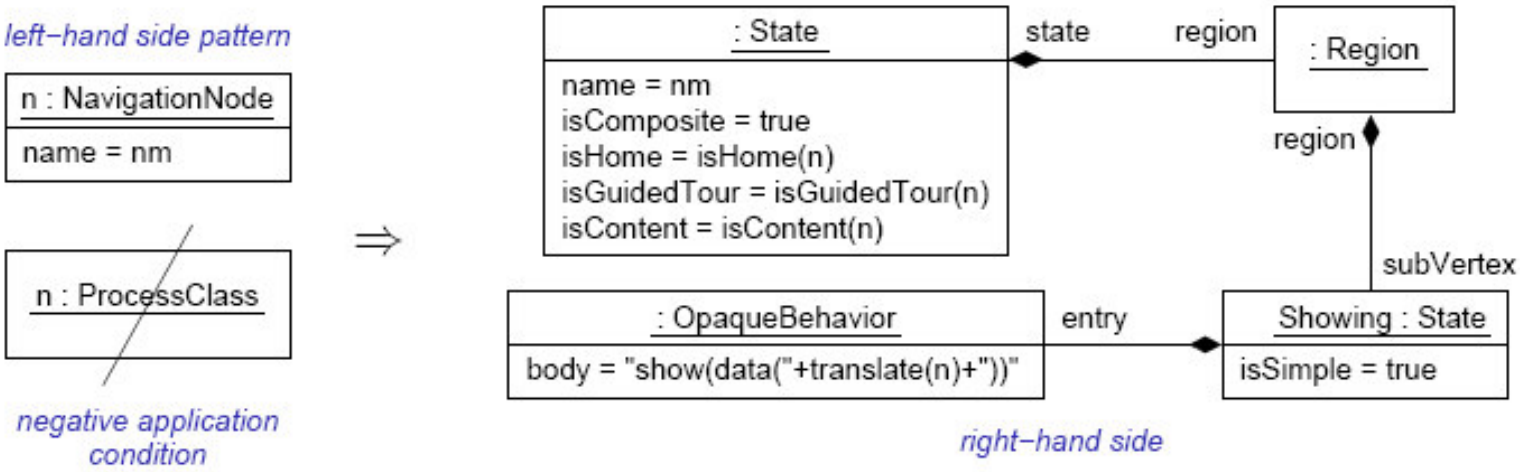
Generating “Big Picture” Model

- Generation of an integrated functional model (“big picture”)
  - transformation target UML state machine for integration of content, navigation and process models
  - graph transformation language
  - tool: Attributed Graph Grammar System (AGG)
  - validation of correctness by model checking

