DAIMLERCHRYSLER

PROACTIVE INFRASTRUCTURE

„Modellierung operationaler Aspekte von Systemarchitekturen“

Master Thesis presentation

October 2005 – March 2006

Mirko Bleyh - Medieninformatik

Agenda

- Goals
- Model-Driven Software Development
- Pro-active Infrastructure (PAI)
- Operational Aspects
- PAI Operational Model
- DSL for the Operational Model
- Model Transformations
- Implementation with Eclipse Tools
- Demo
- Conclusion
- References

Goals

- Analyse modeling approaches for operational aspects
- Evaluate existing technology for domain-specific modeling
- Implement prototype modeling solution

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Model-Driven Software Development

Goals:

- Reduce software development time
- Reduce software complexity
- Increase software quality
- Increase software reusability

Key aspects:

- Use models as primary development artifacts based on DSL
- Transform abstract models into less abstract models (or source code)
- Provide Infrastructure (tools, processes, components)

Model-Driven Software Development

Main paradigms:

- Model-Driven Software Development
  - Use abstract but formal models based on DSLs
  - Use transformations to generate less abstract models or code
- Model-Driven Architecture (MDA)
  - Standardization of Model-Driven Software Development by OMG
  - Usage of OMG standards (MOF, UML, XMI, OCL, QVT)
  - Focus on interoperability and portability
- Software Factories
  - Microsofts vision of Model-Driven Software Development
  - Rejects OMG standards, uses own DSL Metamodel
  - Focus on tooling support

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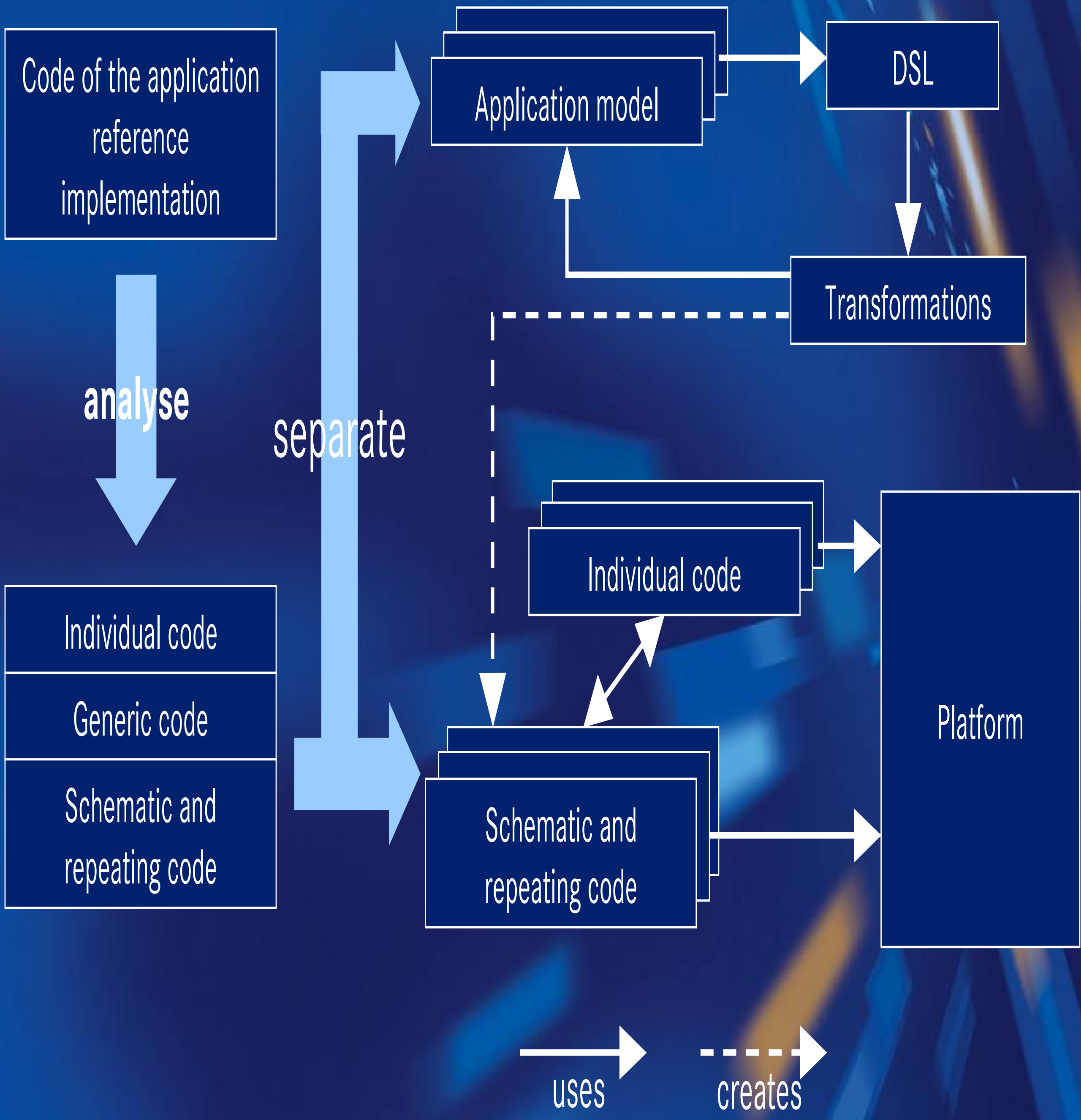
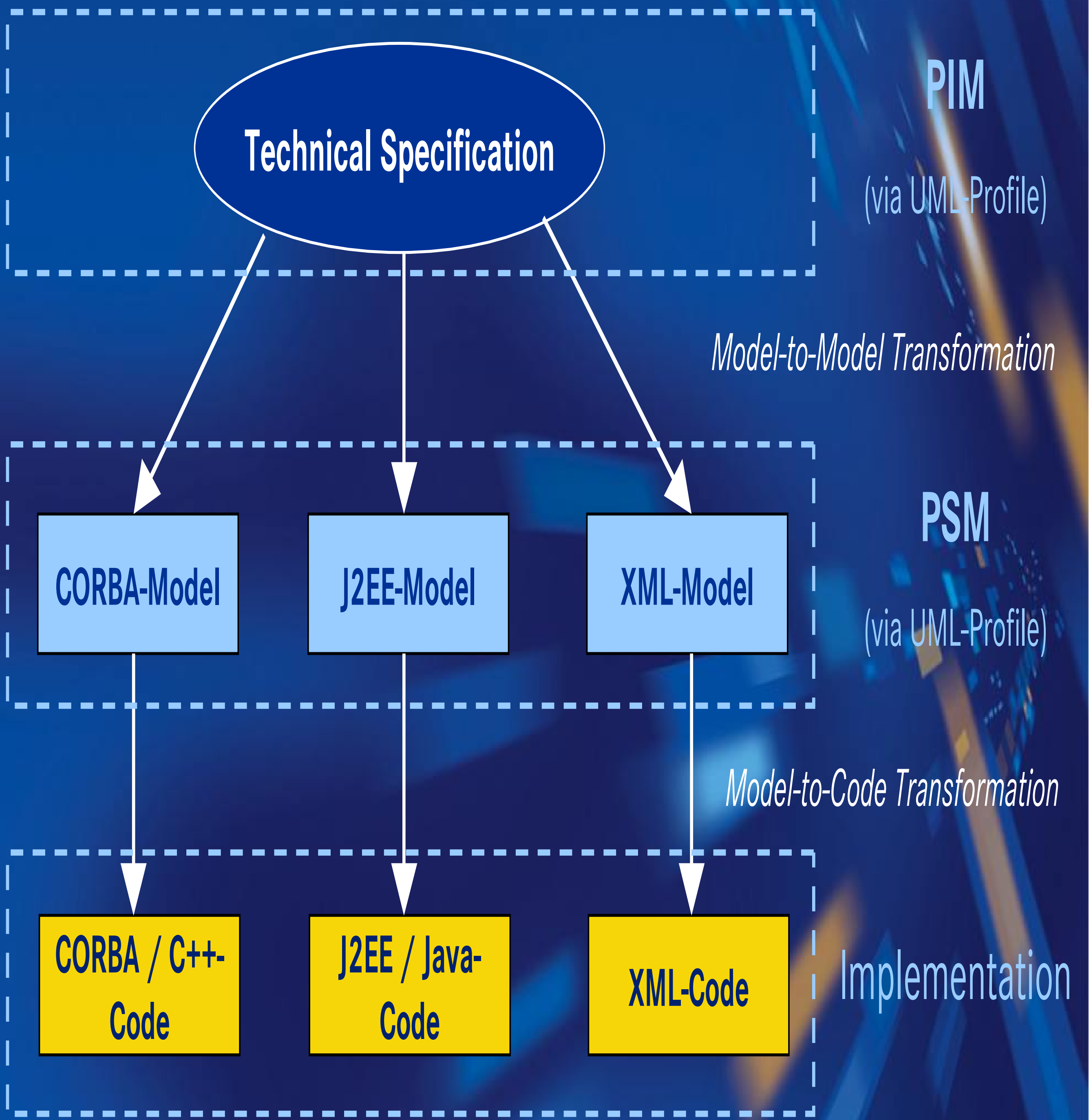
Model-Driven Software Development



Model-Driven Architecture



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Pro-active Infrastructure

"Pro-active Infrastructure is a DCX standardized IT infrastructure foundation to optimize the development and in particular the operations of custom applications within the DaimlerChrysler group."

