TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik - Institut Software- und Multimediatechnik - Softwaretechnologie

6. Introduction to the Architecture of MDSD Tools in a Technical Space

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http://st.inf.tu-dresden.de/teaching/most

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1) Architecture of Tools
2) Repository
    1) Metamodel control
3) Repositories as Collaboration of Tools and Materials
4) Examples of Repositories
    1) Master Data Management

DRESDEN concept
Exzellenz aus
Wissenschaft
und Kultur

Obligatory Literature

- Netbeans Metadata repository (MDR) http://docs.huihoo.com/netbeans/netbeanstp.pdf
- [deep-ROP] D. Bäumer, D. Riehle, W. Silberski, M. Wulf. Role Object. Conf. On Pattern Languages of Programming (PLOP) 97. http://citeseer.ist.pst.edu/baumer97role.html
- Steffen Staab, Tobias Walter, Gerd Gröner, and Fernando Silva Parreiras. Model driven engineering with ontology technologies. In Uwe Aßmann, Andreas Bartho, and Christian Wende, editors, Reasoning Web, volume 6325, Lecture Notes in Computer Science, pages 62-98. Springer, 2010.
  - http://www.uni-koblenz.de/~staab/Research/Publications/2010/reasoningweb2010.pdf

6.1 The Architecture of Tools in TAM

Applications are built from Tools- Automata – Material

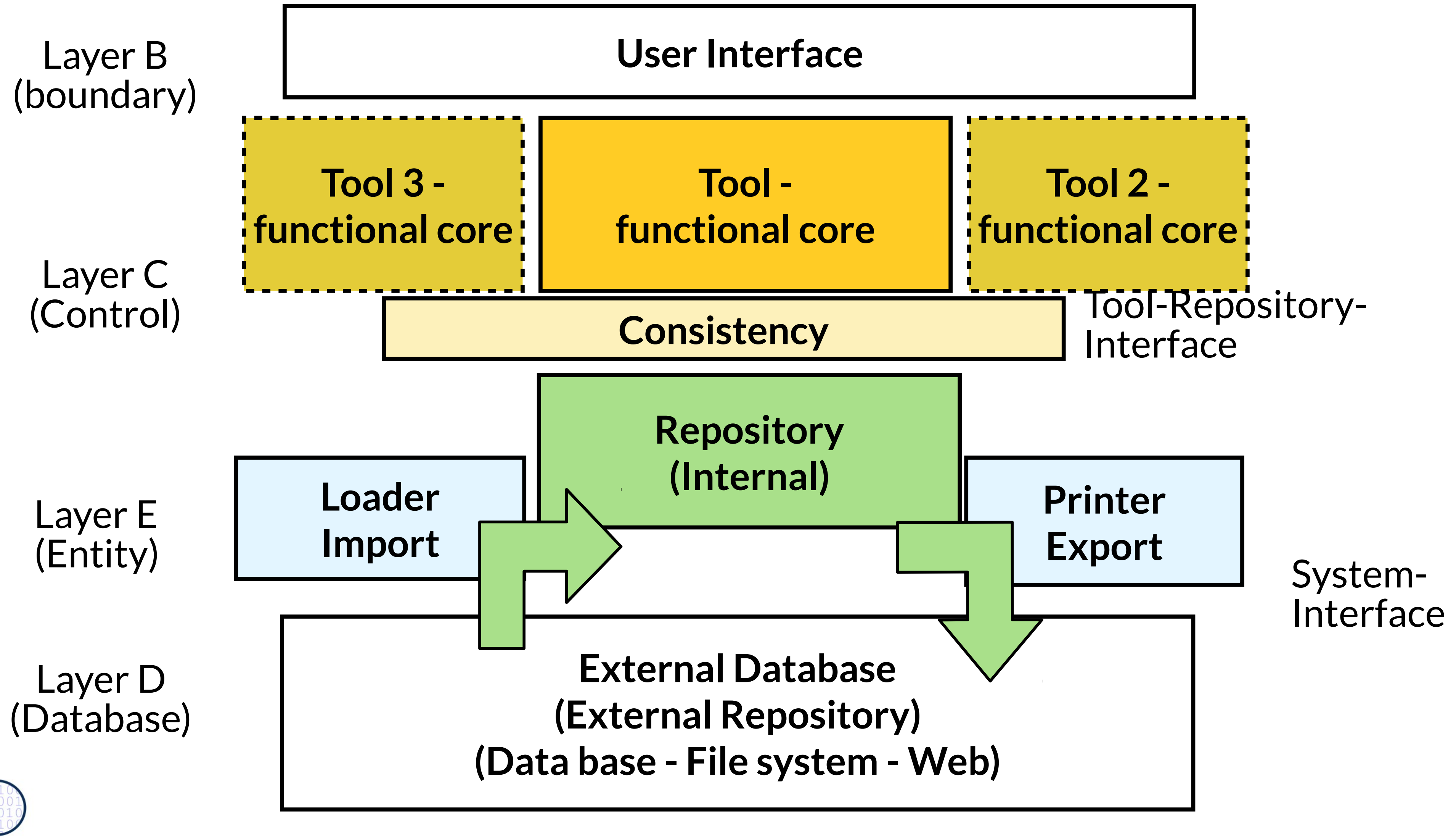
Cmp. The architectural styles of applications from Softwaretechnologie-II:

Algebraic Applications: based on calls

Coalgebraic Applications: based on streams

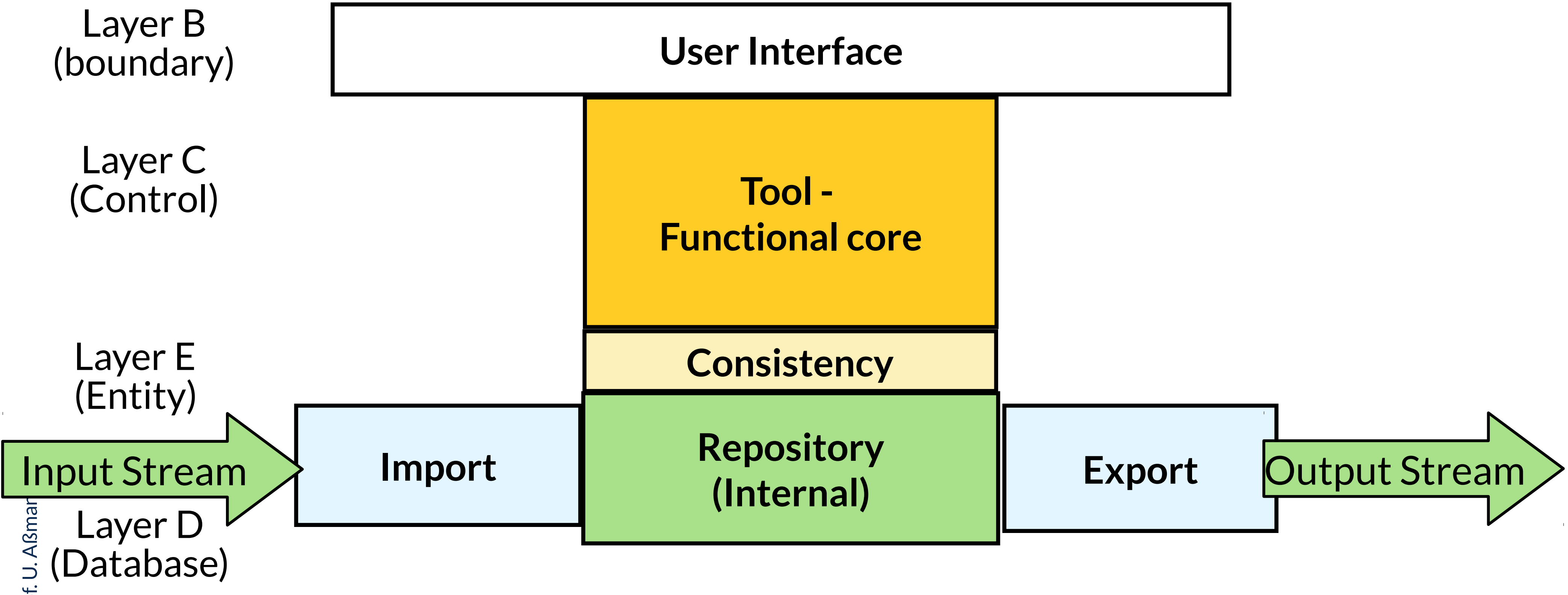
Q5: Architecture of Repository-Based Tools (call-based Repository)

- Repository may be shared between several tools



Q6: Architecture of Stream-BasedTools

- Usually, the repository is internal and non-shared
- Therefore, the work is done piece by piece, as it arrives via the stream

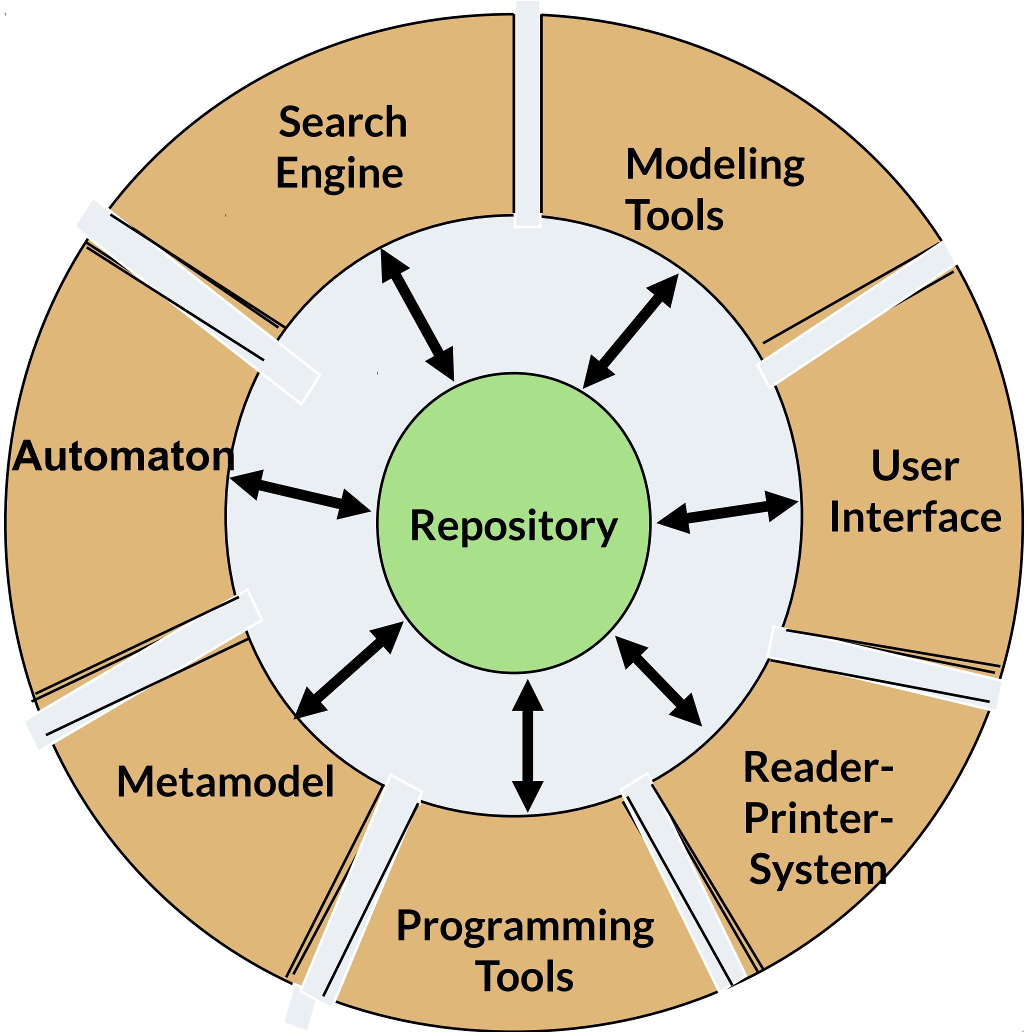


6.2. Repository for the Materials

- A Repository stores
  - Material objects from M0
  - Models from M1
  - Metamodels from M2

Objectives of a Repository

A **Repository (Datenbasis, Datenablage)** is the container of all Materials of a software system.



Objectives of a Repository

- Cooperation of Tools
  - **Synchronisation** on metadata and Materials
  - **Transactions** for consistent change of Materials
  - **Configuration management**: Varianting and versioning
- Collaboration:
  - **Transparent Distribution:** access from everywhere in the company or internet
  - **Efficient access**: Transactions per second)
  - Event-based communication
- **(Transparent) Persistent storage** of Materials from M0, M1, M2
  - Physical data model: should be transparent to the application
    - often in entity-relational schema, then management of an object-relational mapping
- **Administration**: management interfaces
- Development qualities:
  - **Adaptability**: Embedding of repository into applications, IDE and MDSD tools
  - **Extensibility**
  - **Portability**

Quelle: nach Habermann, H.-J., Leymann, F.: Repository - eine Einführung; Oldenbourg Verlag 1993
und Däberitz, D.: Der Bau of SEU mit NDBMS; Diss. Uni Siegen 1997

