FAKULTÄT FÜR INFORMATIK
Faculty of Informatics

Rigorosum — 19 January 2011, 13h
Zemanek Seminarraum

Supporting Model-Based Reflection, Monitoring, and Evolution in Service-Oriented Architectures through Model-Aware Systems

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Chair: Prof. Gerti KAPPEL
Advisor: Prof. Schahram DUSTDAR
External Examiner: Prof. Uwe ZDUN

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Chapter 1
Introduction

千里之行始于足下。
— 老子 [1]

[1] *A journey of a thousand miles begins with a single step.* — LAOZI

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Context and Background

p.2

software systems become increasingly **complex**

- unify different technologies
- are adapted for new and emerging technologies
- need to comply with imposing requirements

Model-Driven Engineering (MDE)

- helps to master complexity (design-time)
- utilizes **models** as central artifacts

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MDE Artifacts

p.3-4

Models

- precisely specified
- instances can be validated
- can be (d|r)efined at different abstraction levels
- are suiteable to be represented to stakeholders
- can be bound to tailored DSLs

Model Transformations

- capture technical expertise (e.g., PIM → PSM)
  ⇒ eases portability & adaptation
- generation step: model to code transformation
  (recurring) code ⇒ eases maintenance

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MDE Artifacts — Examples

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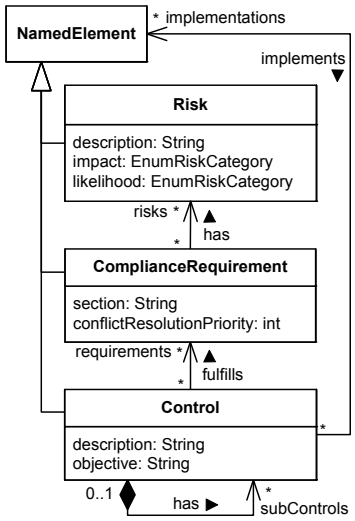


```
<h2>Risk-Control Correlation Matrix</h2>
<table>
  <tr>
    <th>Risks/Controls</th>
«FOREACH cv.control AS c»
    <th>
      <a href="«cv.processName+
        "_C_"+c.uuid+".html"»">«c.name»</a>
    </th>
«ENDFOREACH»
  </tr>
«FOREACH cv.risk AS r»
  <tr>
    <th>
      <a href="«cv.processName+
        "_R_"+r.uuid+".html"»">«r.name»</a>
    </th>
  «FOREACH cv.control AS c»
    <td>
    «IF (c.requirements.risks.contains(r))»
      X
    «ENDIF»
    </td>
  «ENDFOREACH»
  </tr>
«ENDFOREACH»
</table>
```

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MDE — Problems

pp.4,69

- evolution and co-evolution of MDE artifacts and systems
- concurrent work
  - few MDE tools offer collaboration support ⇒ lack of integration
  - common version control systems are too naïve for MDE
    - ⇒ versioning on a model element level is not supported
    - ⇒ relationships between artifacts are not captured/managed
- search & retrieval of models and MDE artifacts
  - missing tool support and infrastructures ⇒ reuse becomes difficult
- traceability (high-level ↔ low-level model-instances and code)
  - essential for meaningful feedback from the runtime to stakeholders and for identifying and understanding the root-cause
- generation step causes different MDE phases to be isolated
  - missing infrastructure that supports dynamic model look-up ⇒ model-based reflection is rarely used
- monitoring of model-driven systems (e.g., in regard to requirements)

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Addressing MDE Challenges

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- Support for *various* stakeholders
  - appropriate model-representations (DSLs)
  - role-based access controls (RBACs)
- Dealing with *concurrency*
  - locking mechanisms
  - raising the awareness of the work of others
  - comparing and merging possibilities
  - support for resolving conflicts
- Management of *MDE Projects & Artifacts*
  - versioning
  - capturing and keeping track of relationships
  - support for model evolution
- Support for model-aware *entities*
  - information retrieval services
  - resource management services