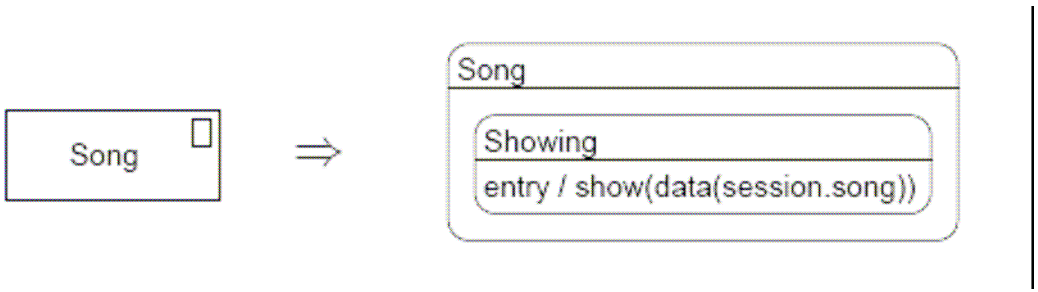


Big Picture: Transformation of Navigation Model

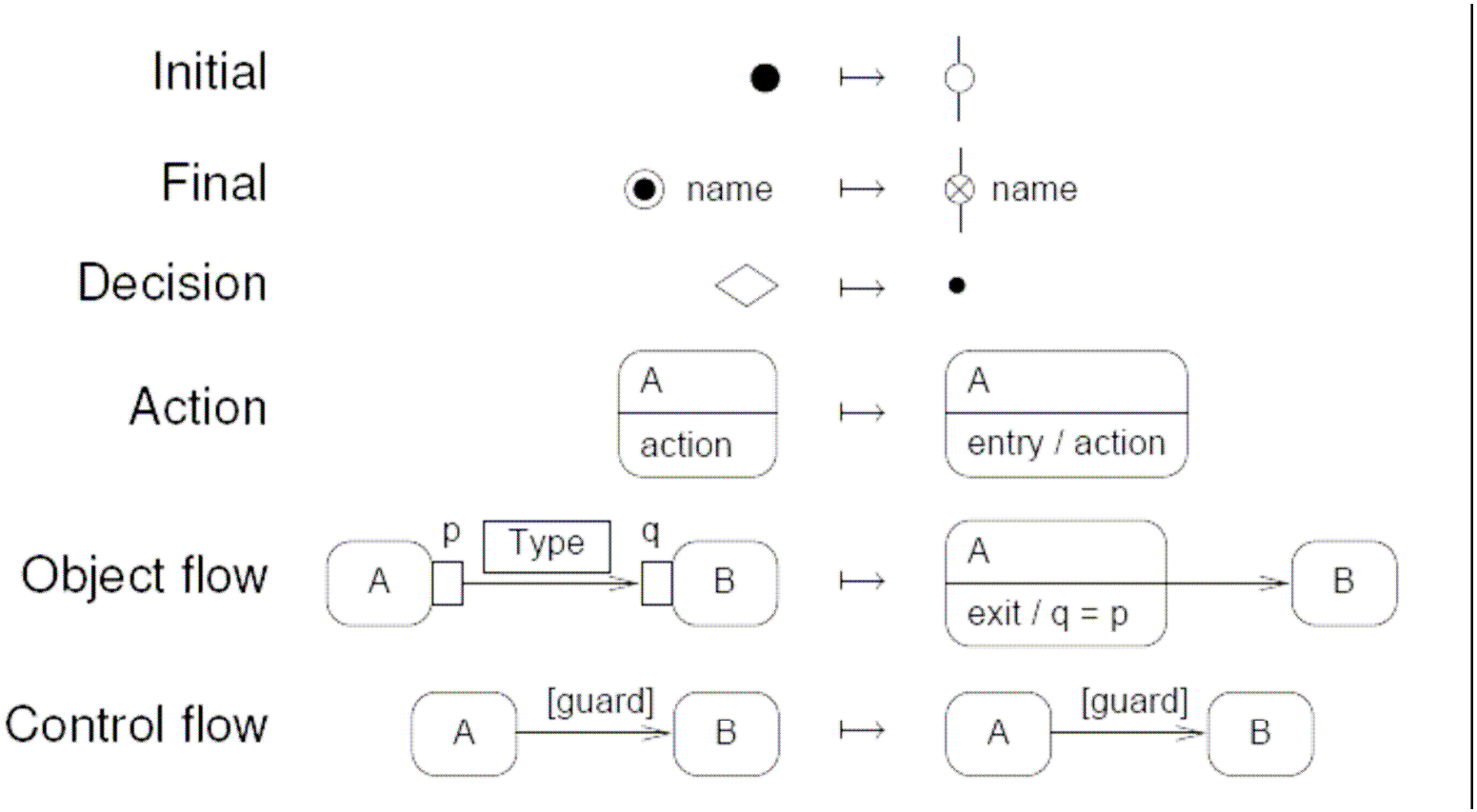
- capture navigation nodes as states (with parameters for data)



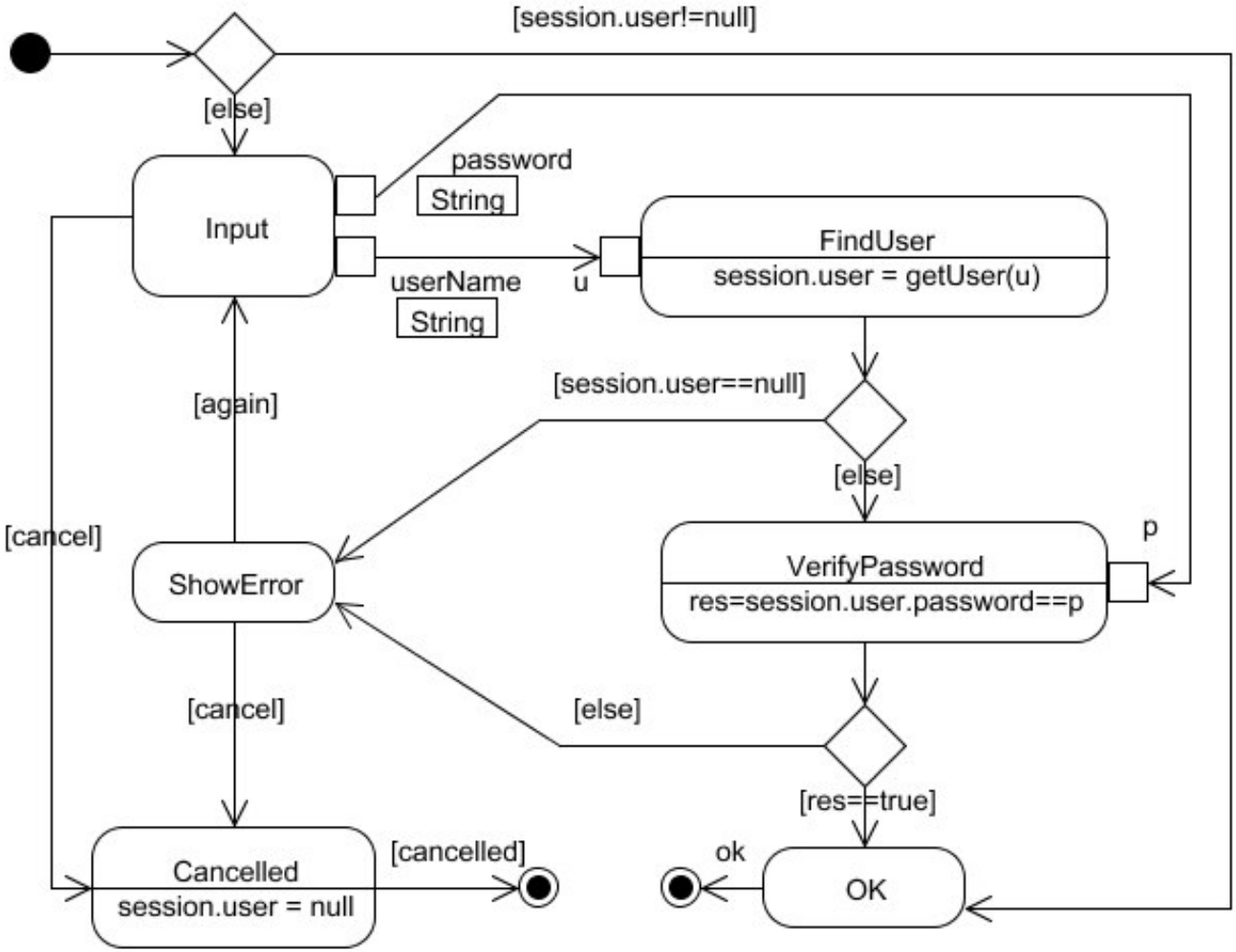
- Example: music portal: transformation for navigation node “song”