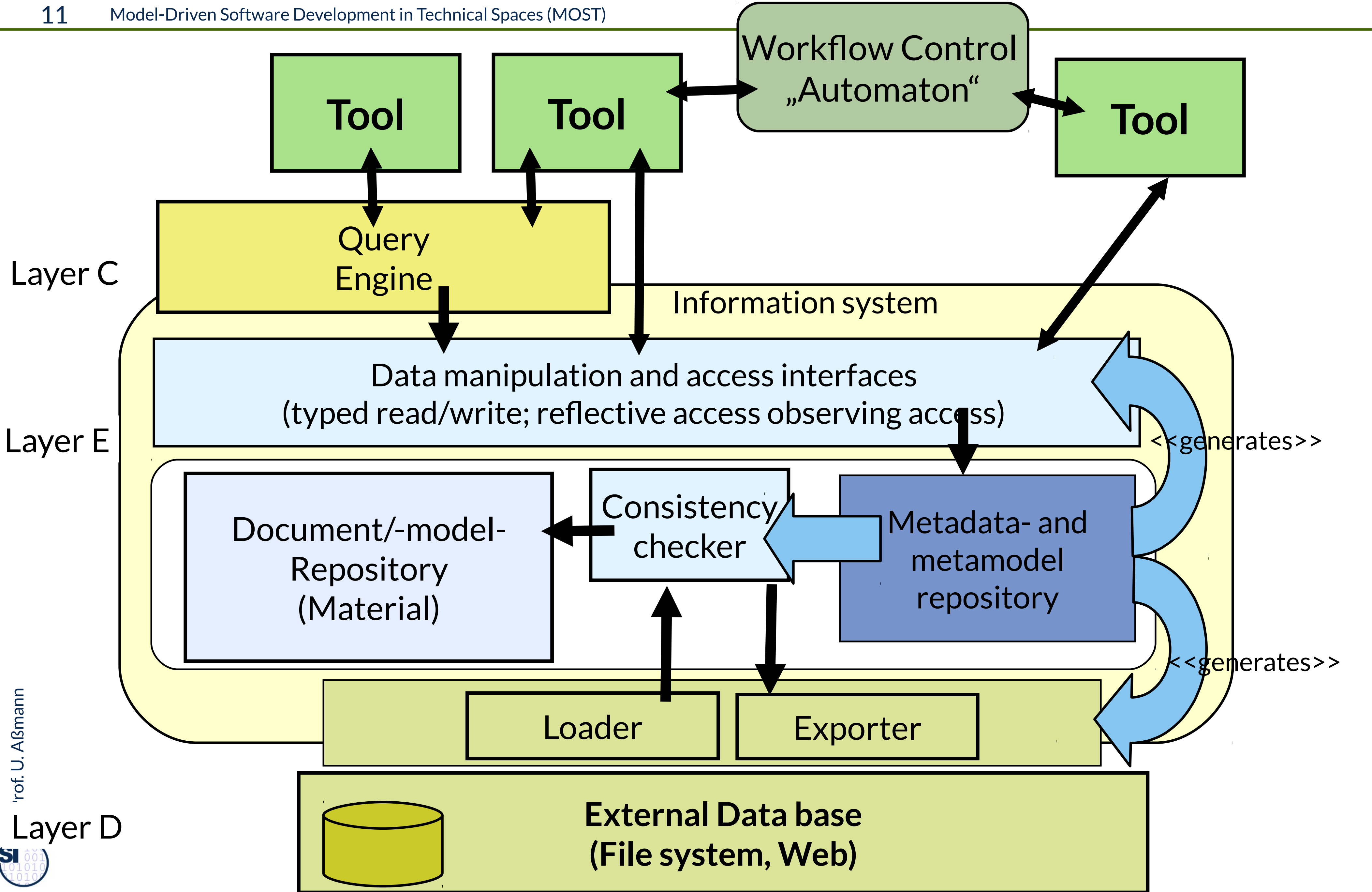
6.2.1 Metamodel-Driven Repositories

Objectives of a Repository

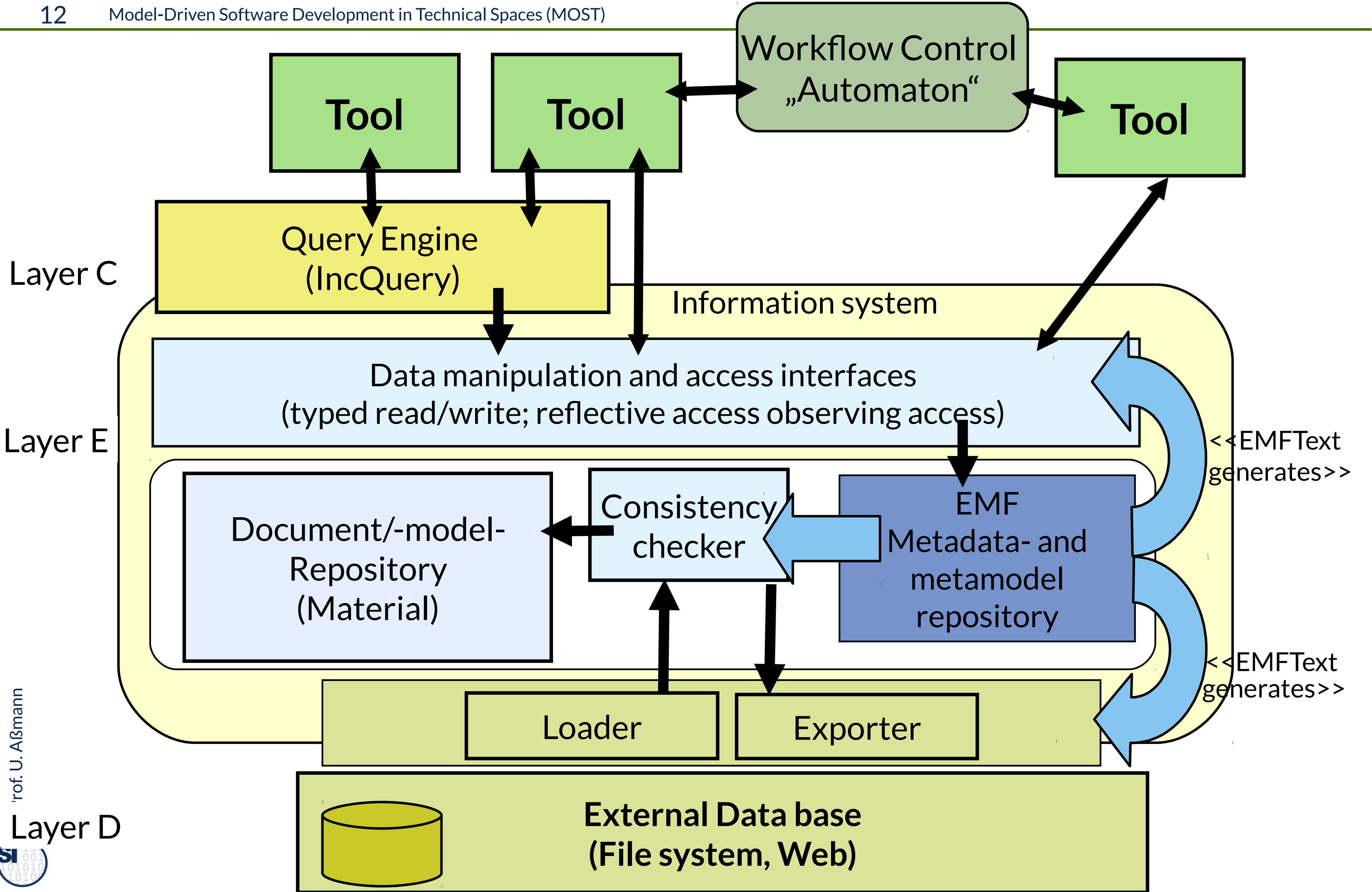
- Support by **metamodels** on M2, of DDL describing the structure of Materials:
  - **Typed access interfaces**: programmable APIs
  - **Untyped access (reflective) interfaces**
  - **Query languages on models and objects**
  - **Logical data model:** application-specific data model
  - **External metamodels** for import and export
    - Textual
    - Exchange formats, such as XML or JSON