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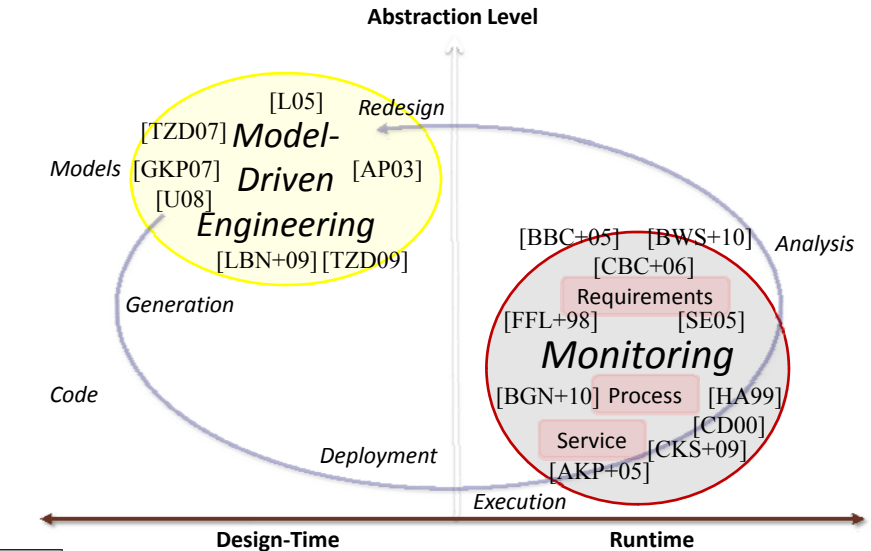
MDE Lifecycle — Positioning



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Research Question 1

p.8

Artifacts are subject to change & evolution of meta-models may require co-evolution of artifacts and systems if navigability is affected:

How can navigation incompatibilities be detected?

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Research Question 2

p.8

During execution, systems could benefit from reflecting on models:

How can MDE projects and artifacts be retrieved, searched for, and managed both at design time and runtime in a distributed setting?

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Research Question 3

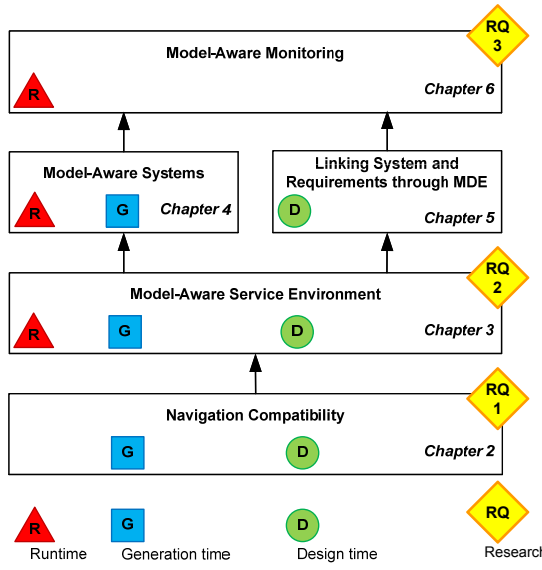
p.8

Monitoring could be enhanced if conceptual models such as requirement and system models would be considered and related at runtime:

How to facilitate
root cause analysis of runtime violations
at the abstraction level of models?

Overview of Contributions

p.10

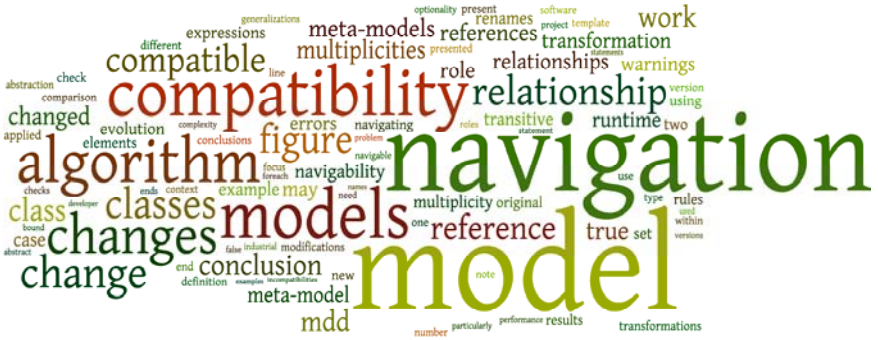


CHAPTER 2

Navigation Compatibility of Models

Ἐν πᾶσι γὰρ τοῖς φυσικοῖς ἔνεστί τι θαυμαστόν.