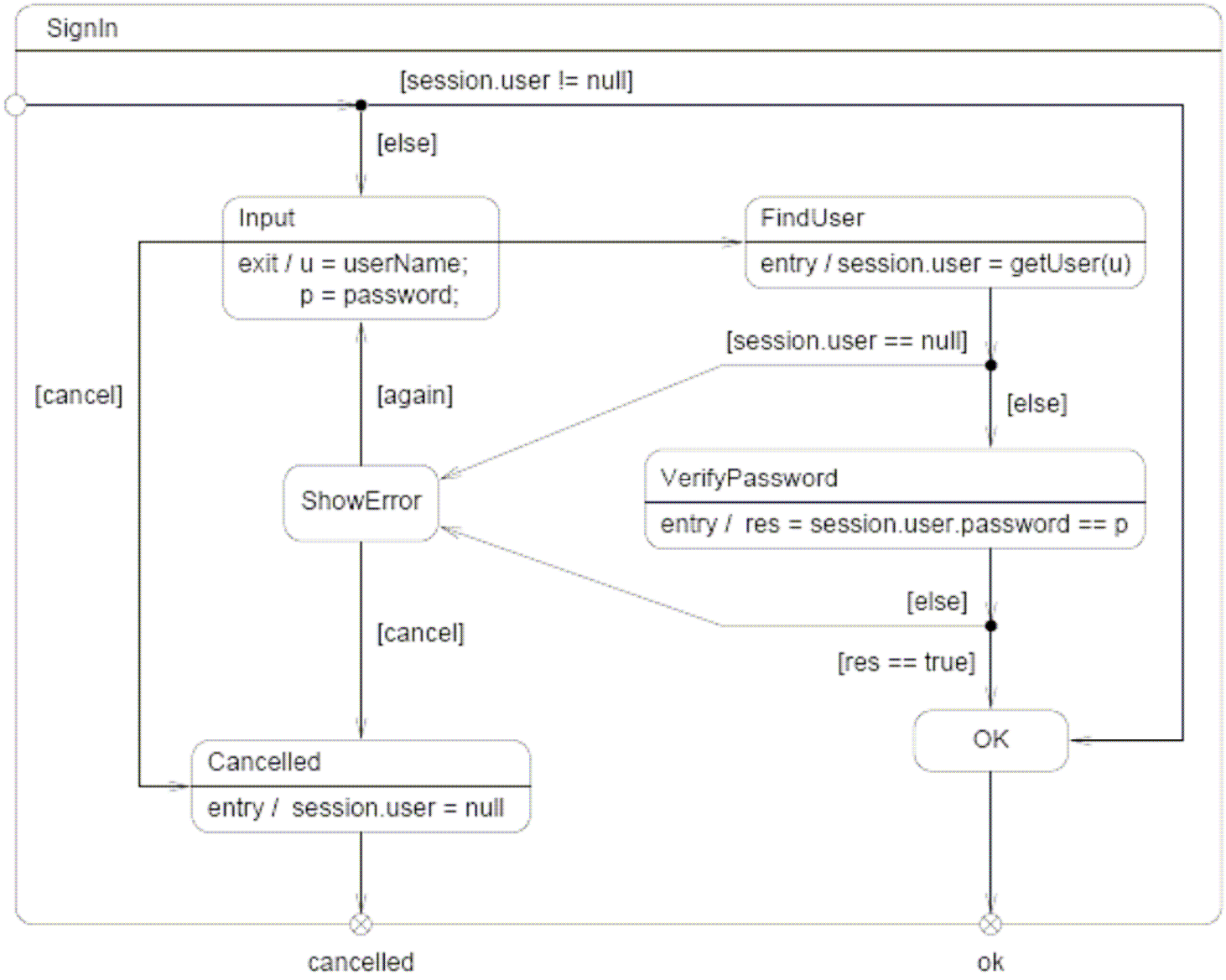
Big Picture: Transformation of Business Process