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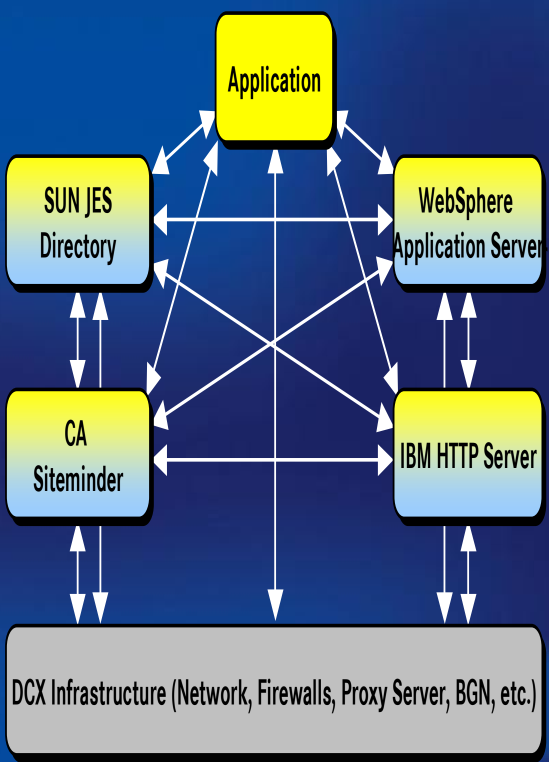
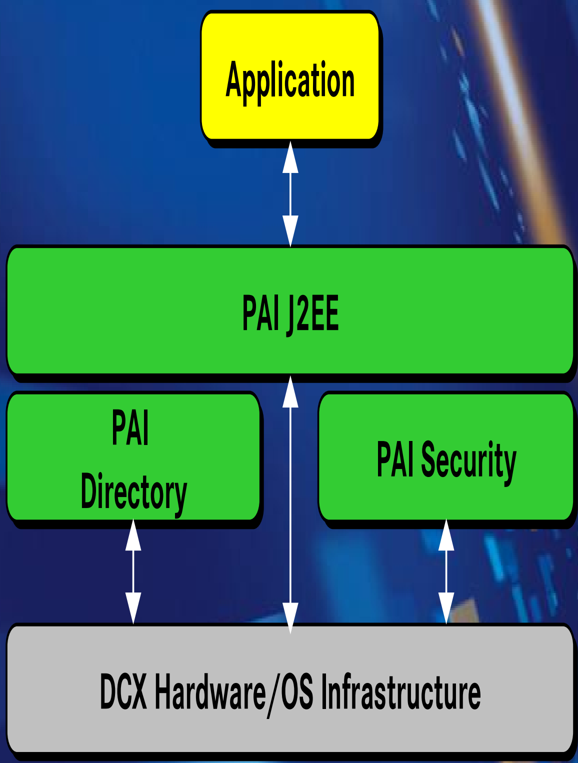
Pro-active Infrastructure

Before the usage of PAI



Infrastructure & Middleware integration issues need to be addressed on an application project level

After the usage of PAI



Standardized, Integrated & Release Managed Platforms for all application projects to minimize complexity and provide standardized solutions.

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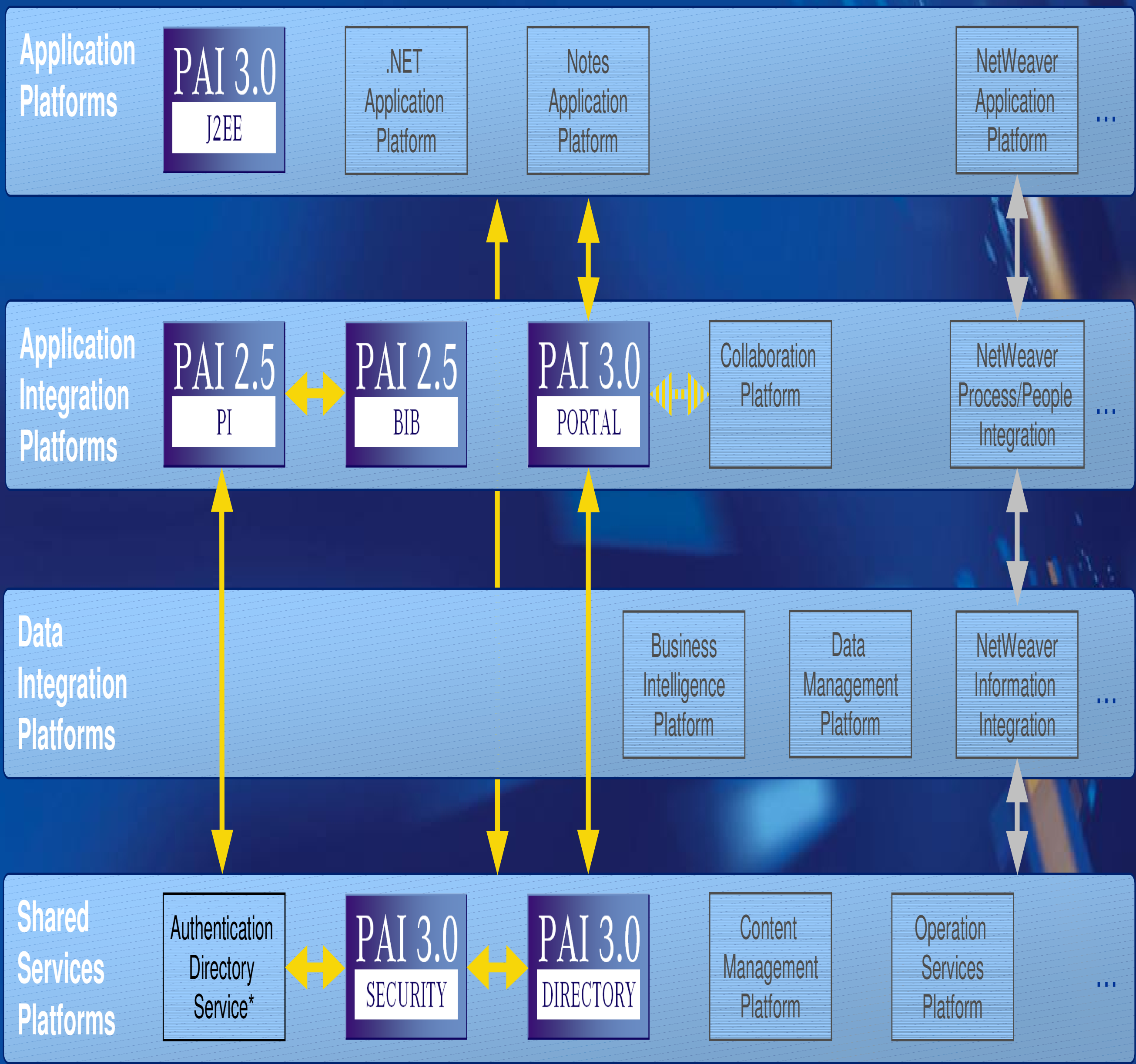
Pro-active Infrastructure



*provided by PAI Security and Directory Providers

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Operational Aspects

Software Architecture is devided into two categories:

Functional Aspects

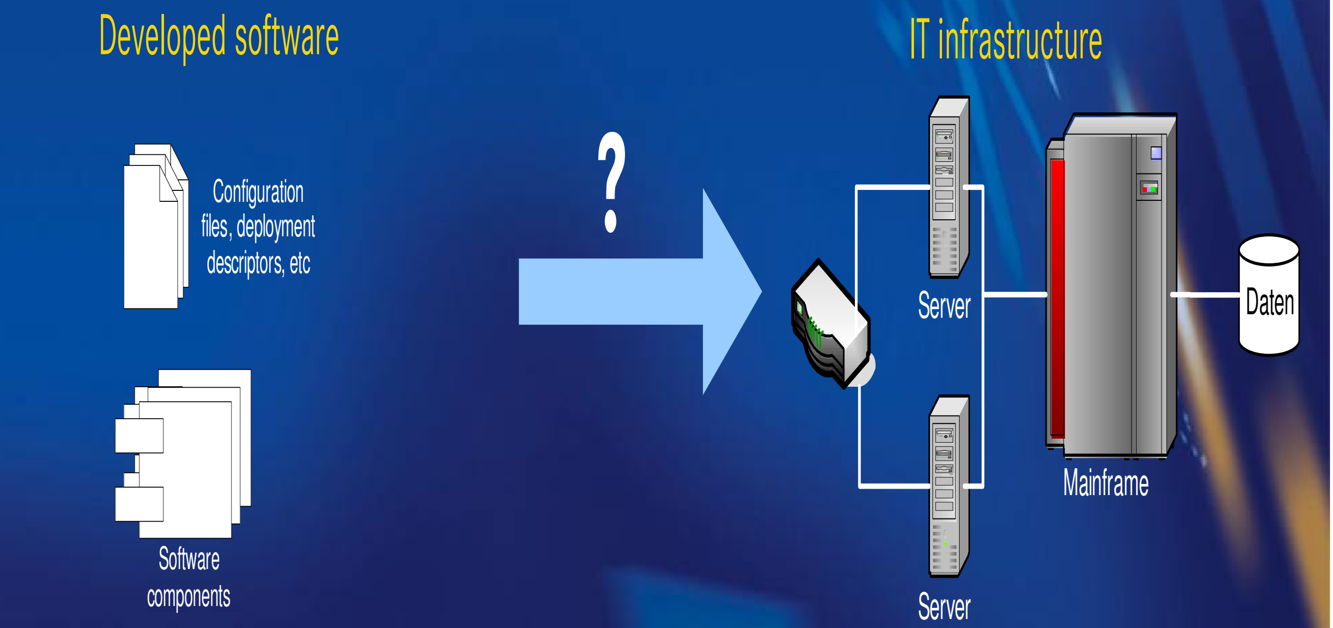
- Structures of software components
- Interaction between components
- Definition of interfaces
- Dynamic behaviour of components