— Ἀριστοτέλης [1]



[1] *In all things of nature there is something of the marvelous.* — ARISTOTLE

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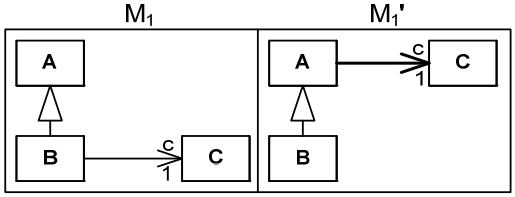
Navigation Compatible Changes

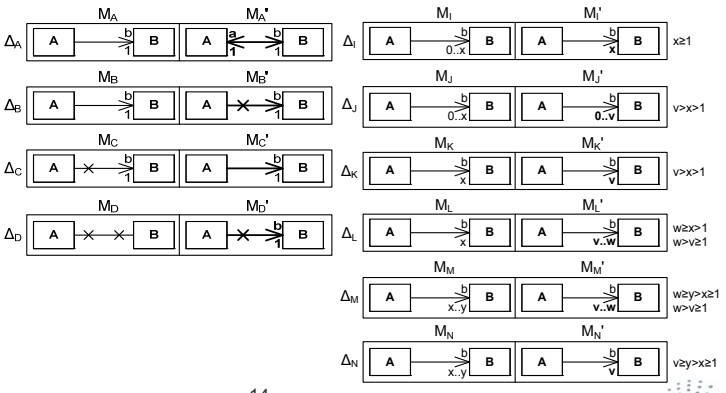
p.16



Definition

Let f be a bijective mapping function M → M' between model elements m ∈ M and m' ∈ M' that have the same model element type.

A model M' is navigation compatible to a model M if ∀ concrete classes c ∈ M there ∃ a class f(c) ∈ M' and if ∀ references r ∈ c referencing a class d ∈ M there ∃ a reference f(r) ∈ f(c) that references a class or subclass of f(d) ∈ M'.



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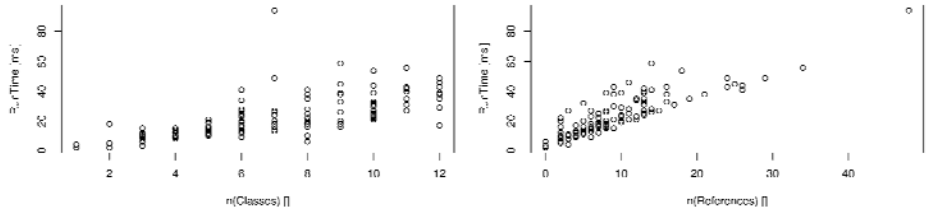
Navigation Compatibility Check

pp.22-28

Real World Meta-Models

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	
1.0	6.0	12.0	19.5	26.0	114.0	n(Classes)
0.00	2.00	7.50	14.42	16.25	96.00	n(Generalizations)
0.00	6.00	13.00	24.08	27.25	231.00	n(References)
0.0000	0.2857	0.6000	0.5537	0.8632	1.7140	n(Generalizations) / n(Classes)
0.0000	0.7411	1.1500	1.2450	1.5770	6.8570	n(References) / n(Classes)
2.0	**18.0**	**39.5**	**87.1**	**98.5**	**725.0**	**RunTime [ms]**



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Applied in an Industrial Setting

pp.29-30

during the development and evolution

- ensuring the downwards-compatibility of evolved meta-model versions
- MDE developers are free to undertake navigation compatible changes frequently
- changes that break navigation compatibility require a formal agreement of the developers as this involves the co-evolution of other artifacts

➢ ***Lines** of Navigation Compatibility*

➢ ***Moments** of Navigation Incompatible Changes*

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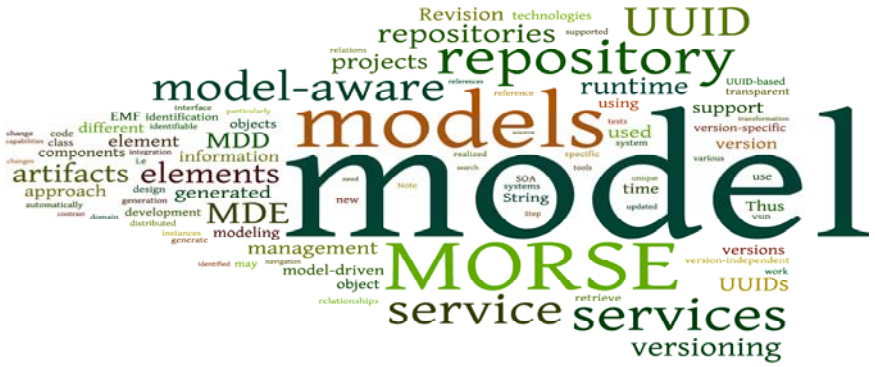
CHAPTER 3
Model-Aware Service Environment