Process Model: UML Activity Diagram: Login



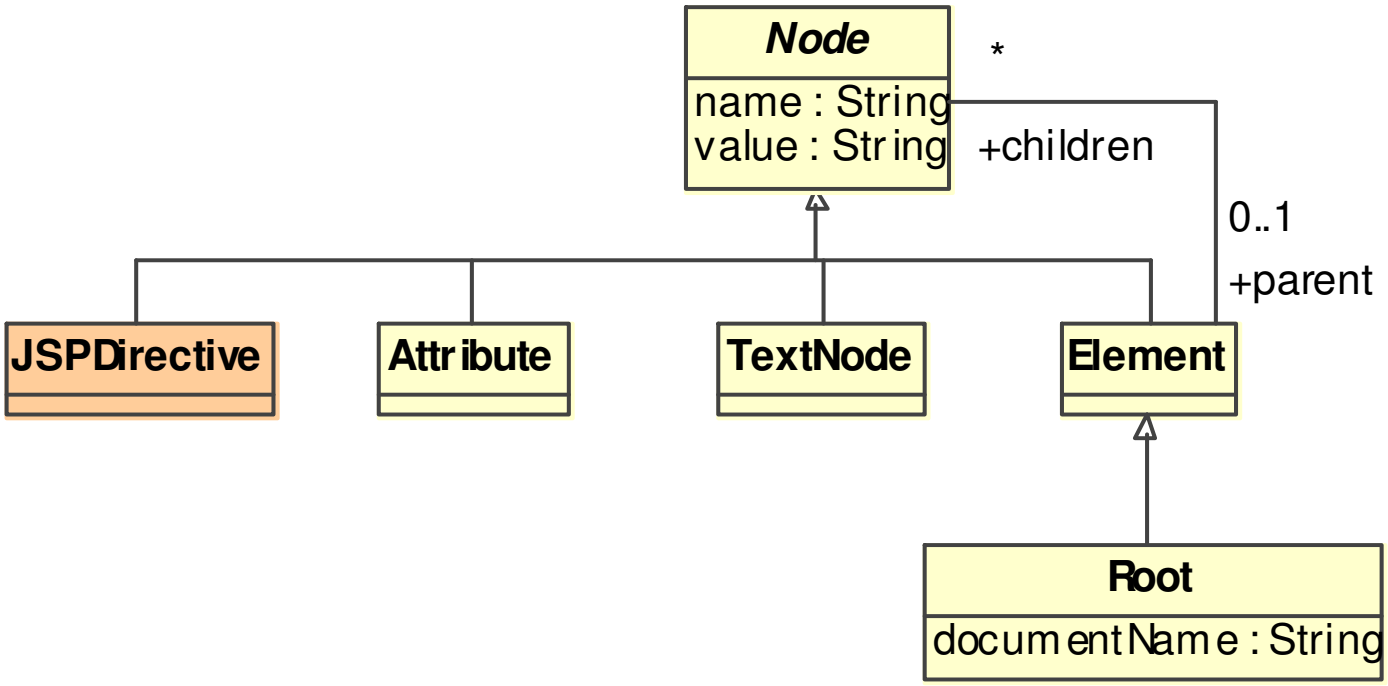
Big Picture: Example Transformation of Business Process



Generation of Web Applications in UWE

- UWE uses a transformational approach
  - to generate data model and presentation layer
  - based on content, navigation structure and presentation models
  - transformation rules from UWE content model to Java beans
  - transformation rules from UWE presentation model to Java Server Pages (JSPs)
- UWE uses an interpretational approach
  - using a virtual machine
  - to interpret the process model (activity diagrams)
  - configuration data for the virtual machine is generated from process and navigation model
- Implemented so far
  - using the Spring framework
  - transformations defined in ATLAS Transformation Language (ATL)

JSP Metamodel



Example: Code Generation in UWE

- Generation of an JSP element for UWE presentation element
  - ATL Transformation