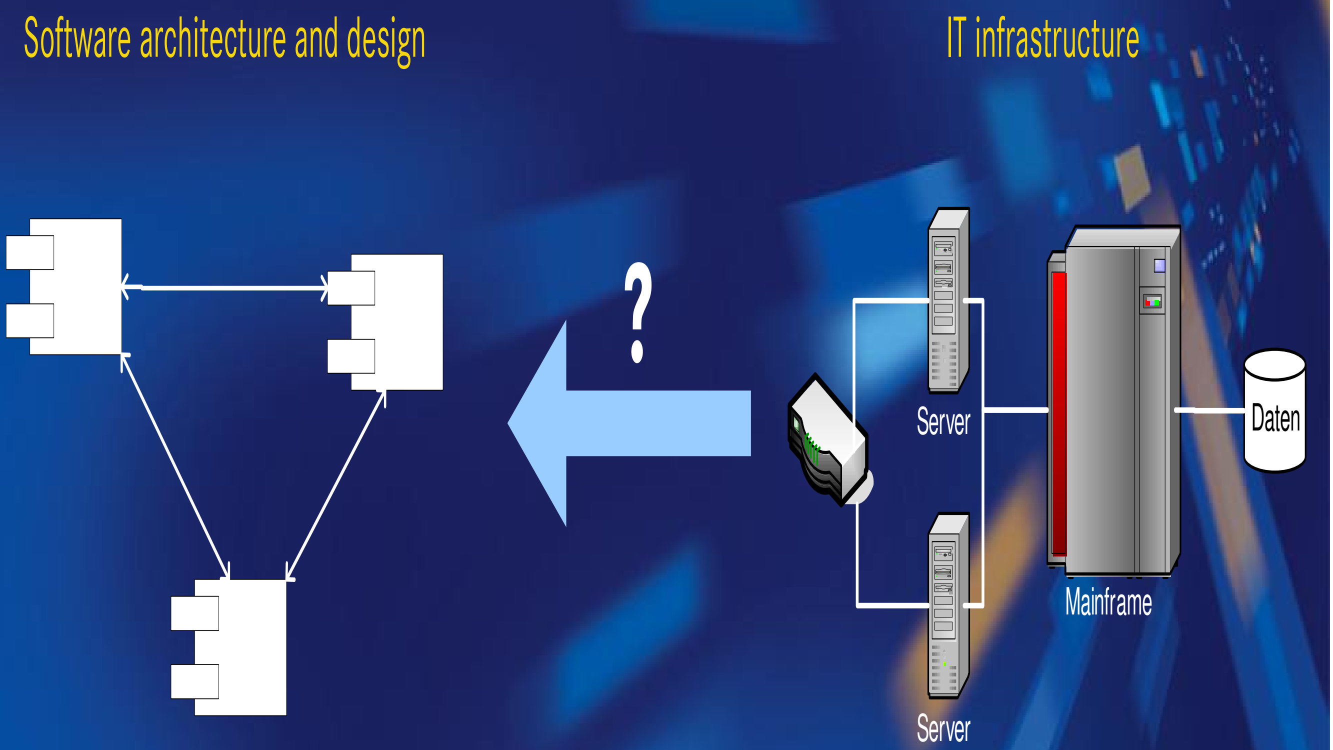
Operational Aspects

- Network organisation
- Distribution of components
- Service level requirements
- Systems Management

IBM Architecture Description Standard defines conventions for notation, terminology and semantics for the architecture of an IT system

Operational Aspects





Operational Aspects

- Vital for the developement and operation of large scale applications
- Need to be addressed in all phases of software development:

Requirements:
- Operational requirements
- Non-functional requirements

Design:
- Distribution of components
- Design for non-functional requirements

Implementation:
- Implement for non-functional requirements
- Implement operational Features

Test:
- Set up test environment
- Test functional and non-functional Requirements

Operation:
- Deploy and configure software
- Maintain and manage software

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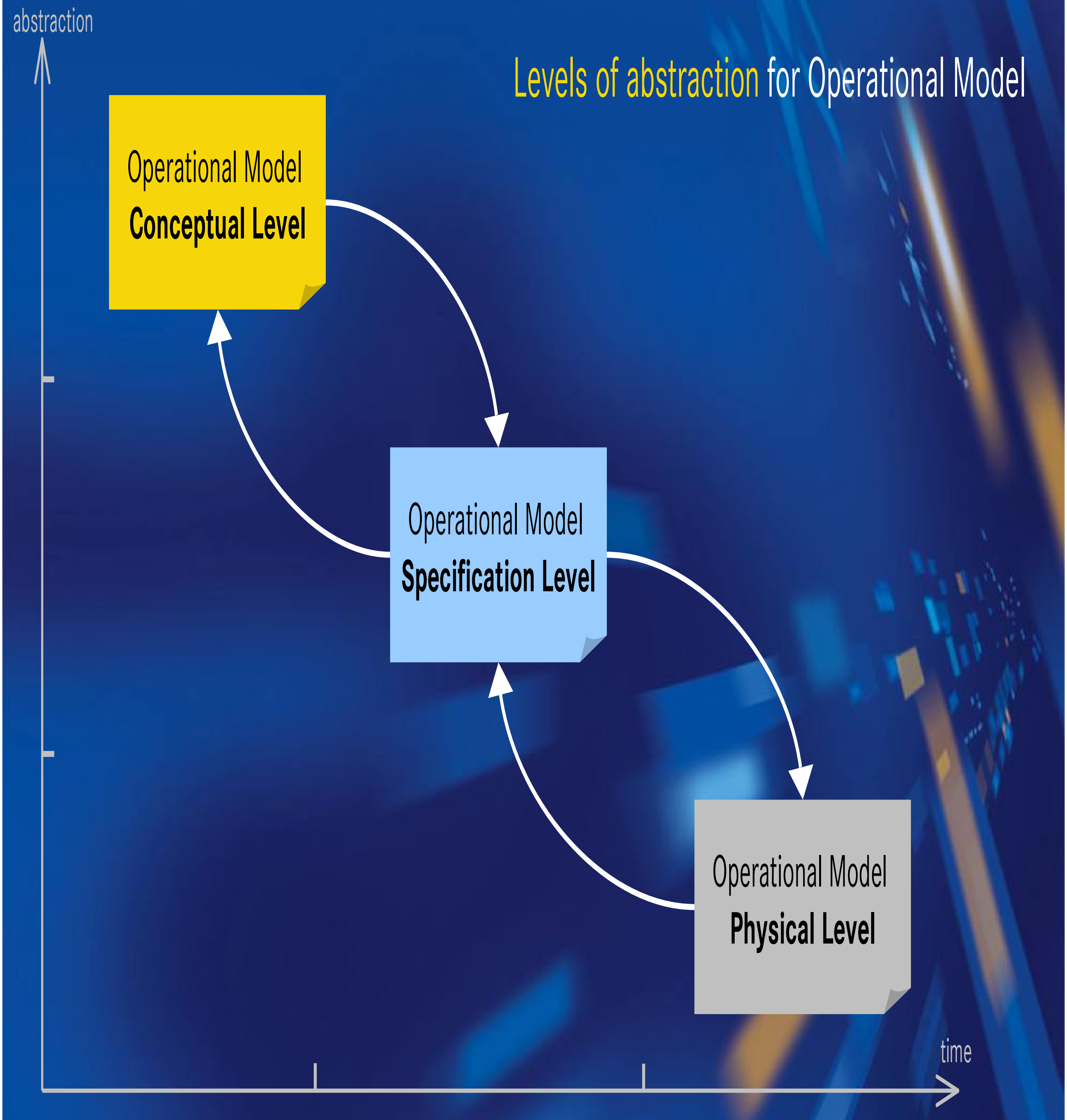
PAI Operational Model

Operational Model (OM) used for operational aspects within PAI:

- Part of IBM Global Services Method
- Defines:
  - **Distribution of components** over
  - **Nodes of the IT infrastructure** and the
  - **Connections required for the interactions of the components** in order to archieve
  - **Functional and non-funtional requirements**
- Contains:
  - One or more relationship diagrams
  - One or more walktrough diagrams
  - Detailed description of nodes and connections
  - Description of how functional and non-functional requirements will be met
  - Description of the systems management strategy
- Devided into two / three different levels of abstraction...

PAI Operational Model



PAI Operational Model

Operational Model
Conceptual Level

Operational Model Conceptual Level (CL)

- defines the set of conceptual nodes (CN) and functional relations between them
- specifies the zoning
- defines deployment units (DU) for each CN
- no product information, no physical specifications