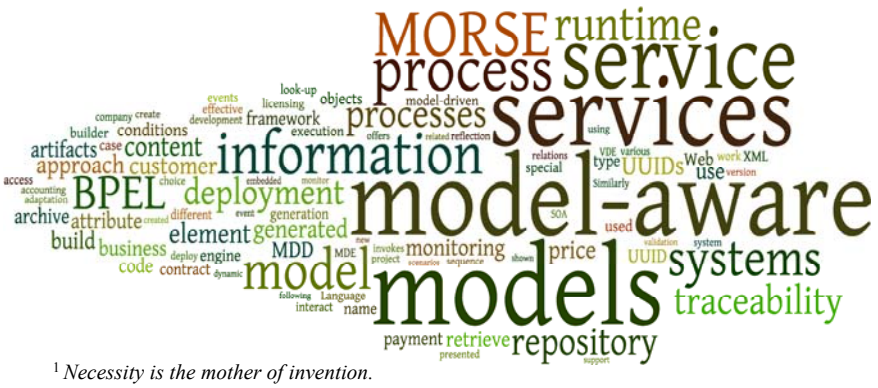
Rien n'est plus dangereux qu'une idée, quand on n'a qu'une idée. [1]
— ÉMILE CHARTIER



[1] *Nothing is more dangerous than an idea, when it's the only one we have.*

CHAPTER 4
Model-Aware Systems

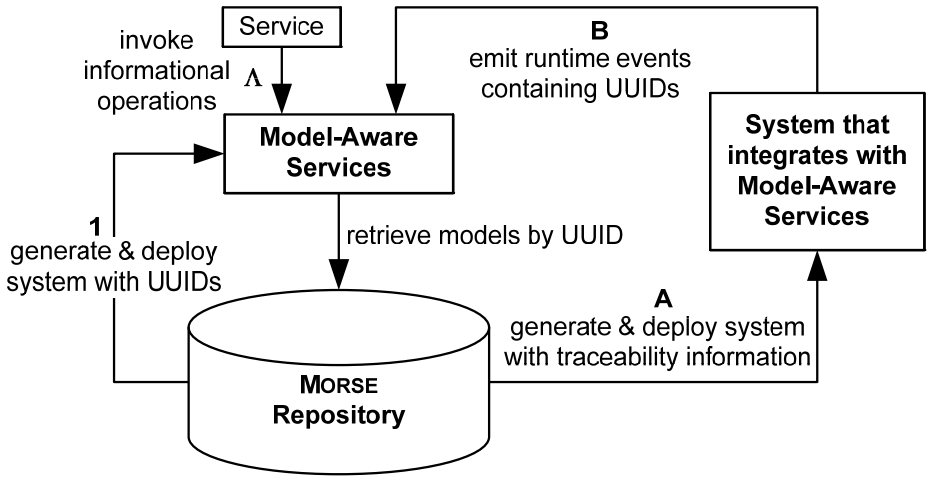
Mater artium necessitas. [1]
— WILLIAM HORMANN [2]



[1] *Necessity is the mother of invention.*
[2] An original author is unknown.

The Model-Aware Service Environment (MORSE) Approach

p.36



Model-Aware Systems

p.56-67

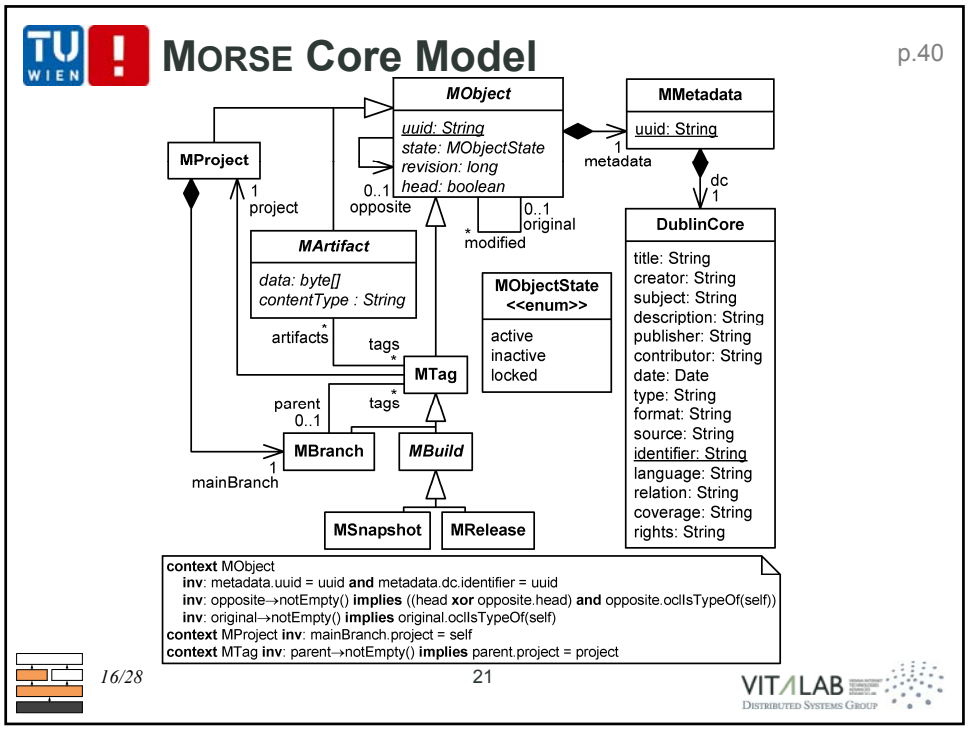
contain, emit, or use model traceability information for model look-up and reflection