Quelle: nach Habermann, H.-J., Leymann, F.: Repository - eine Einführung; Oldenbourg Verlag 1993
und Däberitz, D.: Der Bau of SEU mit NDBMS; Diss. Uni Siegen 1997

Q7: Tool Architecture with Data Sharing in a Metamodel-Driven Repository

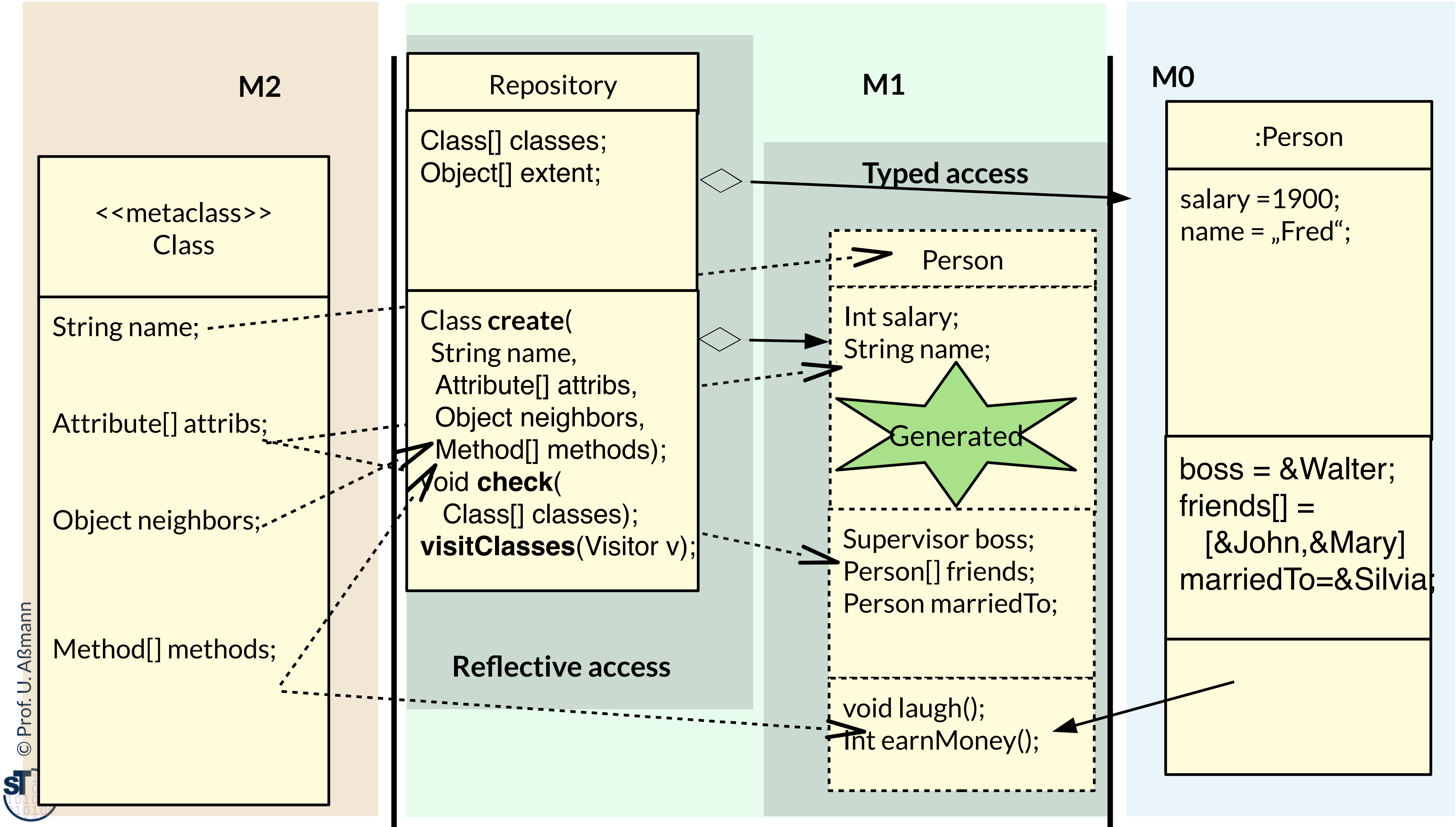


Q6: EMF-Based Tool Architecture with Data Sharing in a Metamodel-Driven Repository



Generation of Typed Interfaces

- From the metaclasses on M2, the structure of the types of the access interfaces and many other code-packages is derived on M1 (compartments):