Operational Model
Specification Level

Operational Model
Physical Level

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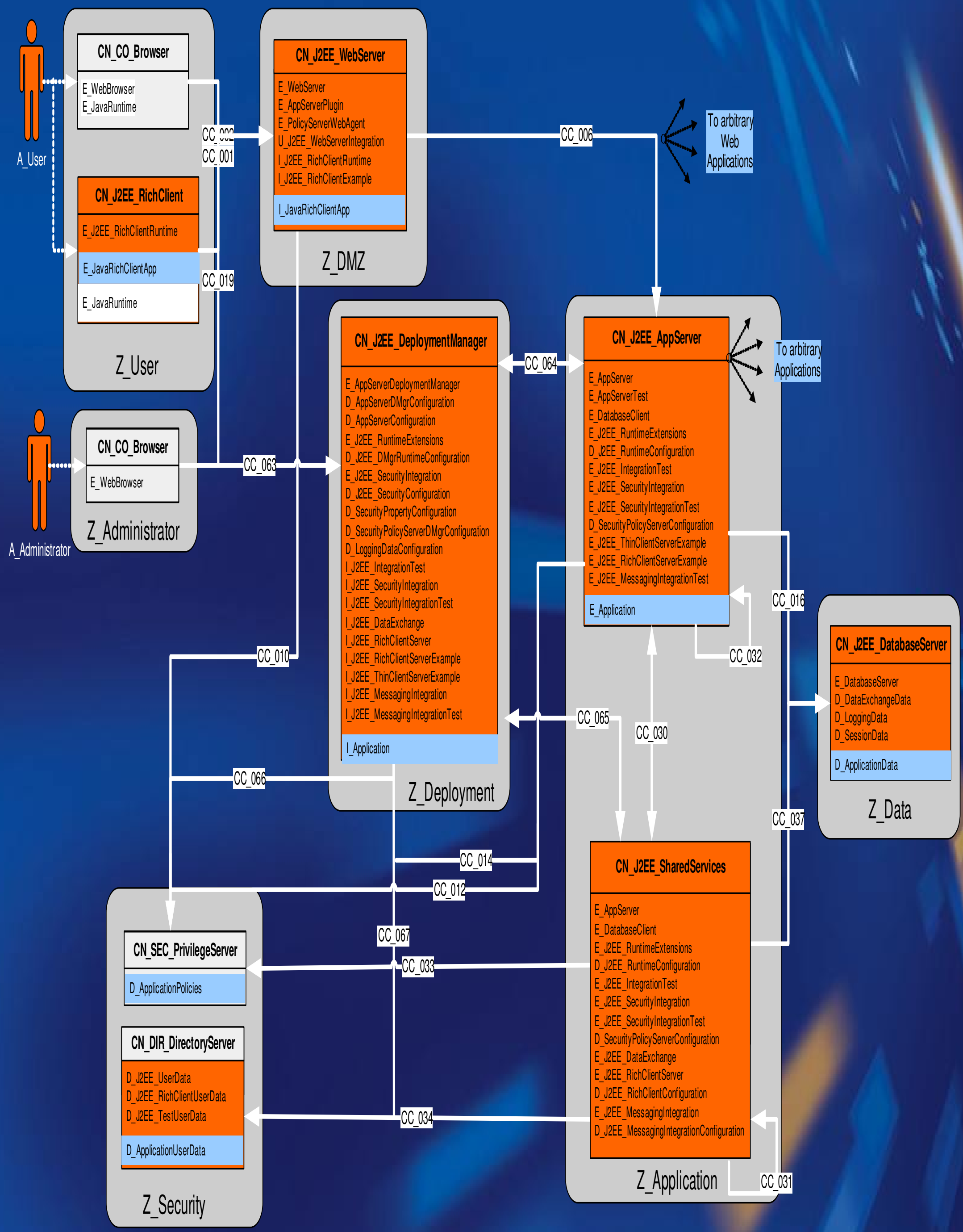
PAI Operational Model



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PAI Operational Model

Operational Model
Conceptual Level

Operational Model
Specification Level

Operational Model
Physical Level

Operational Model Specification Level (SL)

- Specific instance of conceptual level
- Defines the products and major versions to use
- Specifies the type of CN's (cluster, HW pattern, ..)
- No hostnames, no information about real instances

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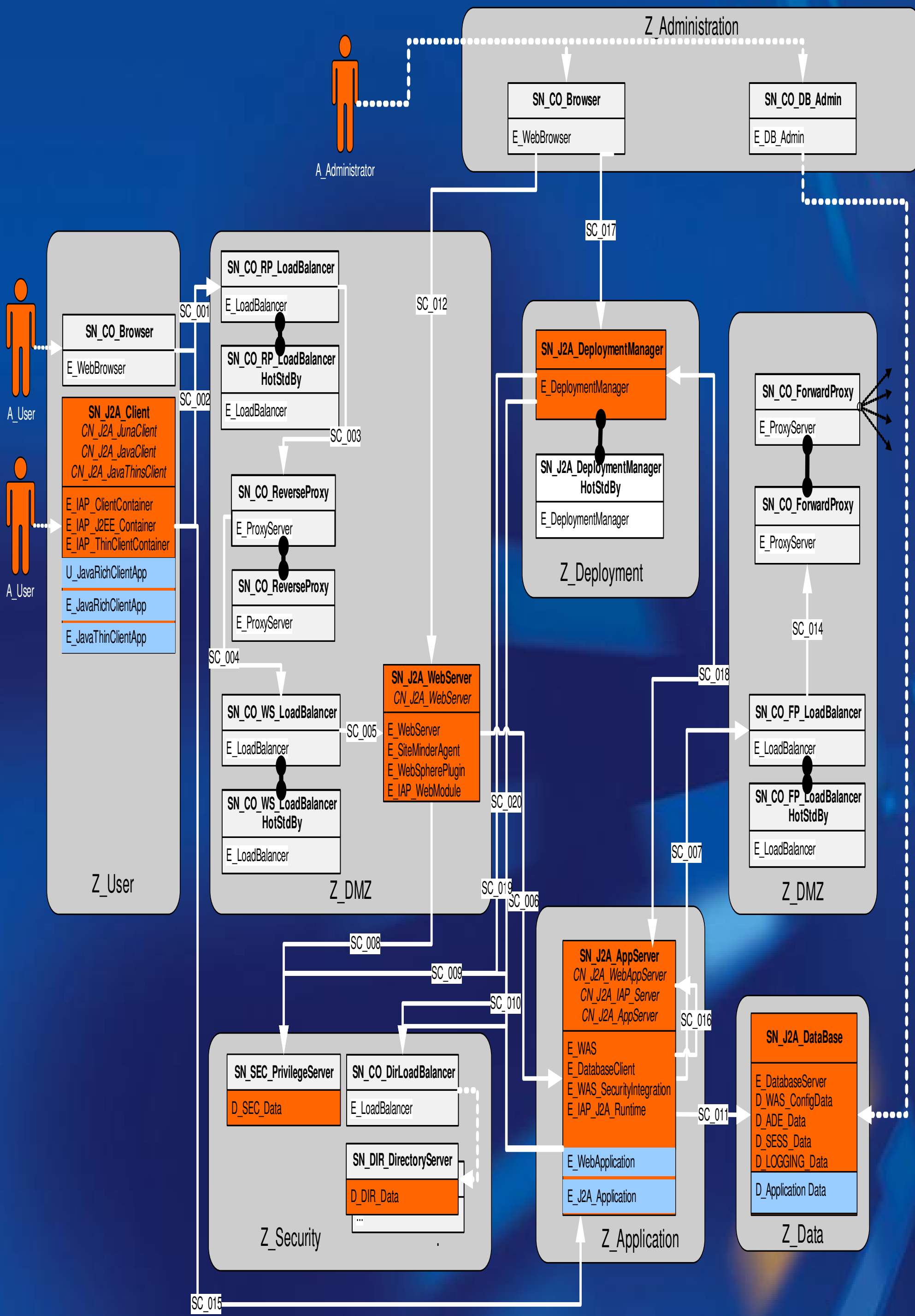
PAI Operational Model



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PAI Operational Model

Operational Model
Conceptual Level

Operational Model
Specification Level

Operational Model
Physical Level

Operational Model Physical Level (PL)

- Defines all aspects required for setting up the environment in a real hosting environment
- IP's, hostnames, ports, FW
- Machine specification, references to asset management

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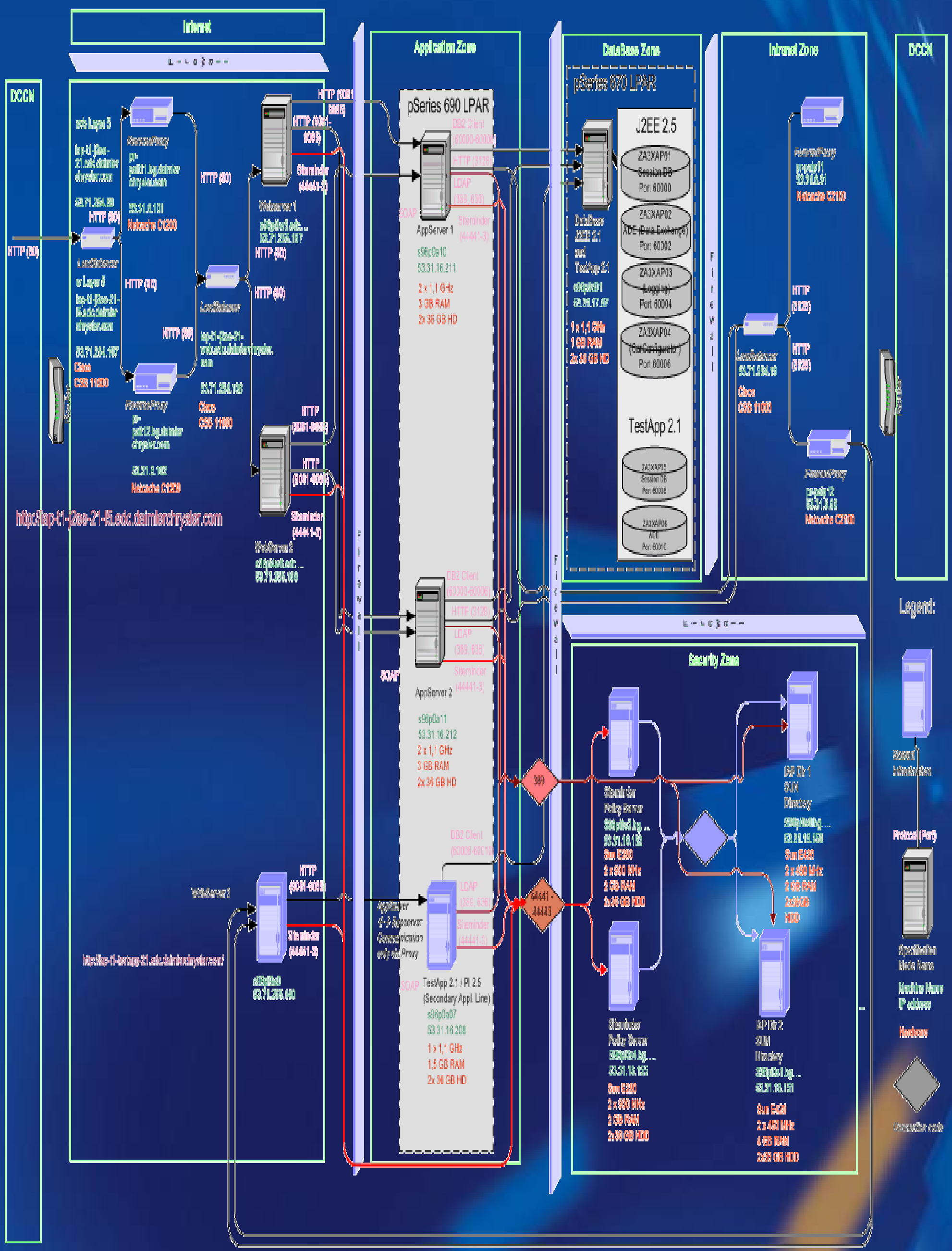
PAI Operational Model



