MDA-based Teaching and Research in Software Engineering

Ludwik Kuźniarz
Blekinge Institute of Technology
School of Computing
Sweden

Ludwik.Kuzniarz@bth.se

Plan

- Myself
- Model Driven Architecture
- MDA based Reaserch
- Sample 1: Empirical Research
- MDA based Teaching
- Sample 2: Software Development Course

Researh Overview

- Formal Methods
  - Formal verification of programs
  - Investigation of a specification language
  - Formalizations in MultiMedia
- Consistency in UML
  - Series of workshops on MoDELS
  - Classification framework
    - *Consistency Issues in Modelling*
- Didactics
  - Educators Symposium on MoDELS
    - *Best Practices for Teaching UML Based Software: MoDELS 2004*
- Software Development and Empirical Methods
  - Validation of stereotypes with experiments
    - *Empirical assessment of using stereotypes to improve comprehension of UML models: A set of experiments*
  - Validation using survey
    - Empirical extension of a classification framework for addressing consistency in model based development

Researh Overview

- Formal Methods
  - Formal verification of programs
  - Hiding deadlocks in Lotos
  - Formalizations in MultiMedia
- Consistency in UML
  - Series of workshops on MoDELS
  - Classification framework
    - *Consistency Issues in Modelling*
- Didactics
  - Educators Symposium on MoDELS
    - *Best Practices for Teaching UML Based Software: MoDELS 2004*
- Software Development and Empirical Methods
  - Validation of stereotypes with experiments
    - *Empirical assessment of using stereotypes to improve comprehension of UML models: A set of experiments*
  - Validation with survey
    - Empirical extension of a classification framework for addressing consistency in model based development

Teaching Overview

- WUT
  - OO Software Development,
  - Formal methods in SE
- BIT
  - OO Software Development – 1st y BSc level
  - Product Line Architecture – 2nd y MSc level
  - Master Thesis course – 2nd y MSc level
- Double Diploma BIT - WUT
  - Research Methodology
- NUR – National University of Rwanda
  - OO Software Development
  - Product Line Architecture
  - Master Thesis
- NU – Newcastle University
  - Introduction to UML

Teaching Overview

- WUT
  - OO Software Development,
  - Formal methods in SE
- BIT
  - OO Software Development – 1st y BSc level
  - Product Line Architecture – 2nd y MSc level
  - Master Thesis course – 2nd y MSc level
- Double Diploma BIT - WUT
  - Research Methodology
- NUR – National University of Rwanda
  - OO Software Development
  - Product Line Architecture
  - Master Thesis
- NU – Newcastle University
  - Introduction to UML

M D A

OMG´s MDA

Object Management Group (OMG)

an open membership, not-for-profit consortium

that produces and maintains computer industry specifications

for interoperable enterprise applications.

- Bad news

  There will never be a single OS, PL, Netwwork Architecture that replaces all that have passed

- Good news

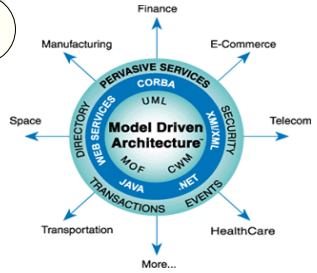
  You can still manage to build systems economically in this environment

- Remedy

  A specific approach to software development – Model Driven Architecture (MDA)