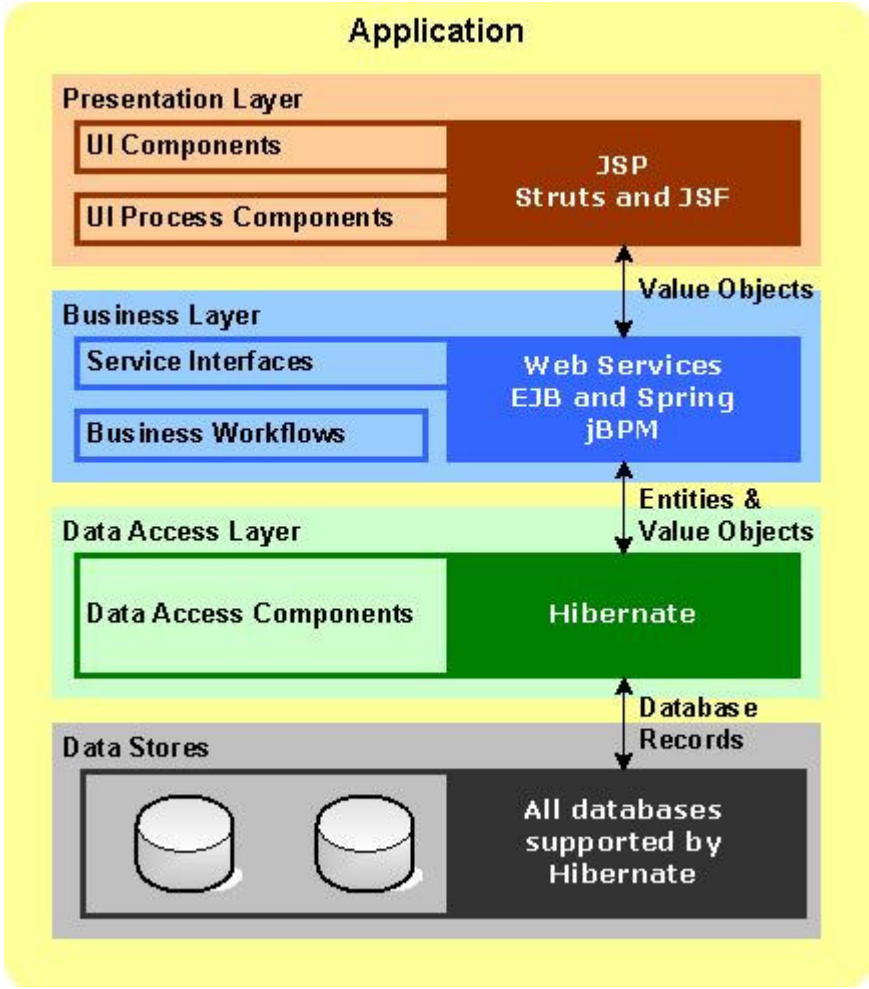
```
rule PresentationClass2JSP {
  from
    pc : UWE!PresentationClass
  to
    jsp : JSP!Root(documentName <- pc.name + '.jsp',
      children <- Sequence{ htmlNode }),
    htmlNode : JSP!Element(name <- 'html',
      children <- Sequence{ headNode, bodyNode }),
    headNode : JSP!Element(name <- 'head',
      children <- Sequence{ titleNode }),
    titleNode : JSP!Element(name <- 'title',
      children <- Sequence{ titleTextNode }),
    titleTextNode : JSP!TextNode(value <- pc.name),
    bodyNode : JSP!Element(name <- 'body',
      children <- Sequence{ pc.ownedAttribute->collect(p |
p.type) })
}
```

Generation of Web Applications in WebRatio

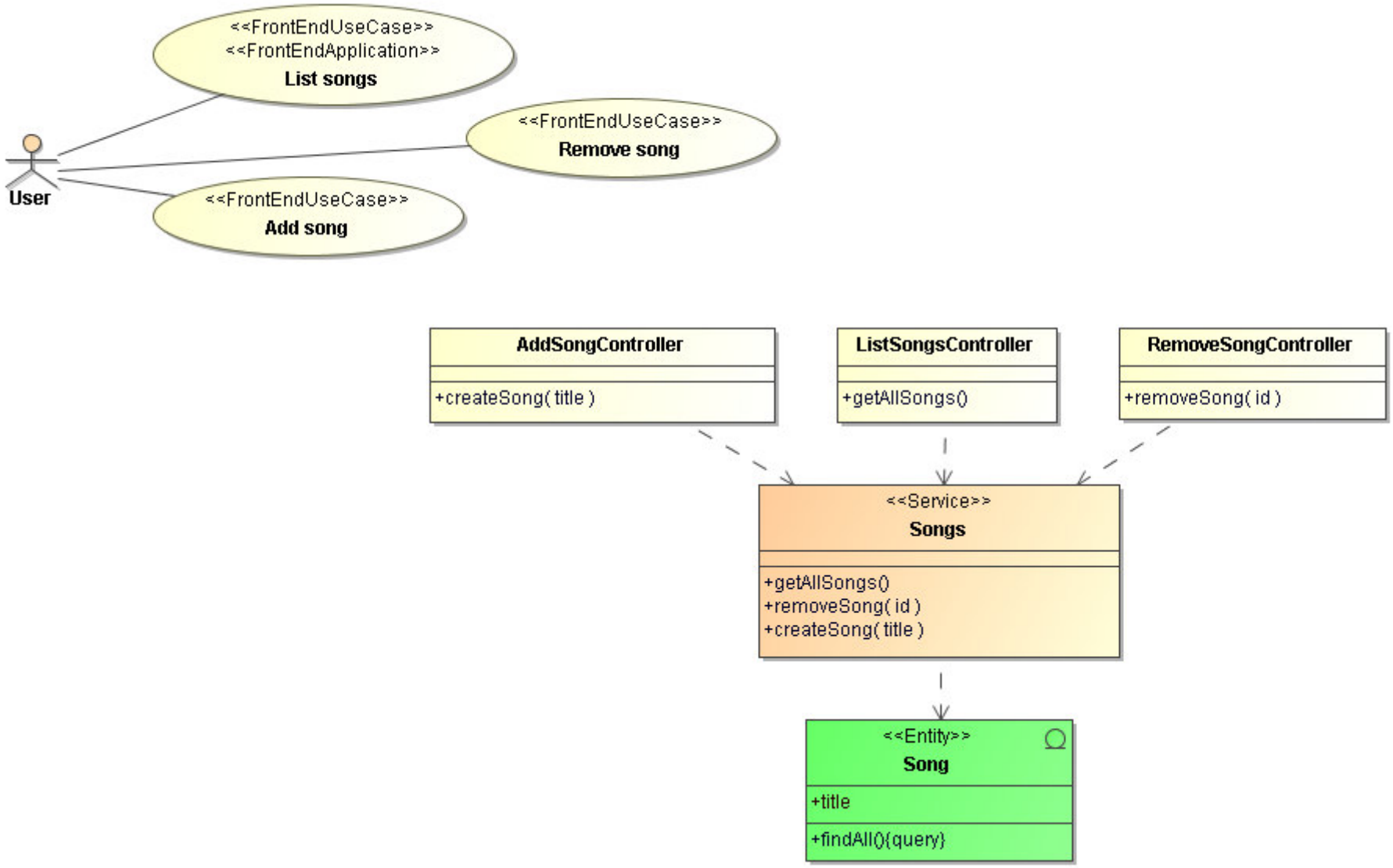
- WebRATIO graphical editor
  - produces an internal representation of the WebML models in XML
- WebRATIO integrated EasyStyler presentation designer
  - allows the user to define XSL style sheets from XHTML mockups
- WebRATIO code generator
  - translates XML specifications into application code
  - produces dynamic page templates (e.g. JSP file) to express content and mark-up of pages in HTML
  - produces unit descriptors containing dependency with data layer (name of database and SQL queries)
- WebRATIO runtime layer
  - is built on top of J2EE platform
  - executes the application code