PAI Operational Model

Other operational artifacts:

- Operational Description (OD):
  - XML-based document
  - Central repository for operational information
  - Contains data from Operational Model of all levels
  - Detailed configuration parameters for base products and PAI components
  - Used for PICS
- Platform Installation and Configuration Solution (PICS)
  - Automated installation and configuration of PAI J2EE Platform
  - Based on predefined solutions and user-guided wizard
  - Uses OD as major input

PAI Operational Model

Current state:

- Operational Model only used in informal way (Visio diagrams, Word files...)
- No consistency checks possible
- No standard notation so far for Operational Model
- Only rarely used by PAI projects (due to lack of tools?)

- Operational Description for J2EE has around 3000 lines of XML
- Complex and not human readable
- Difficult to maintain

→ Modeling approach could solve some problems here!

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DSL for the Operational Model

Domain Specific Languages:

- Used to define the key aspects of a specific domain
- Enriches models with semantic
- Captures the knowledge of the domain expert
- Already widely used (SQL, FORTRAN, etc.)
- Key item for model-driven software development

Ingredients:

- Abstract Syntax
- Static Semantic
- Dynamic Semantic
- Concrete Syntax

Abstract Syntax, Static Semantic → Metamodel

Dynamic Semantic → Model transformations

DSL for the Operational Model

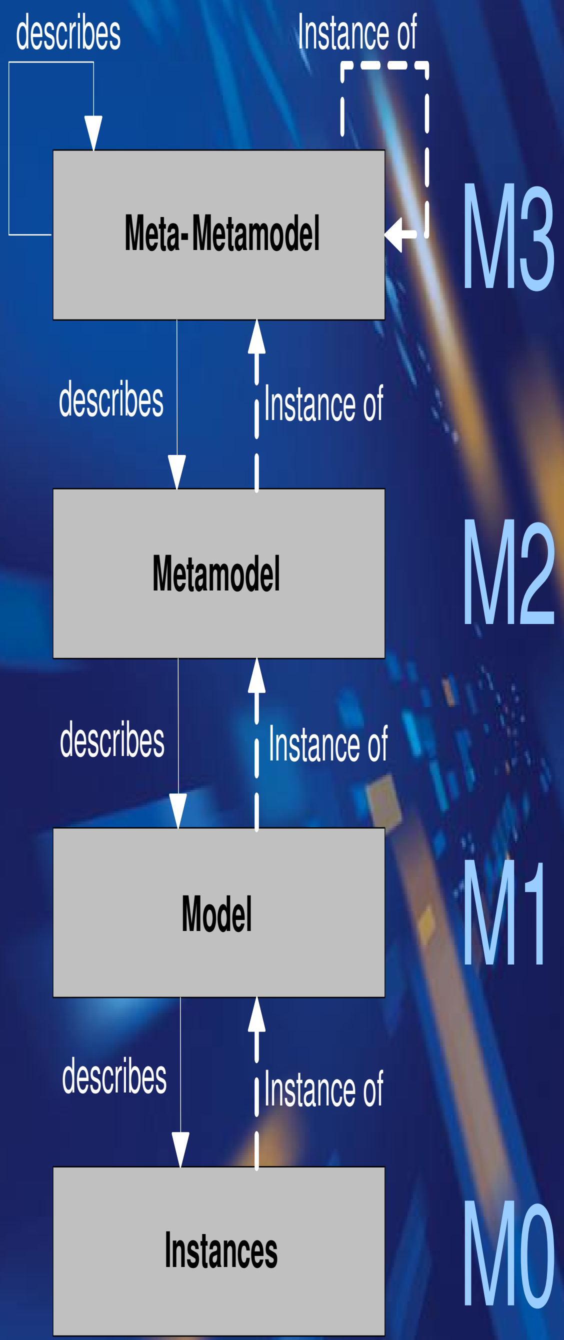
Metamodeling

- 4 layers defined by Meta-object Facility (MOF)
- Java Code on M0 (as instance of UML-model)
- UML-Models on M1
- UML-Metamodel on M2
- MOF on M3

Possible metamodels for DSL:

1. Extend UML-Metamodel in M2 with profiles (stereotypes, tagged values)
2. Create new M2 metamodel based on MOF
3. Create new M2 metamodel based on other M3 metametamodel

→ DSL as new M2 metamodel based on MOF



DSL for the Operational Model

Metamodeling approach:

- Analyse existing models
- Extract key elements
- Model key elements in metamodel
- Use modeling techniques known from UML modeling

Best-practices:

- Keep it simple
- Interatively check and extend metamodel against model
- Model containment in one single element (direct or indirect)

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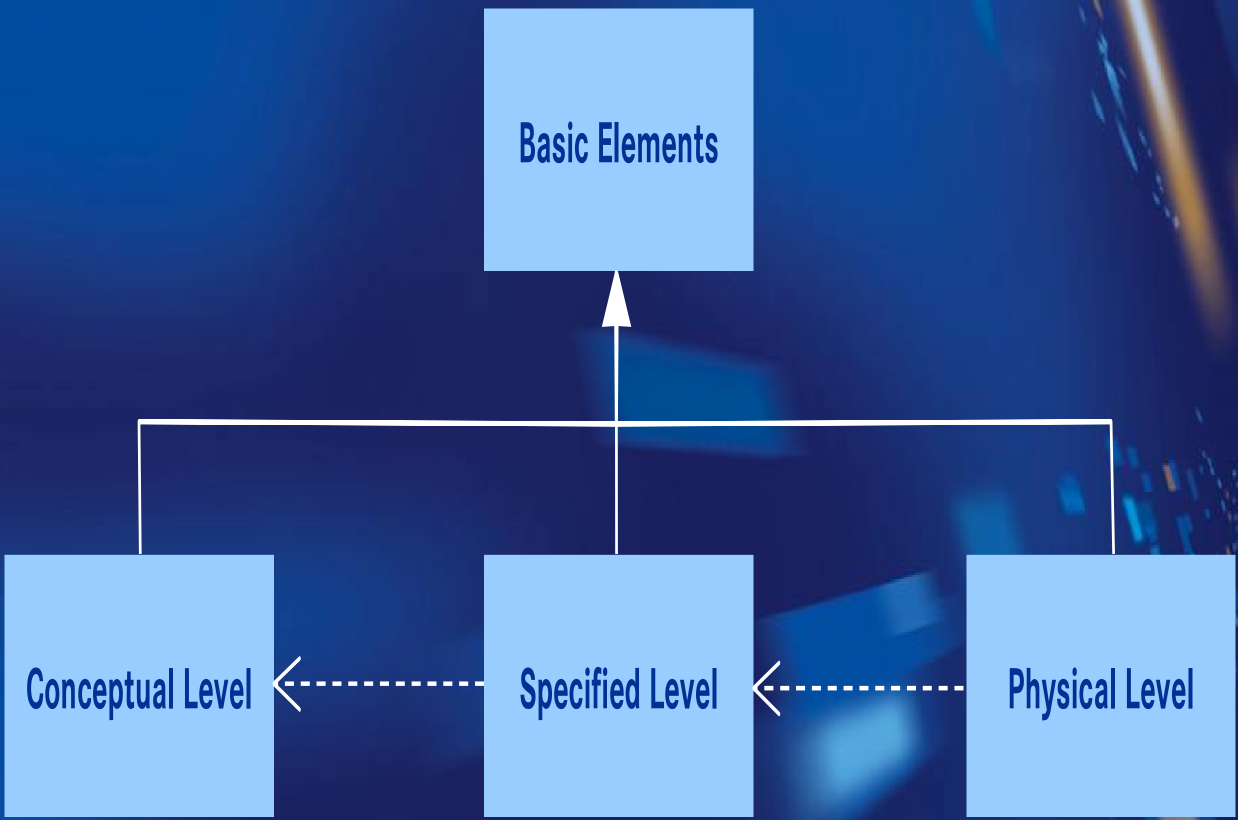
DSL for the Operational Model

Structure of the Metamodel:



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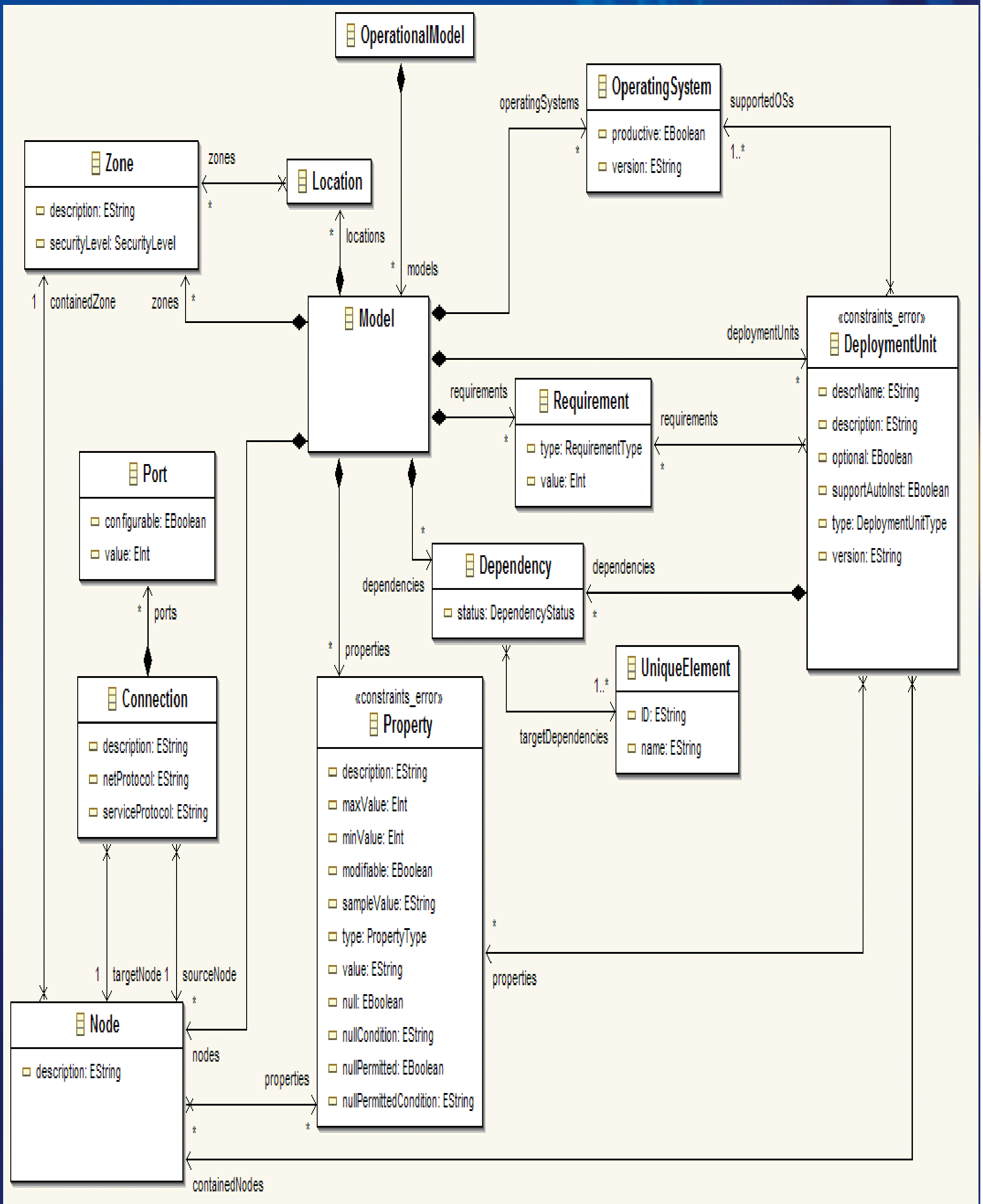
DSL for the Operational Model

Metamodel

Basic elements



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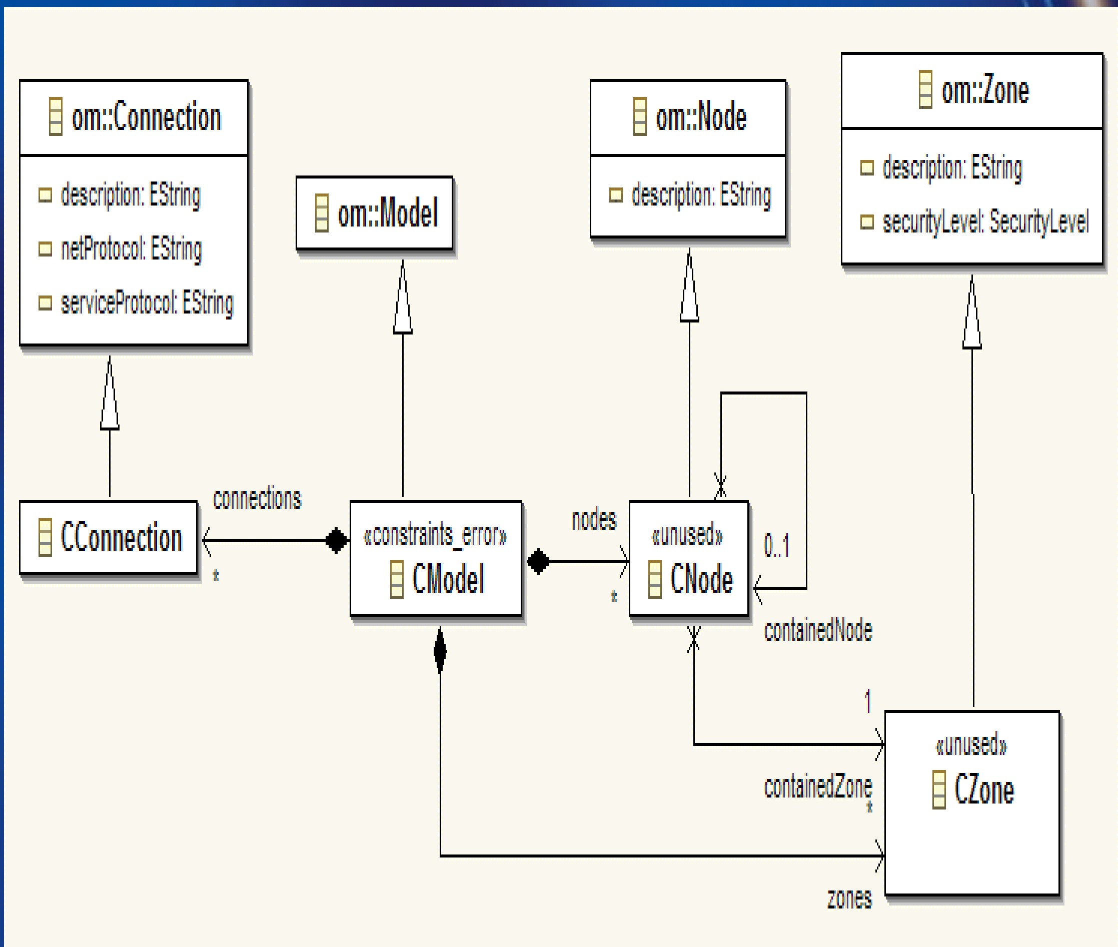
DSL for the Operational Model

Metamodel

Elements of conceptual level



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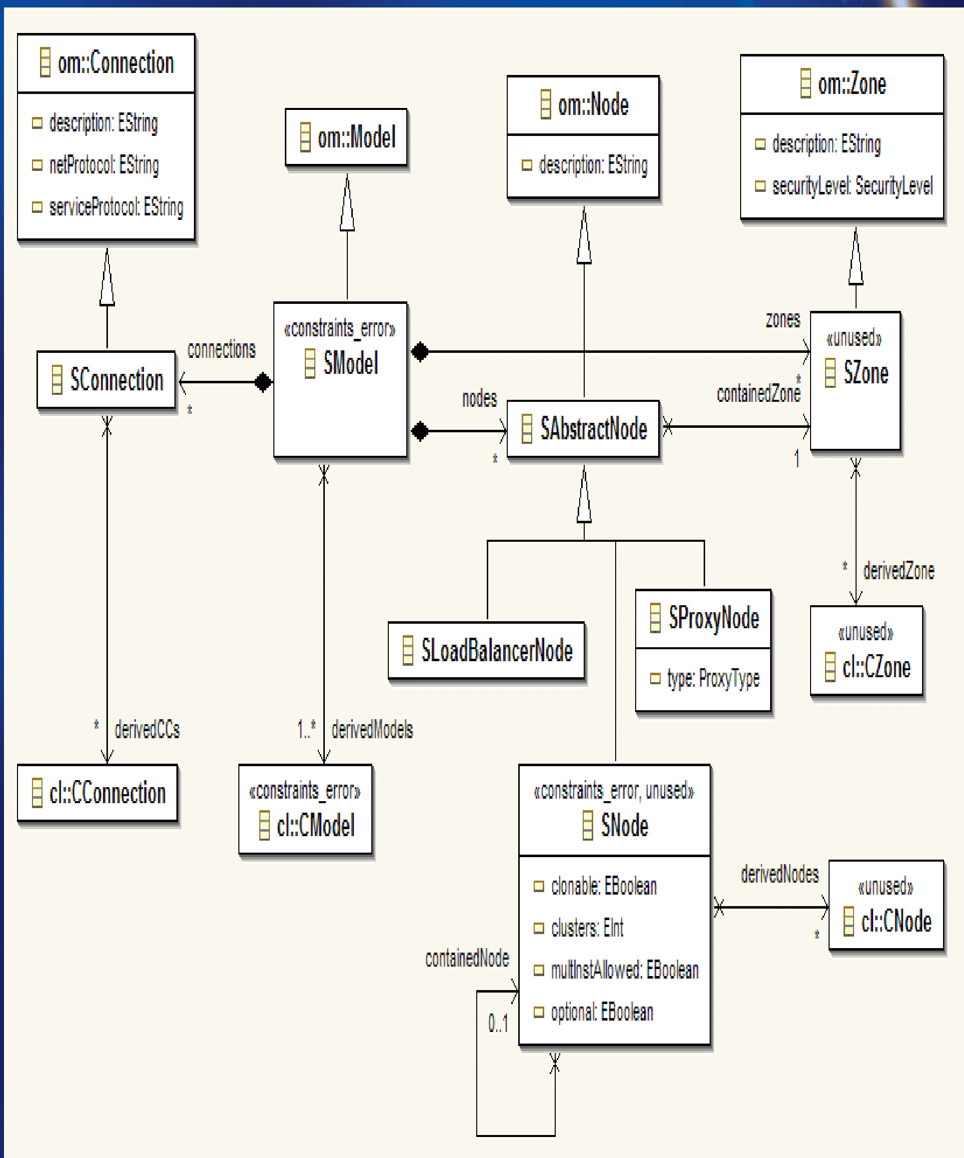
DSL for the Operational Model