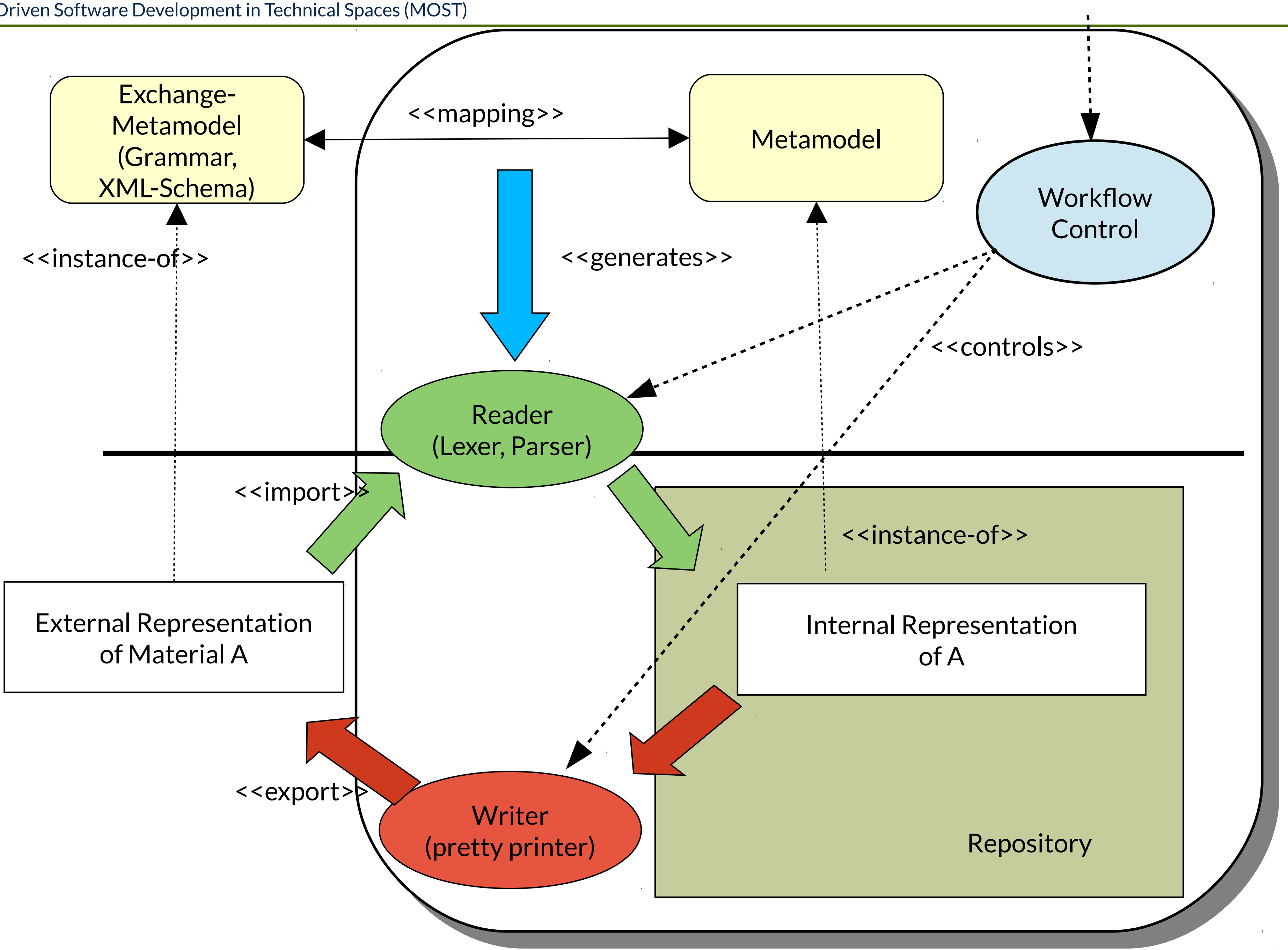
Metamodel-Driven Repositories

- A **metamodel-driven repository** enables to create typed repositories with typed Materials
  - Able to load one or several metamodels
  - Metamodels are stored as metadata in the metadata (sub-)repository
  - Metamodels must be defined in one metalanguage (or lifted DDL)
- Benefits:
  - Structural information about the objects and models conforming to the metamodels is known
    - Members of classes and objects
    - Atomic, set-based, structured or reference attributes
    - Collections or graphs
    - Cardinalities of neighbors
  - From these informations typed access interfaces to the Materials can be generated

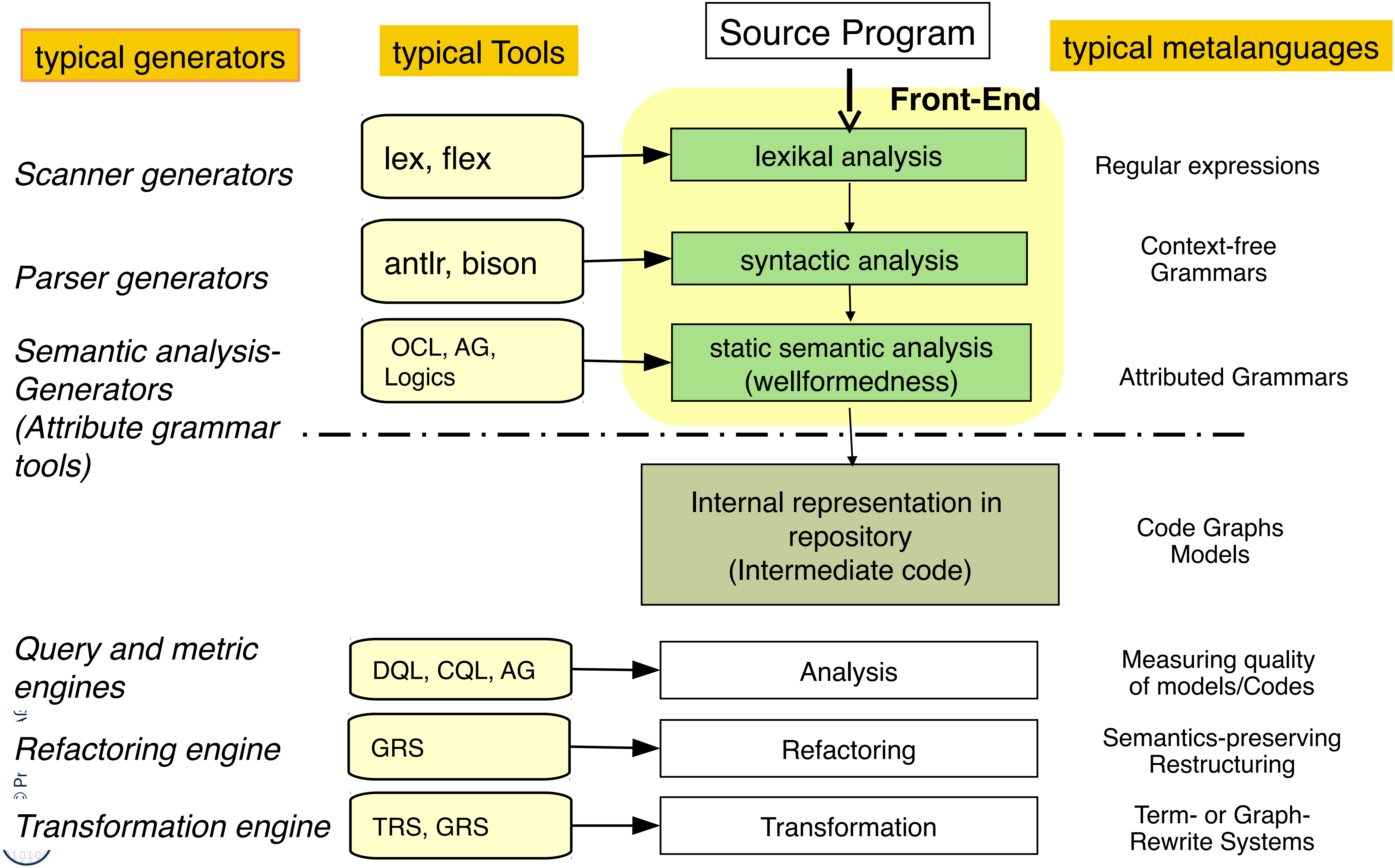
Generation of Interfaces and Packages in a Metamodel-Driven Repository