AndroMDA

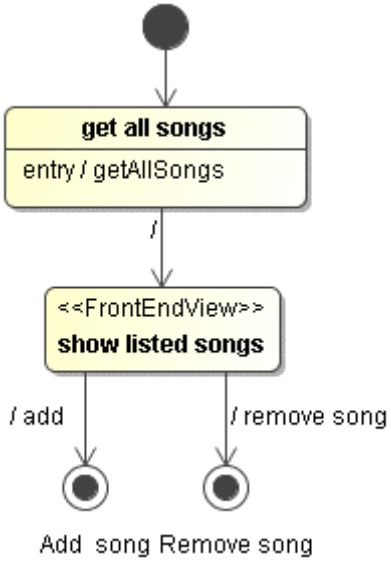
- Generator framework
  - transformation of UML (1.4) models
    - input validation using OCL
    - further meta-model planned for AndroMDA 4.0
- Transformations
  - model-to-model currently in Java
    - QVT and ATL planned for AndroMDA 4.0
  - model-to-code currently template based (Velocity)
    - MOFScript planned for AndroMDA 4.0
  - bundled as cartridges
    - EJB, Spring, Hibernate, Struts, JSF, …

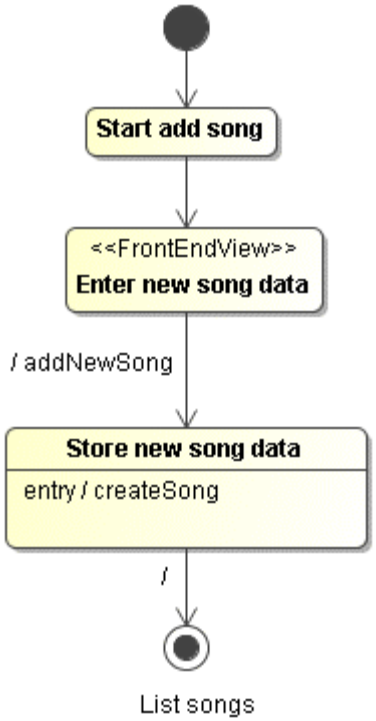


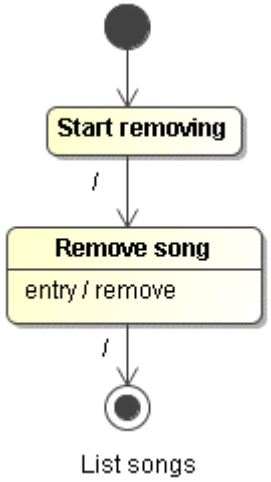
AndroMDA: UML Models (1)



AndroMDA: Models (2)