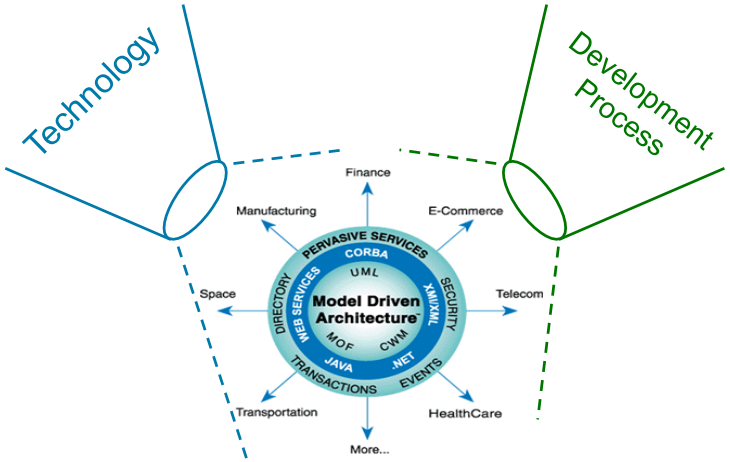
OMG's MDA

- Provides **open, vendor neutral** approach to the challenge of technology change.
- Is a broad **conceptual framework** that describes an overall approach to software development.
- Is the OMG **implementation of MDD** approach to software development by **standards** and a set of **tools** that can be used within MDD.
- Based on OMG standards **separates application logic** from **underlying platform** technology
- **Does not define** a particular **software architecture** or an architectural style
- **Raises the level of abstraction** in software development.



- CIM - Computation Independent business functionality and behaviour
- PIM - Platform Independent software functionality and behaviour
- PSM - Platform Specific realisation of the PIM on a given platform/technology

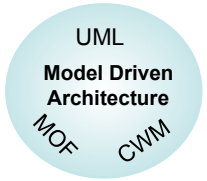
MDA Aspects / Perspectives



MDA Core Standards - Technology Space

- MOF - Meta-Object Facility
  - an abstract **language** and a framework for specifying, **constructing**, and managing *technology neutral* **metamodels** => languages
- UML - Unified Modeling Language
  - a graphical language for specifying, constructing, visualizing & documenting

  the artifacts of distributed object oriented systems
- XMI - XML Metadata Interchange
  - technology mappings from MOF metamodels conforming to XML DTDs and XML documents.
- Others still coming ….



Represents a collection of best engineering practices that have proven successful in modeling of large and complex systems.

MDA: Development Process Perspective

- MDA (Model-Driven Architecture)

  is a type of

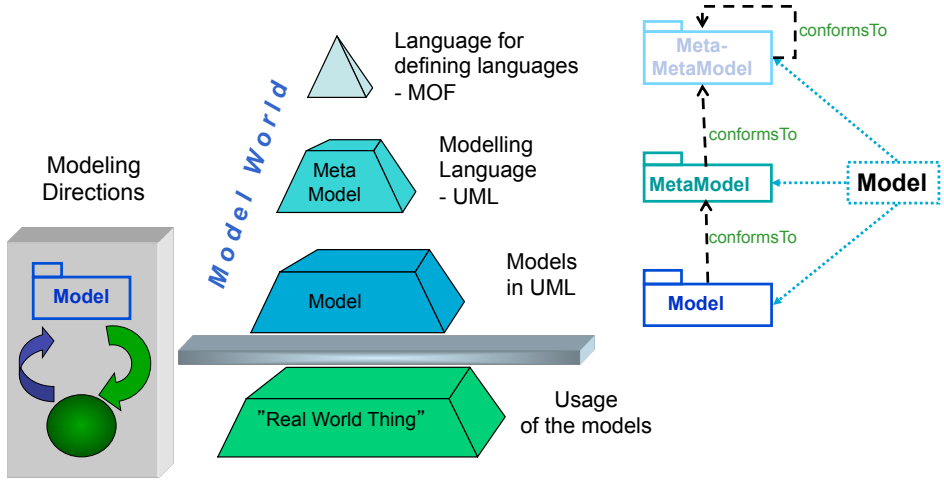
  MDD (Model-Driven Development)
- Not a Software Architecture design
  - "Architecture" refers to a framework of concepts, tools etc.
- But a Development Paradigm