Model-Aware Services

- UUIDs are embedded during transformation
- may interact with MORSE (e.g., retrieve models from which they have been generated)
- may expose traceability information

Model-Aware Processes

- emit UUIDs during process execution
  proposed and realized as a BPEL-extension


MORSE Core Model
p.40
MObject
uuid: String
state: MObjectState
revision: long
head: boolean
MMetadata
uuid: String
MProject
MArtifact
data: byte[]
contentType : String
MObjectState
<<enum>>
active
inactive
locked
DublinCore
title: String
creator: String
subject: String
description: String
publisher: String
contributor: String
date: Date
type: String
format: String
source: String
identifier: String
language: String
relation: String
coverage: String
rights: String
MTag
MBranch
MBuild
MSnapshot
MRelease
project
opposite
metadata
modified
original
artifacts
tags
parent
mainBranch
dc
context MObject
inv: metadata.uuid = uuid and metadata.dc.identifier = uuid
inv: opposite→notEmpty() implies ((head xor opposite.head) and opposite.oclIsTypeOf(self))
inv: original→notEmpty() implies original.oclIsTypeOf(self)
context MProject inv: mainBranch.project = self
context MTag inv: parent→notEmpty() implies parent.project = project
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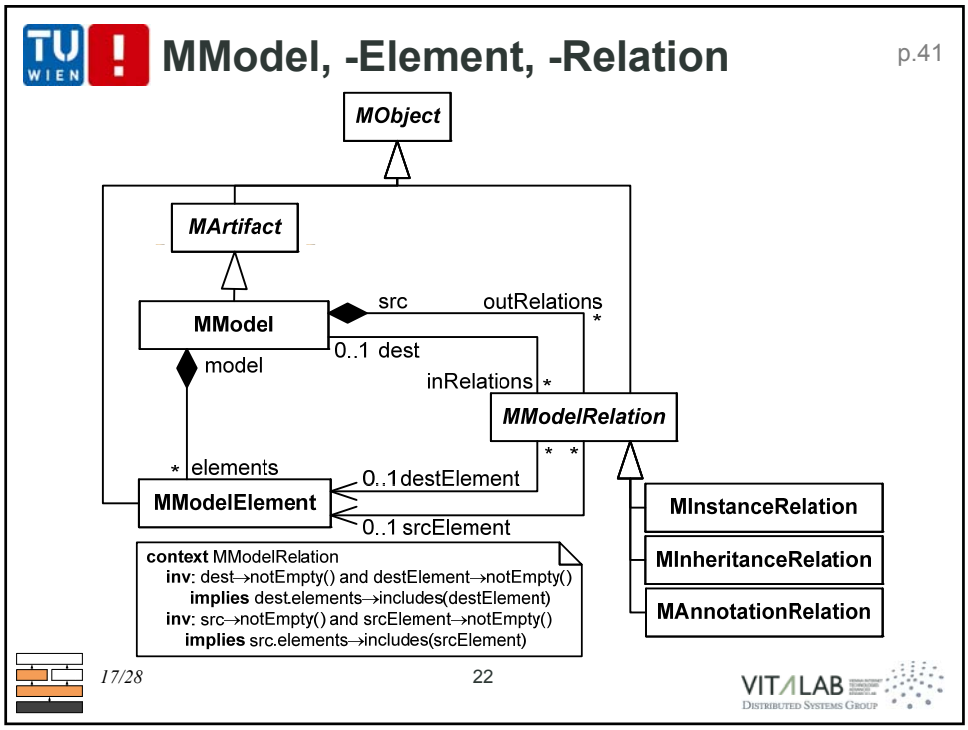
MModel, -Element, -Relation
p.41
MObject
MArtifact
MModel
src
outRelations
0..1 dest
model
inRelations
MModelRelation
elements
MModelElement
0..1 destElement
0..1 srcElement
MInstanceRelation
MInheritanceRelation
MAnnotationRelation
context MModelRelation
inv: dest→notEmpty() and destElement→notEmpty()
implies dest.elements→includes(destElement)
inv: src→notEmpty() and srcElement→notEmpty()
implies src.elements→includes(srcElement)
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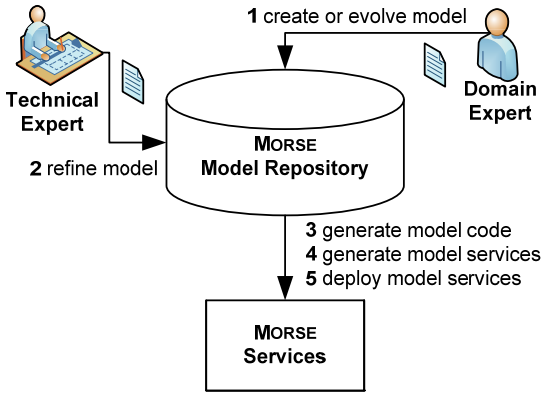
MORSE Services