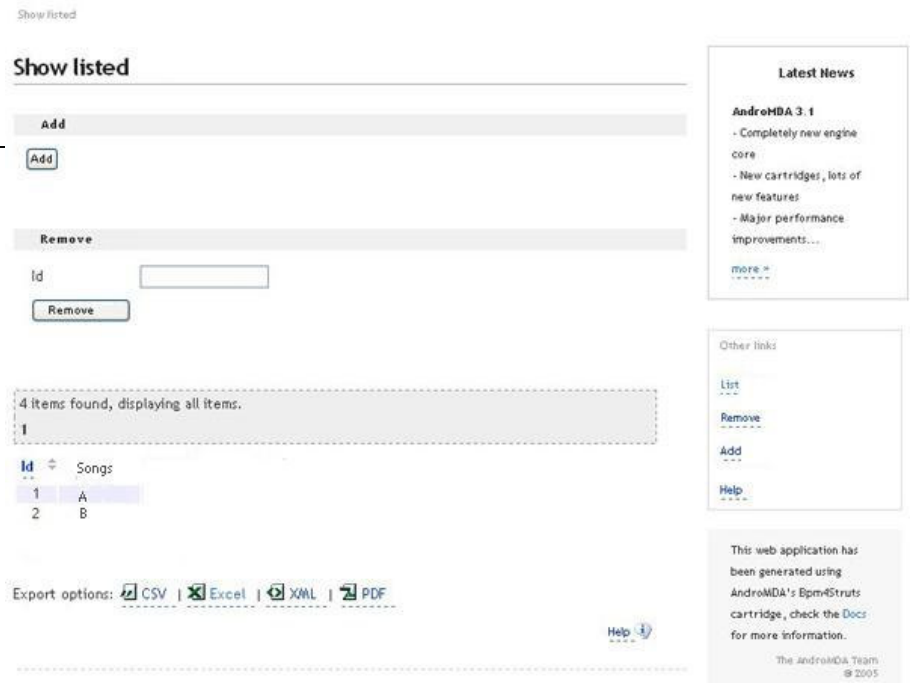






AndroMDA: Manual Coding

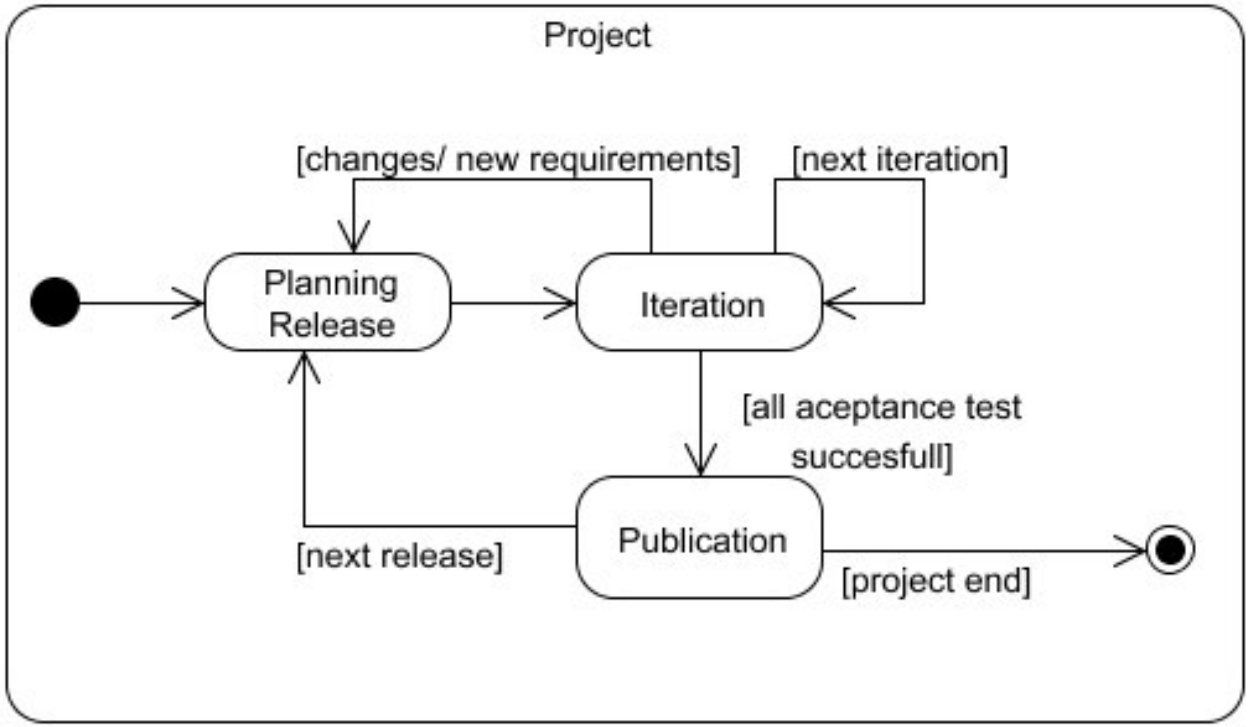
```
public class SomgsImpl extends SongsBase {
  protected java.util.Collection handleGetAllSongs()
      throws java.lang.Exception{
    return this.getCarDao().findAll();
  }
  protected void handleRemoveSong(String id) throws Exception {
    this.getSongDao().remove(Long.valueOf(id));
  }
  protected void handleCreateSong(String title) throws Exception {
    this.getSongDao().create(title);
  }
}
```