  Approach to developing software

MDA: Development Process Perspective

- MDA = **approach + tools** for:
  - **Specifying**
    - platform-independent system – application platforms
  - Choosing
    - a platform for the system
  - **Transforming**
    - the platform-independent specification into a platform-specific one
- Concepts
  - Application : the functionality being developed
  - Platform : technology that provides functionality through interfaces and usage patterns (generic, standard, manufacturer)
  - System : application(s) supported by platform(s)

Models Hierarchy: Four Layers Architecture



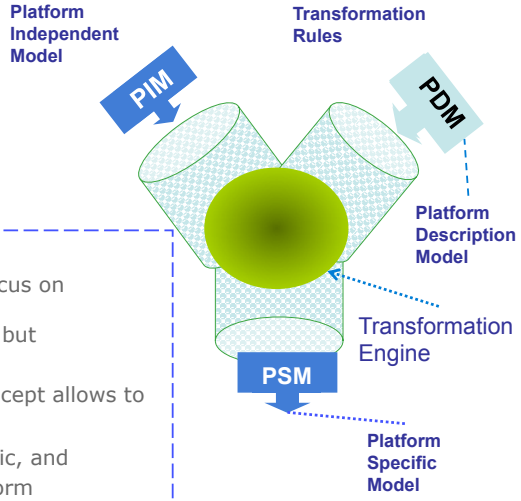
Categories of Models in MDA

- Computation Independent Model - **CIM**
  - Does not show details of system structure
  - Independent of how the system will be implemented
  - "domain model" or "business model"
  - Bridges the gap between domain experts and design/development experts
- Platform Independent Model - **PIM**
  - Structure, functionality and behavior of the software system built using OMG standards
- Platform Specific Model - **PSM**
  - Realization of the PIM on a given platform/technology

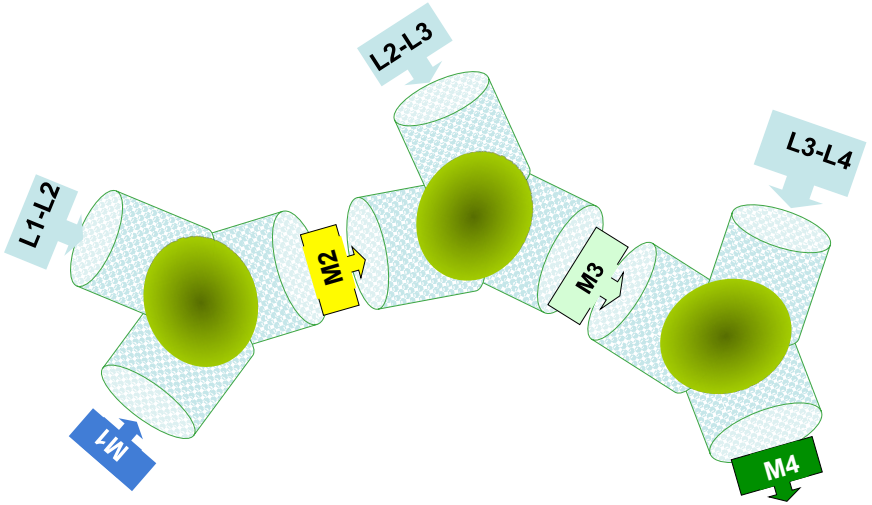
MDA Model Transformation : Initial Idea

MDA Tool
- Modelling components
  - To build and maintain PIMs
- Code generation component
  - To perform a series of transformations that map PIM elements to lements in PSMs