p.47

- generated for each concept of a model
  - information retrieval
  - resource management
  - versioning



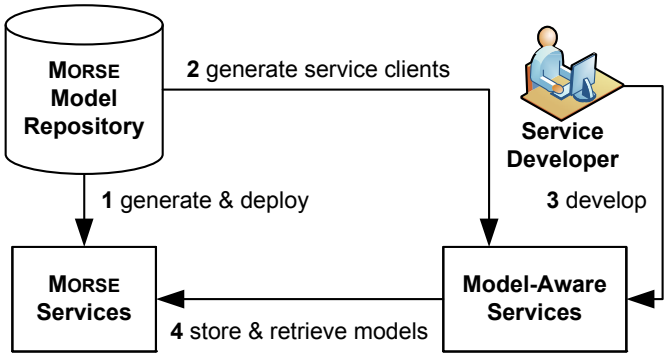
MORSE Service Operations

p.49

Response	Operation	Description
boolean	**exists**	does a model with a UUID exist?
boolean	**isHead**	is the object (specified by UUID) version-independent?
UUID[]	**list**	returns the VIIDs of all models
UUID[]	**versions**	returns all VSIDs of a model
<Class>[]	**query**	search for models; support of various query parameters
<Class>	**retrieve**	a model is retrieved by UUID
UUID	**create**	a VIID is returned
UUID	**update**	a VSID is returned
UUID	**delete**	a VSID is returned
UUID[]	**list<Role>**	returns the UUIDs for a role
UUID	**add<Role>**	a VSID is returned
UUID	**remove<Role>**	a VSID is returned
UUID	**clear<Role>**	a VSID is returned

MORSE Service Clients

p.48



Model Repository Comparison

pp.50,52

Repository	Model Identification	Model Element Identification	Model Navigation	Complex Search
AMOR	URL	ID	✗	✗
AtlanticZoo	URL	✗	✗	✗
CDO	URL	URI-Fragment	✓	✓
EMFStore	ID	ID	✓	✗
MDR	ID	URI-Fragment	✗	✗
ModelBus	URL	✗	✗	✗
MORSE	**UUID**	**UUID**	✓	✓
Odyssey-SCM	ID	URI-Fragment	✗	✗
Odyssey-VCS 2	ID	URI-Fragment	✗	✗

CHAPTER 5

Linking Systems and Requirements through Model-Driven Engineering

A good marriage is one which allows for change and growth.

— PEARL BUCK [1]

[1] 賽珍珠

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A Practical Modeling Approach

pp.69-83

Focus: Business Process Compliance

Models are used for describing the

- System
  Process View Models
- System Requirements
  Compliance Concerns of Business Processes