Metamodel

Elements of specification level



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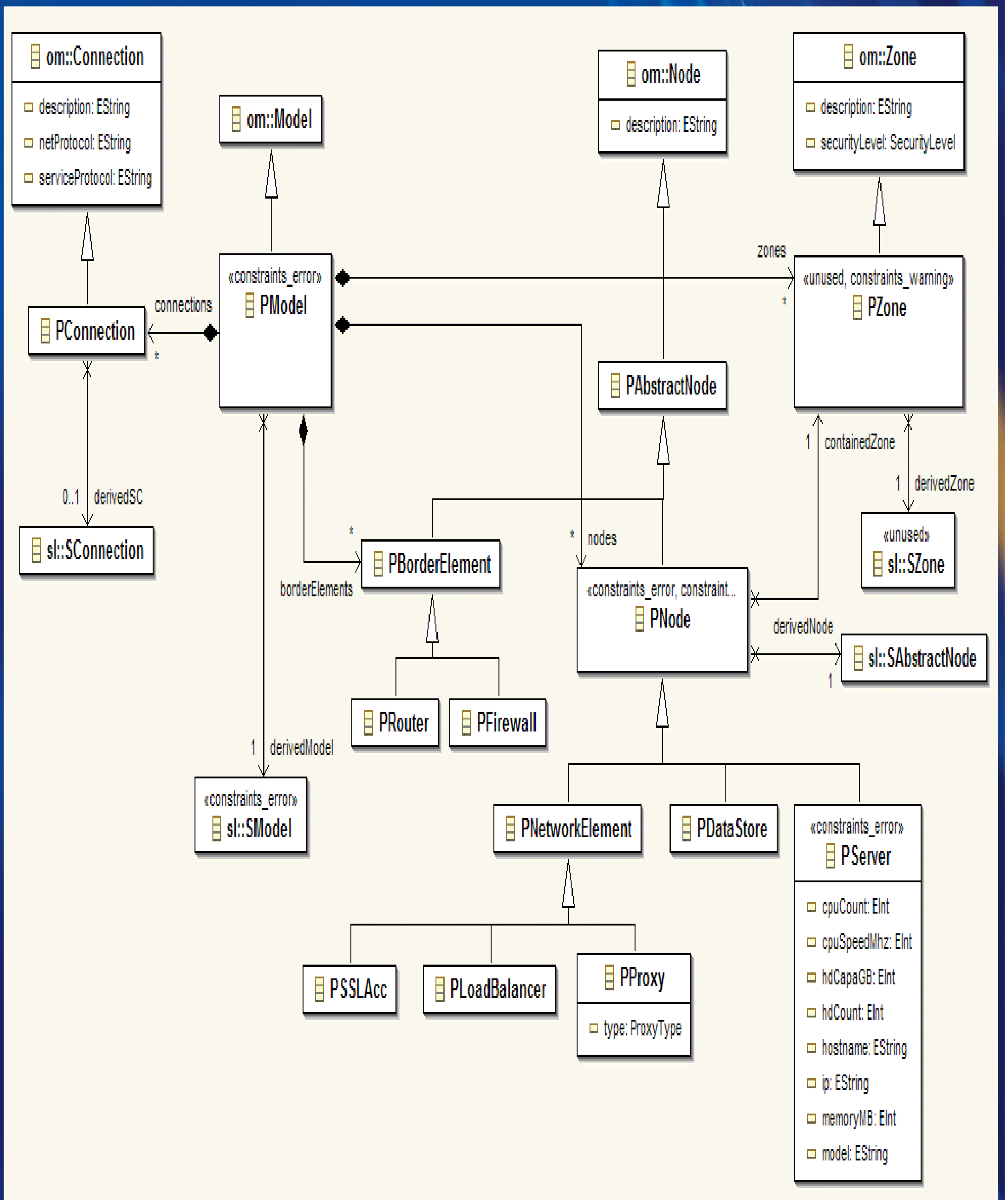
DSL for the Operational Model

Metamodel

Elements of physical level



DSL for the Operational Model

Semantics:

- Semantics define the meaning of a language
- Static semantics define the well-formedness of a model
- Static semantics can be expressed as contraints in the metamodel
- Dynamic semantics define the meaning of elements of the metamodel
- Dynamic semantics expressed on forms of transformations

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DSL for the Operational Model

Static Semantic with OCL

- Object Constraint Language (OCL) is a declarative, side-effect free language for the definition of constraints on a model (or metamodel)
- Can be applied on M1, M2 or M3

Example for the Operational Model metamodel:

```
context sl::SNode
inv:
   self.deploymentUnits->select(du | not du.supportedOSs
      ->exists(os | os.ID = self.operatingSystem.ID))
      ->union(
         self.derivedDUs->select(du | not du.supportedOSs
            ->exists(os | os.ID = self.operatingSystem.ID))
      )
```

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Model Transformations

Why model transformations?

- Capture the semantics of the metamodel
- Reduce modeling complexity and effort
- Ensure consistency between models

Model Transformations vs. Text Transformations (XSLT)

- Validation of transformation rules based on metamodel
- Only valid models are generated
- Reduced complexity
- Support for synchronisation of models

Model Transformations

IBM Model Transformation Framework

- Based on EMF metamodels
- Bidirectional Transformations
- Reconciliation of transformed models
- Based on RFP on QVT (Query, View, Transformation)
- Available as Eclipse Plugin

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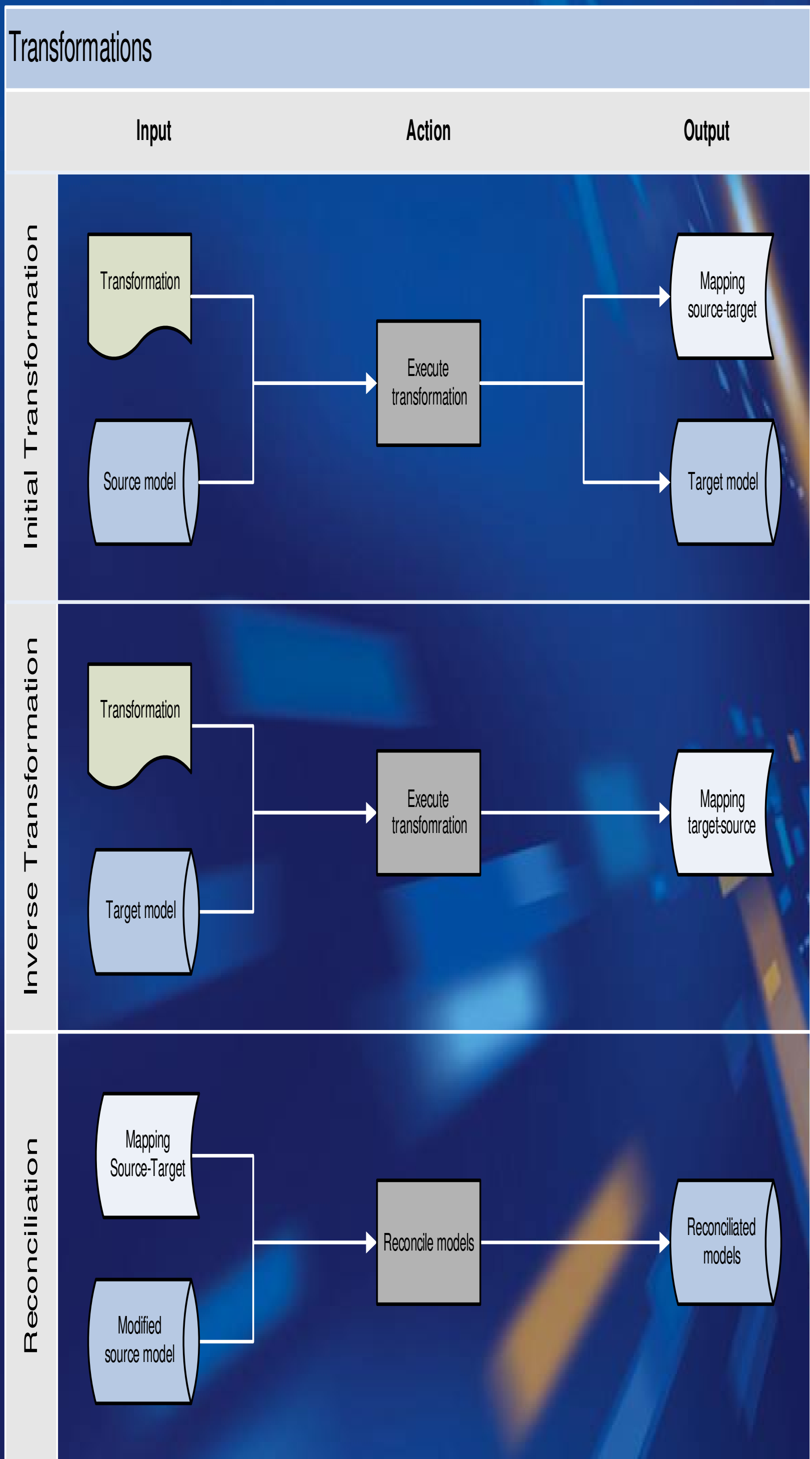
Model Transformations