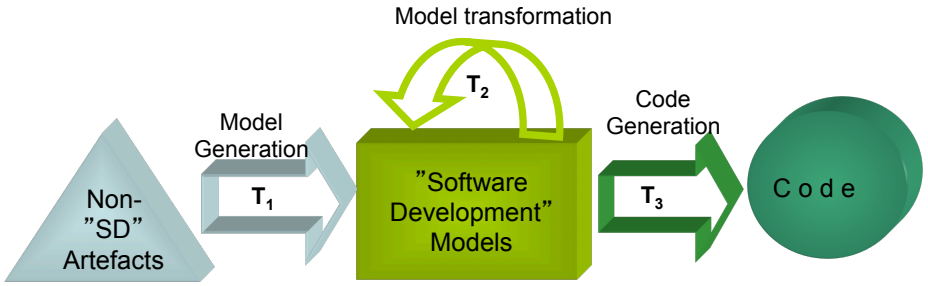
MDA Benefits
- Instead of writing PS-code, focus on developing models that are specific to application domain but independent of the platform
- A tool that implements MDA concept allows to
  1. produce models of the application and business logic, and
  2. generate code for a target platform by means of transformations



MDA Model Transformation in General



MDA-based SD : Research Areas



T1 : Model generation
– construting UMLmodels based on non-UML artefacts

T2 : Model transformation
– construting UML models based on UML artefacts

T3 : Code generation
– construction of the software based on UML artefacts

Model Consistency
Model Quality

Quality in modeling

Reasearch

Empirical Methods in Engineering

- **Confirmation** of (more or less accepted) hypotheses.
  For example: object-orientation is good for reuse.
- **Evaluation** of methods, models, languages and tools.
  For example: whether Java produces higher quality code than C+
- **Identification** of relationships.
  For example: find relationship between fault-prone components and design concepts.
- **Validation** of models or measures.
  For example: to validate a specific cost estimation model.
- **Understanding** of methods, techniques and models.
  For example: to understand relationship between inspections and test
- **Guidance** to help in management.
  For example: for migration from one technology to another.

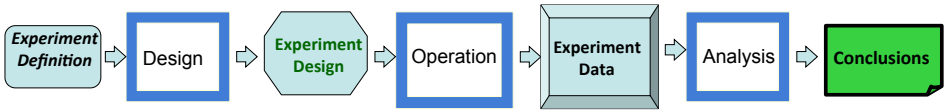
Experiment

Basic characteristic

- carefully planned and fully controlled,
- should be replicable.

Experiment Model

Experiment Process



Sample Experiment Design

- Idead Behind Empirical Research

  Investigate how stereotypes influence understanding of UML encoded artefacts
- Method
  - Experiment
- Design
  - Pair comparison on design artefacts
  - Subjects: SE students of different background
  - Input / Objects: (4 sets of) design artefacts (with 6 stereotypes)
  - Instruments (initial): questionares (on 4 types) of diagrams
    - Component Model & Collaboration Diagram
    - non stereotypes and stereotyped
  - Output:
    - time
    - level of understanding

Experiment Design - Instrumentation

Experiment schema

	Round 1	Round 2
Group 1	Set A – S	Set B – N
Group 2	Set A – N	Set B - S

The experiment
- Short Lecture
  - Introduction to stereotypes
  - Not to telecommunication profile
- Questionare

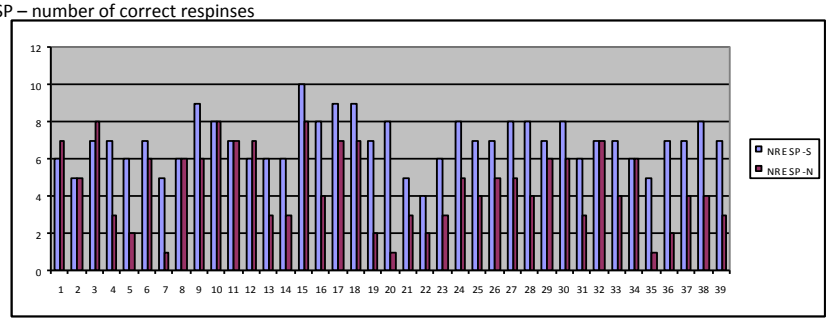
Pilot study
- 2 subject
- Results
  - Questionaires not at the same level