Requirement Models **annotate** System Models

⇒ *novel, direct linkage and correlation of system & requirements models*

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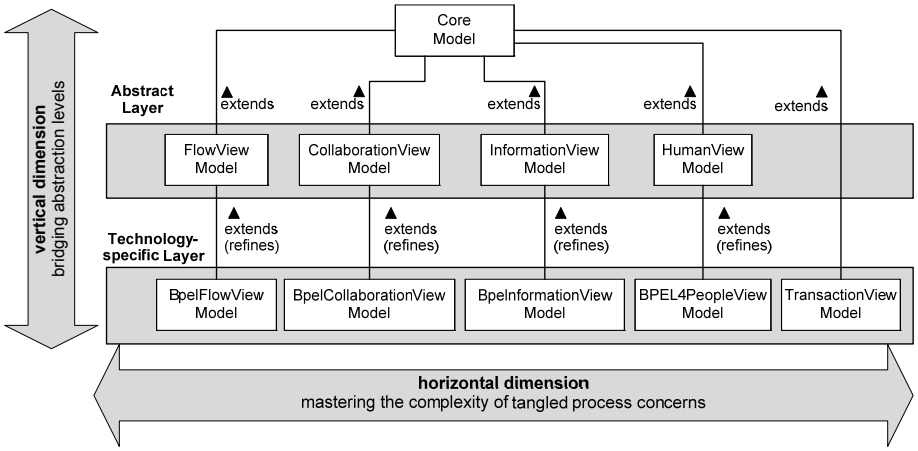
View-based Modeling Framework

p.71



Huy Tran, Uwe Zdun, and Schahram Dustdar.
"View-based and Model-driven Approach for Reducing the Development Complexity in Process-Driven SOA".
In: BPSC. Vol. 116. LNI. GI, 2007, pp. 105–124.

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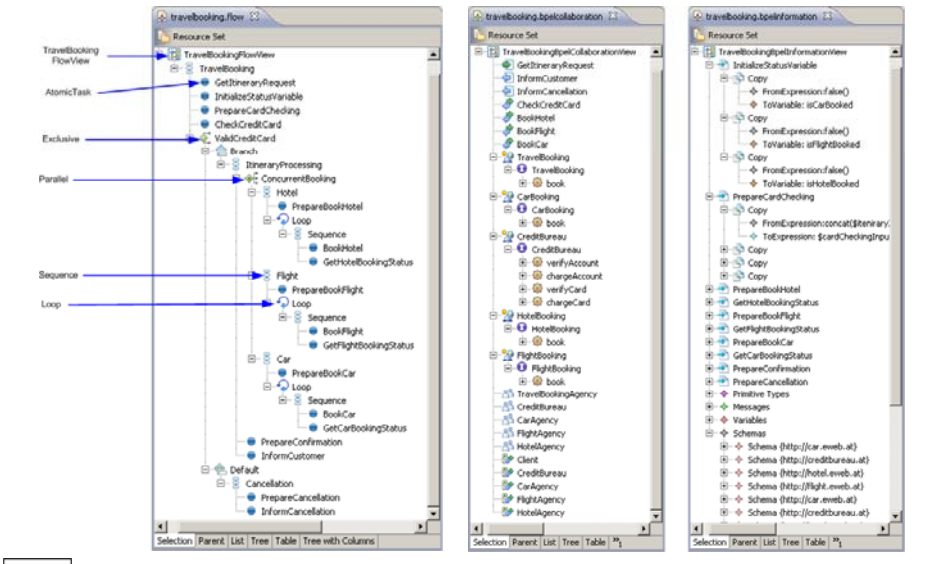
System Models: Process Views

p.71



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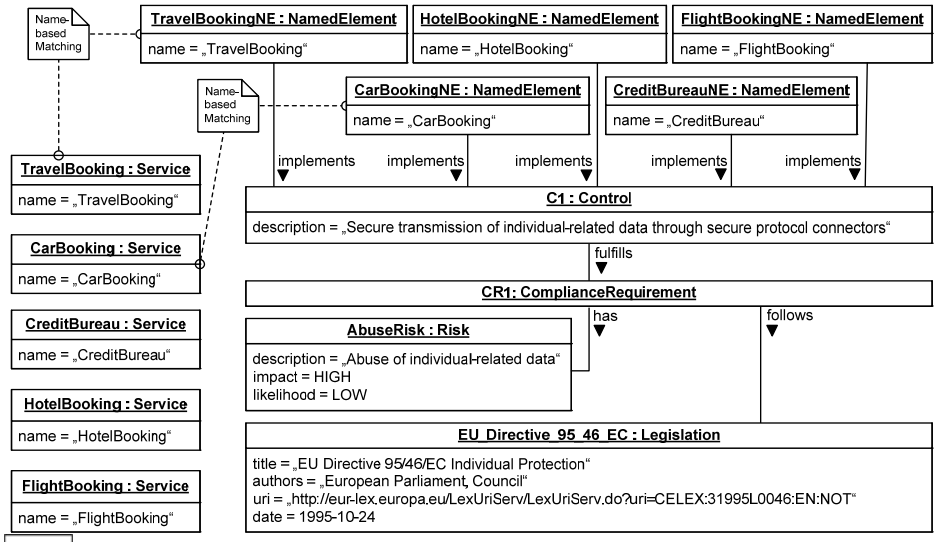
Requirement Model: Compliance Metadata Instance

p.79



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CHAPTER 6
Model-Aware Monitoring