- Generation of **statically typed access interfaces** to the models and objects. **Typing and structuring** stems from metamodel:
  - Generation of **Access interfaces** for **Read und Write**, with implementation of Reader/Writer synchronisation- and transaction protocols
  - Generation of **Observer interfaces**: for observation of models and objects
  - Generation of **Reflective access interfaces** (weak typing or even untyped)
    - Access to object set (extend) of a clabject or the graphs of a model
- Generation of **Query interfaces** to the models and objects
  - implementation of a query interpreter from a query language
- Generation of **Consistency checkers**, to check the context-sensitive structure of the models and objects (wellformedness, Wohlgeformtheit, Integrität)
- Generation of **Visitor-Packages**: navigation over the models and objects (with Visitor Pattern) (from DDL)
- Generation of **Navigation packages:** for more general navigation (depth-first, breadth-first, inside-out, outside-in, layer-wise, etc.)
- Generation of **Data exchange interfaces:**
  - Generation of **Importers** und **Exporters**, to transform the Materials into exchange formats of external metamodels (with a technical space bridge)
  - Implementations of **persistent objects** (activation, passivation)

Use of Generated Importers and Exporters



Q8: Phases of a Source Code Importers into a Repository and the Generating Tools



typical generators

typical Tools

Source Program

typical metalanguages

Front-End

Scanner generators | lex, flex | lexikal analysis | Regular expressions

Parser generators | antlr, bison | syntactic analysis | Context-free Grammars

Semantic analysis-Generators (Attribute grammar tools) | OCL, AG, Logics | static semantic analysis (wellformedness) | Attributed Grammars

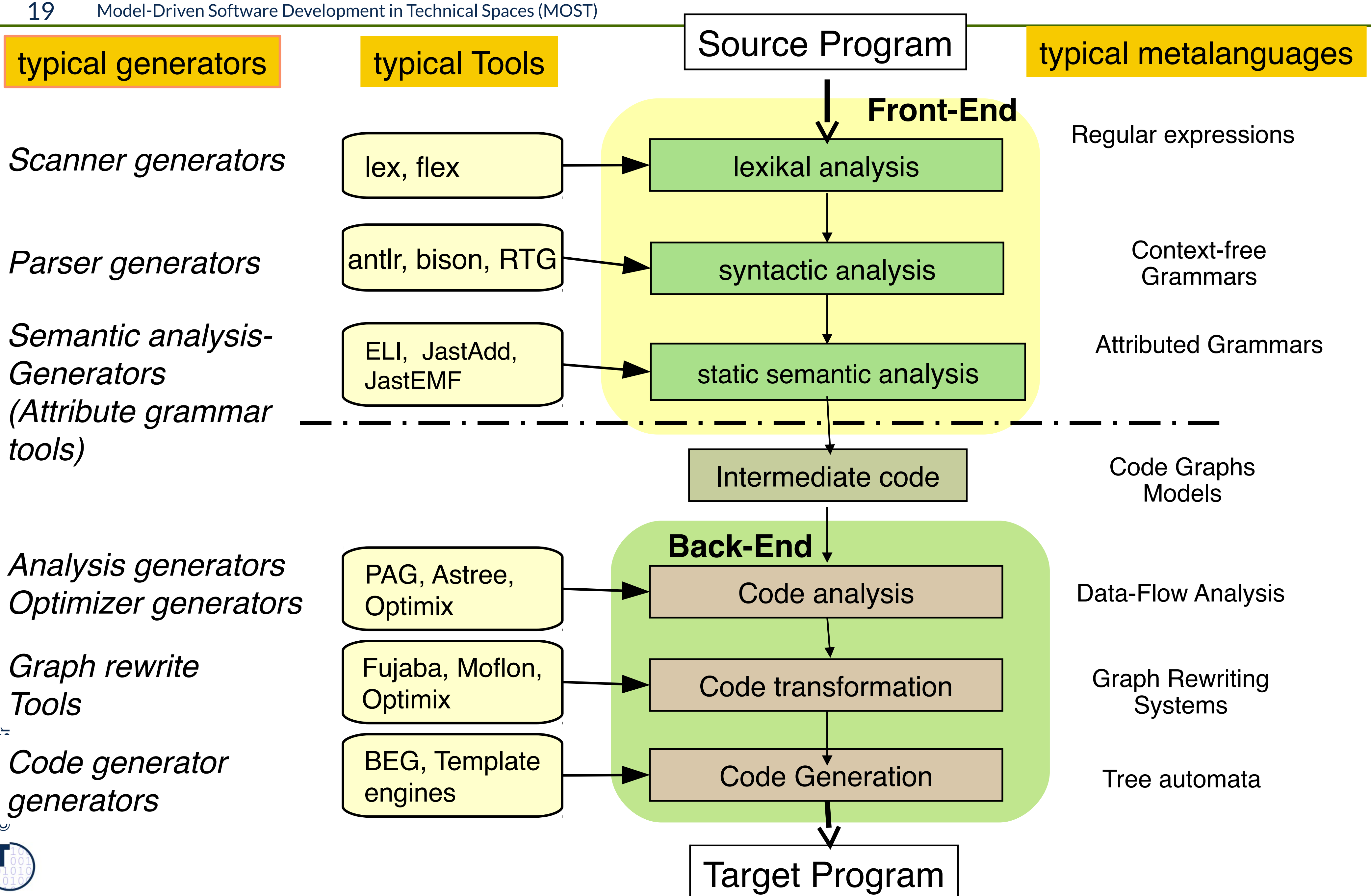
Internal representation in repository (Intermediate code) | Code Graphs Models

Query and metric engines | DQL, CQL, AG | Analysis | Measuring quality of models/Codes

Refactoring engine | GRS | Refactoring | Semantics-preserving Restructuring

Transformation engine | TRS, GRS | Transformation | Term- or Graph-Rewrite Systems

Q9: Phases of Compilers and Software Tools and Generators



typical generators

typical Tools

Source Program

typical metalanguages

Front-End

Scanner generators — lex, flex → lexikal analysis — Regular expressions

Parser generators — antlr, bison, RTG → syntactic analysis — Context-free Grammars

Semantic analysis-Generators (Attribute grammar tools) — ELI, JastAdd, JastEMF → static semantic analysis — Attributed Grammars