- Four set of artefacts
  - Set A-S: stereotyped model A and description of stereotypes used
  - Set B-N: non-stereotyped model B,
  - Set A-N: non-stereotyped model A,
  - Set B-S: stereotyped model B and description of stereotypes.
- Artifact set A-x describes a domain of **radio transmissions**.
  - a **class diagram** describing different types of existing objects (radio station, retransmission station, different types of antennas, etc)
  - a corresponding **object diagram** describing one of possible situations (like sending a news program across a country).
- Artifact set B-x describes a domain of **GSM telephony**.
  - a class diagram describing different types of existing objects (mobile phone, BTS station, connection to conventional telephone network, etc) and
  - a corresponding object diagram describing one of possible situations of using the network (like making phone calls in a given time).

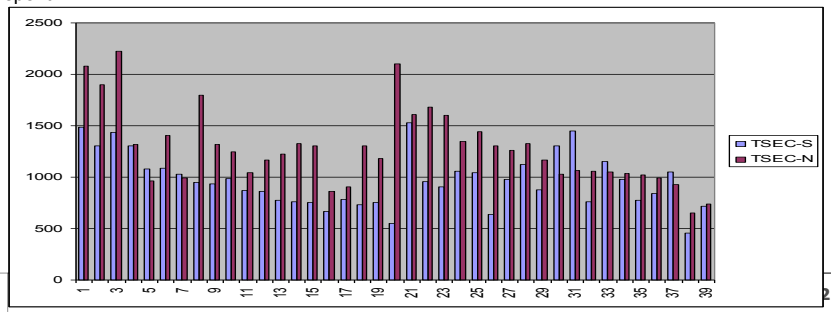
Sample artefacts

Name	Icon	Description
<<sender>>		**•makes the class capable of sending messages to classes stereotyped <<receiver>> or <<transmitter>>, •allows the class to send messages without receiving them first, •prevents the class from receiving any message,**
<<receiver>>		**•makes the class capable of receiving messages from classes stereotyped <<sender>> or <<transmitter>>, •enables the class to receive a message without sending it further, •prevents the class from sending any messages to other classes,**
<<transmitter>>		**•makes the class capable of receiving messages from classes stereotyped <<sender>> or <<transmitter>> and sending the received messages to classes stereotyped <<receiver>> or <<transmitter>>, •any message that is sent from such a class must be preceded by receiving of the message by this class**

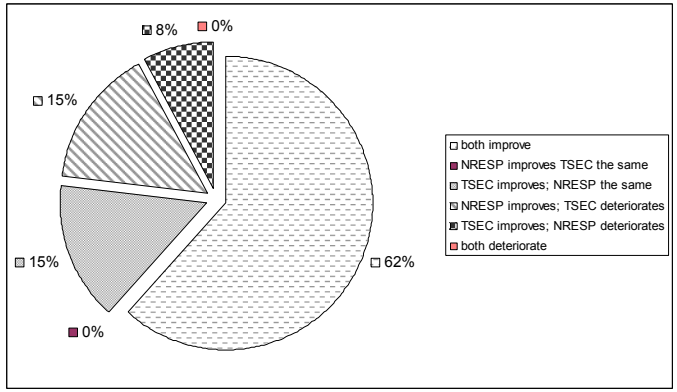
- NRESP – number of correct respinses



- Time spent



- Overall improvement



- Follow Up
  - Replication
  - Categorization
  - Teaching

Education

Best Practices

- Tailoring of Development Process
  - Defined Artefacts and Creation Procedures
  - Effective Usage of Models and Modelling – MDA conforment
- Consistency Awareness and Management

- Research elements
  - Participation - Conducting Experiments During the Course
    - Passive nd Active
  - Transfer of Research Results
    - proper and effective usage of advanced UML elements – for instance where and how introduce stereotypes, how they can help, what benefits can be obtained
    - usage of capabilities included in modelling tools

- Industrial and Professional Relevance
- *Constant Feedback from Participants*