Is it not delightful to acquire knowledge and put it into practice from time to time? — 孔子 [1]

[1] CONFUCIUS

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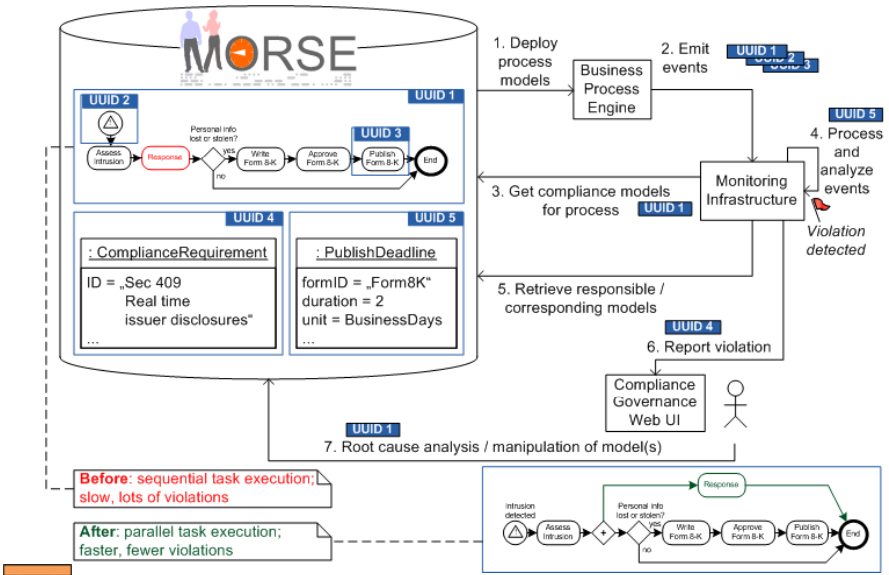
Model-Aware Monitoring

p.95



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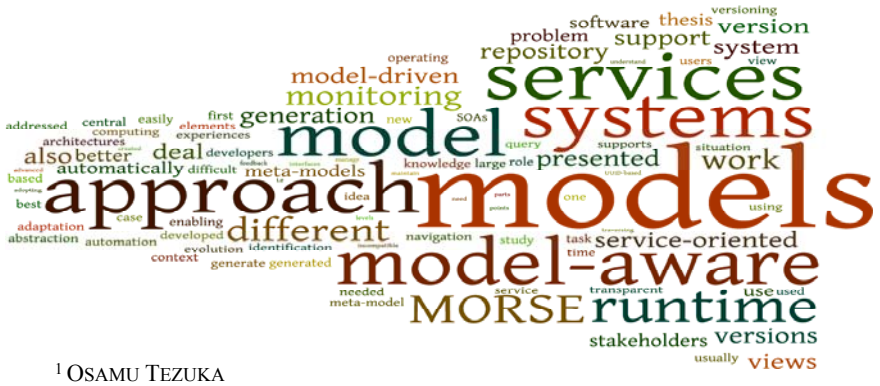
CHAPTER 7
Summary

I'm begging you, let me work!
— 手塚 治虫 [1]



[1] OSAMU TEZUKA

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Main Scientific Contributions

p.9

- We defined the *novel* notion of a navigation compatible model change and presented an algorithm for determining navigation compatibility.
- In a SOA we made MDE artifacts uniquely identifiable and retrievable and facilitated their design- and runtime use and management.
- We demonstrated a direct linkage of system & requirement models, presented model-aware systems and realized model-aware monitoring.

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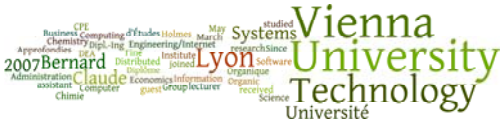
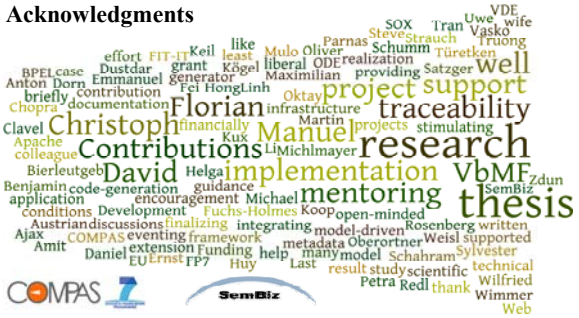
Thanks for your participation and attention!

Ta'id HOLMES



Acknowledgments



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