Intermediate code — Code Graphs Models

Back-End

Analysis generators Optimizer generators — PAG, Astree, Optimix → Code analysis — Data-Flow Analysis

Graph rewrite Tools — Fujaba, Moflon, Optimix → Code transformation — Graph Rewriting Systems

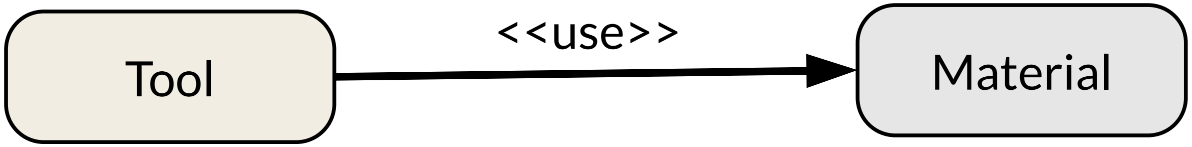
Code generator generators — BEG, Template engines → Code Generation — Tree automata

Target Program

6.3 Tools as Tool Objects accessing Materials in the Repository

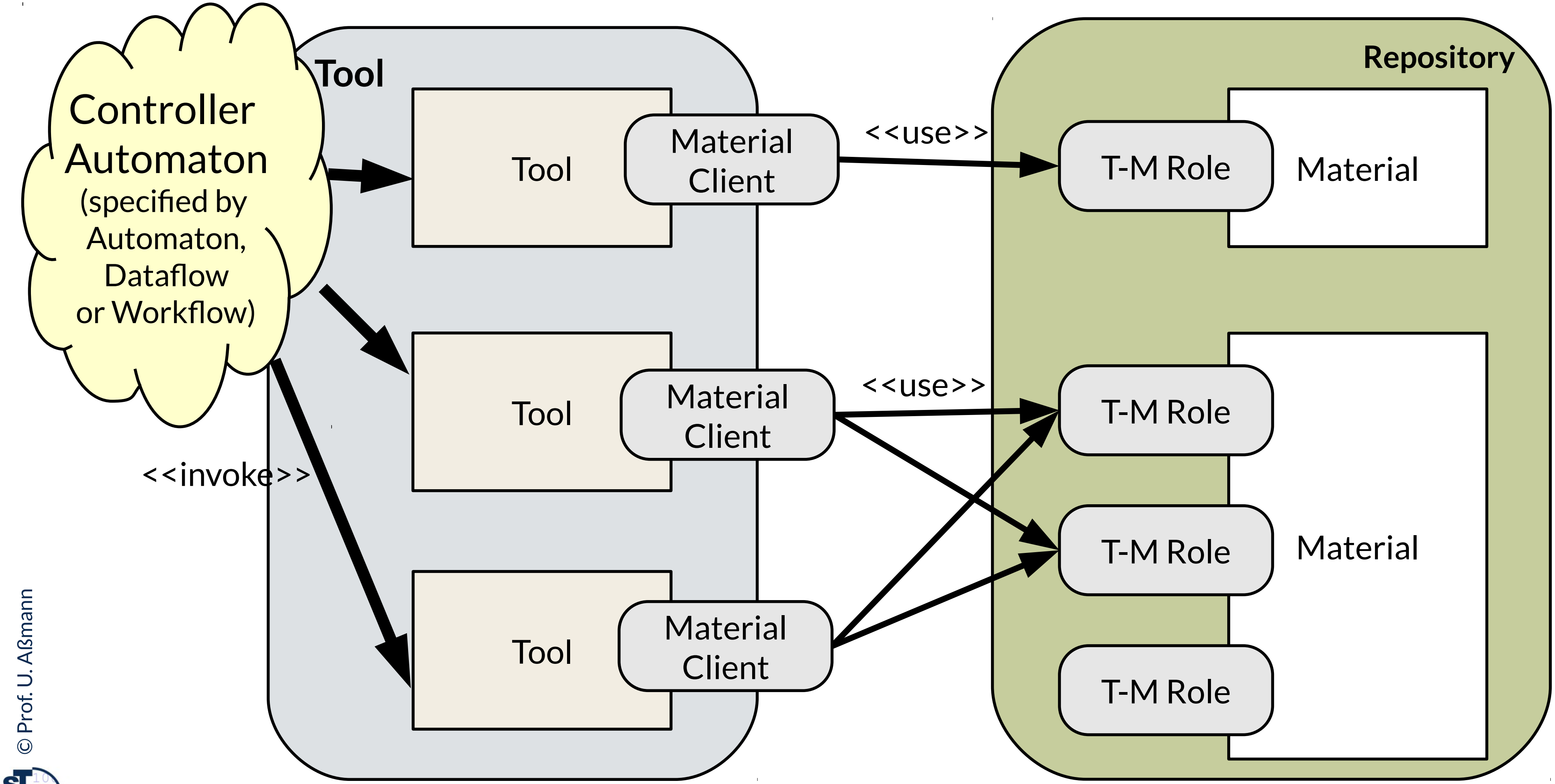
Tool-Material Collaboration Pattern

- A ***tool-material collaboration*** (T&M role model, T&M access aspect) expresses the relation of a tool and the material
  - The tool is active, has control; the material is passive and contains data
  - Characterizes a tool in the context of the material, and the material in the context of a tool
- The tool's access of the material. The tool has a view on the material, several tools have different views
  - The tool sees a *role* of the material, in collaboration with a tool
    - Roles of a material define the necessary operations on a material for one specific task
  - They reflect usability: how can a material be used?
  - They express a tool's individual needs on a material