Agile Methods

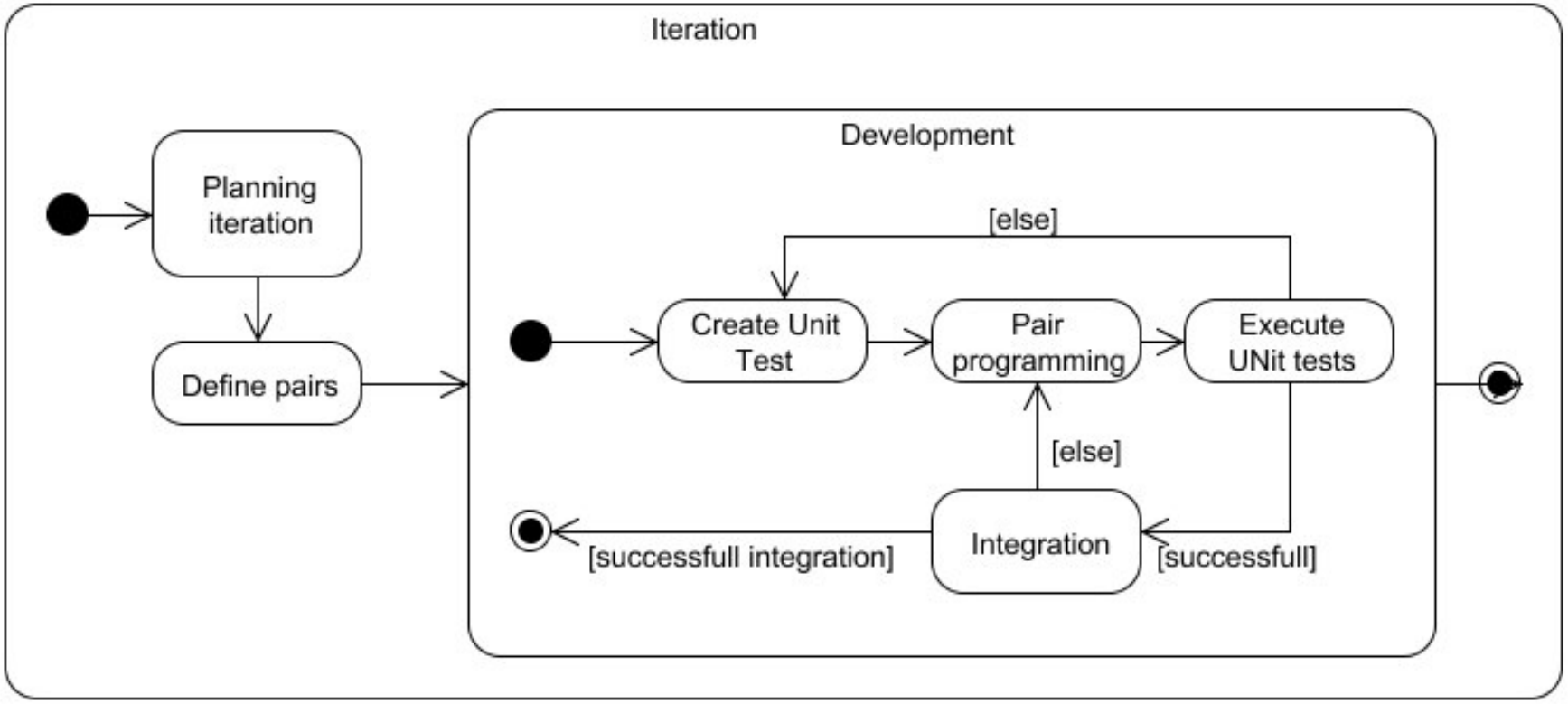
- Agile methods are a family of development processes
  - XP- Extreme Programming
- Agile methods focus on adapting quickly to changing realities
- Iterative and light weighted processes (documentation)
- Agile Manisfesto (2001)
  - individuals and interactions over processes and tools
  - working software over comprehensive documentation
  - customer collaboration over contract negotiation
  - responding to change over following a plan .

XP-Project



Engels, Lohmann & Wagner (2003)

XP Iteration



Engels, Lohmann & Wagner (2003)

Summary

- Web application development requires flexible and adaptable development processes
- Trend is model-driven development (MDD)
- Model transformation languages play an important role in MDD (QVT, ATL)

Literature

- Transformation Techniques in the Model-Driven Development Process of UWE
  Nora Koch, ICWE´06 Workshops, 2006,
  http://www.lcc.uma.es/~av/mdwe2006/camera_ready_papers/koch-mdwe-2006-final.pdf
- Model-Driven Generation of Web Applications in UWE
  Andreas Kraus, Alexander Knapp and Nora Koch
  3rd International Workshop on Model-Driven Web Engineering (MDWE 2007), Como, Italy, to appear
- Query/View/Transformation (QVT) Language
  OMG. Meta Object Facility (MOF) 2.0 Query/View/Transformation Specification Final Adopted Specification. http://www.omg.org/ docs/ptc/05-11-01.pdf
- ATLAS Transformation Language and Tool
  http://www.eclipse.org/m2m/atl/doc/
- Attribute Graph Grammar System
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- W3C. XSL Transformations (XSLT) Version 1.0
  www.w3.org/TR/xslt
- ArgoUWE: http://www.pst.informatik.uni-muenchen.de/projekte/uwe/argouwe.shtml
- WebRATIO:http://www.webratio.com/
- AndroMDA: http://www.andromda.org/