Workflow model transformations



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Implementation with Eclipse Tools

Eclipse Tooling Landscape:

- Eclipse:
  - extensible Rich-Client Framework and IDE
- Eclipse Modeling Framework (EMF):
  - modeling framework and code generation facility for building tools and other applications based on a structured data model
- Eclipse Graphical Editing Framework (GEF):
  - framework for creating rich graphical editors based on existing application model
- Eclipse Graphical Modeling Framework (GMF):
  - provides a generative component and runtime infrastructure for developing graphical editors based on EMF and GEF

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Implementation with Eclipse Tools

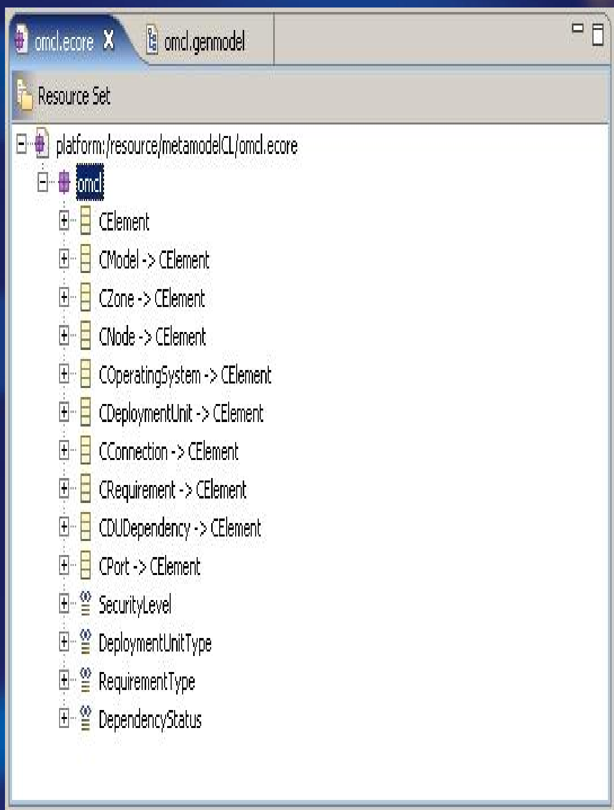
Tasks:

1. Create metamodel in EMF *(abstract syntax)*
2. Add constraints in OCL to the metamodel *(static semantic)*
3. Create GMF editor definition from metamodel (*concrete syntax)*
4. Generate metamodel and editor code
5. Adjust generated code
6. Run editor in Eclipse

Implementation with Eclipse Tools

1. Create metamodel in EMF

- EMF metametamodel is Ecore → similar to EMOF or UML class diagram
- Eclipse EMF provides simple Ecore editor
- EMF metamodel can be imported from Rational UML model, annotated Java classes, or XMI
- Graphical Editor can be used from GMF or e.g. Omondo EclipseUML



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Implementation with Eclipse Tools

2. Add constraints to metamodel

- No native „constraint“ element in Ecore metamodel!
- In UML, annotations are used to visualize constraints
- *EAnnotation* elements can be used to add constraints to metamodel
- Constraints expressed in OCL
- Validation of constraints by external tool (e.g. Kent OCL Library)

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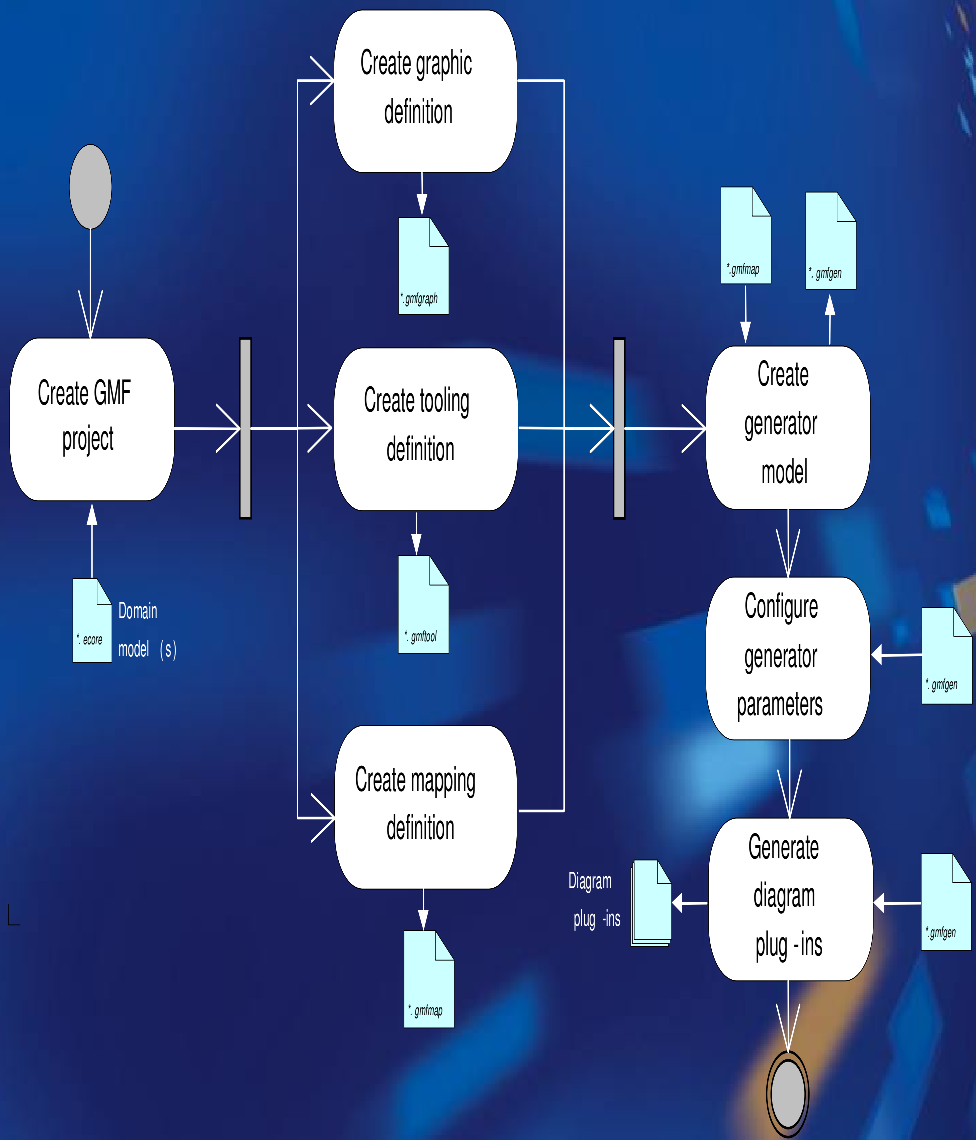
Implementation with Eclipse Tools

3. Create GMF editor from metamodel



Implementation with Eclipse Tools

3. Create GMF editor from metamodel

A) Graphical definition (gmfgraph):

- Define Figure Gallery based on simple shapes (rectangle, rounded rectangle, polygon, ellipse, polyline, etc.) or custom shapes based on programmatic GEF figures
- Define graphical nodes for the specific editor
- Map graphical nodes to elements of the figure gallery (can be external figure gallery as well)

→ No direct relation to metamodel

→ Can be reused for different editors

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Implementation with Eclipse Tools

3. Create GMF editor from metamodel

B) Tooling definition (gmftool):

- Define tools required for editor:
  - Menu contributions
  - Context menu
  - Toolbar
  - ...
- Minimum tooling definition contains creation tools for the toolbar for each metamodel element

→ No direct relation to metamodel

→ Can be reused for different editors

Implementation with Eclipse Tools

3. Create GMF editor from metamodel

C) Mapping definition (gmfmap):

- Connect all created models (metamodel, gmfgraph, gmftool)
- Map metamodel elements to corresponding graphical element and creation tool
- Define root diagram element

→ Direct relation to metamodel
→ Can use multiple models

→ Create Generator Model from gmfmap

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Implementation with Eclipse Tools

4. Generate metamodel and editor code

- Generate Java representation of metamodel from EMF generator model
- Generate editor code from GMF generator model

→ resulting projects:

1. *Metamodel project* - contains models and metamodel code
2. *Edit project* - contains model editing code (properties, etc.)
3. *Editor project* - contains editor code (wizards, file extension, etc.)
4. *Diagram project* - contains GEF code for diagram editor

All projects are Eclipse Plug-ins and can be launched!

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Implementation with Eclipse Tools

5. Adjust generated code

- Source code of plugins is available
- JavaDoc-tags mark generated code parts (`@generated`)
- Changes of code required for special use-cases
- Mark manually changed code parts with `@generated NOT`
- Code generation will not override changed parts

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Implementation with Eclipse Tools

6. Run editor in Eclipse

- Generated projects all Eclipse Plugins
- Run plugins withing runtime workbench or export as feature
- Plugins include:
  - Creation wizards
  - Menu extensions
  - Simple model editor
  - GMF graphical editor
  - File extension registration

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Conclusion

- Formal modeling is essential for managing complexity
- Operational aspects are too komplex NOT to be modeled
- Metamodeling approaches based on MOF / Ecore provide solid foundation for the creation of custom DSLs
- Eclipse Tools (EMF, GEF, GMF, etc.) can be good starting point for the implementation of DSLs

- GMF still in heavy development, major changes to be expected until version 1.0
- Advanced modeling support (multi-user, rights management, change management, versioning, etc.) has to be provided by other tools or to be self-implemented
- For complete modeling solution for PAI Operational Model, some major effort has to be applied, but generative approach makes solution very flexible and changes can be applied easily

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The End

Thank you!

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