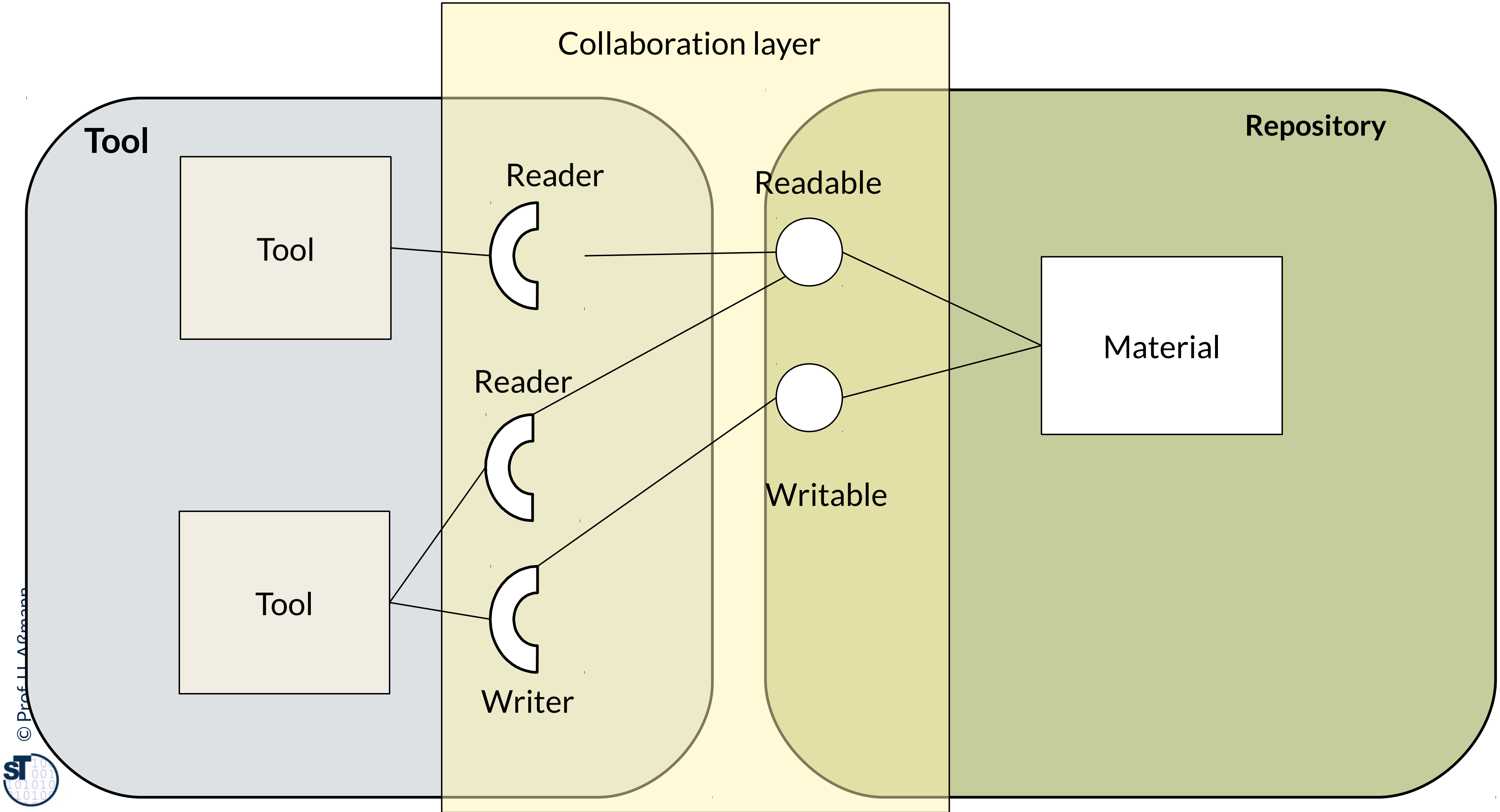
Controler Automaton, Tools and Their Views on Material

- Tools are controled by automata or workflows (TAM)



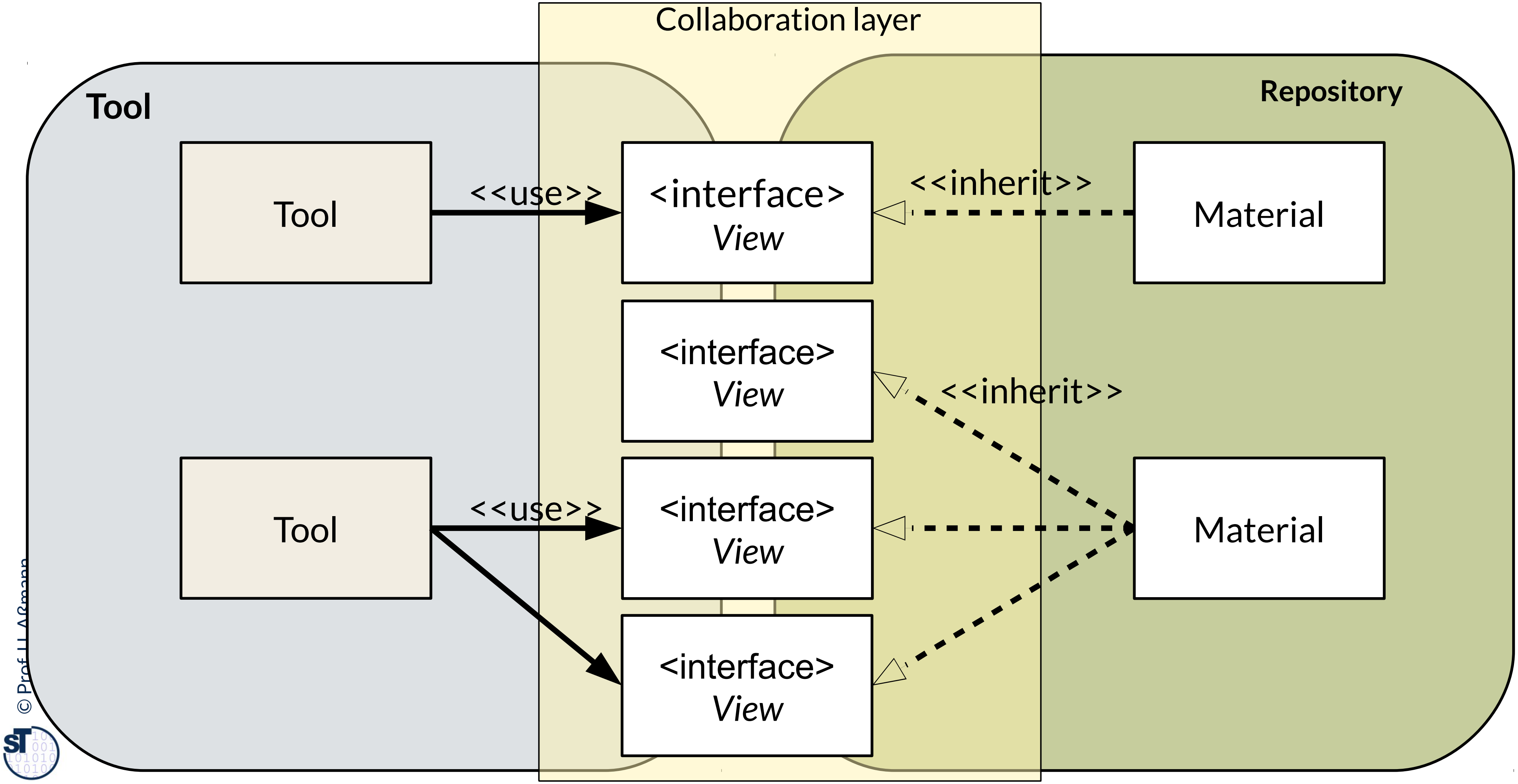
Collaboration Layer in UML Component Diagram Notation

- In UML, roles are represented by “lollipops” and “plugs”

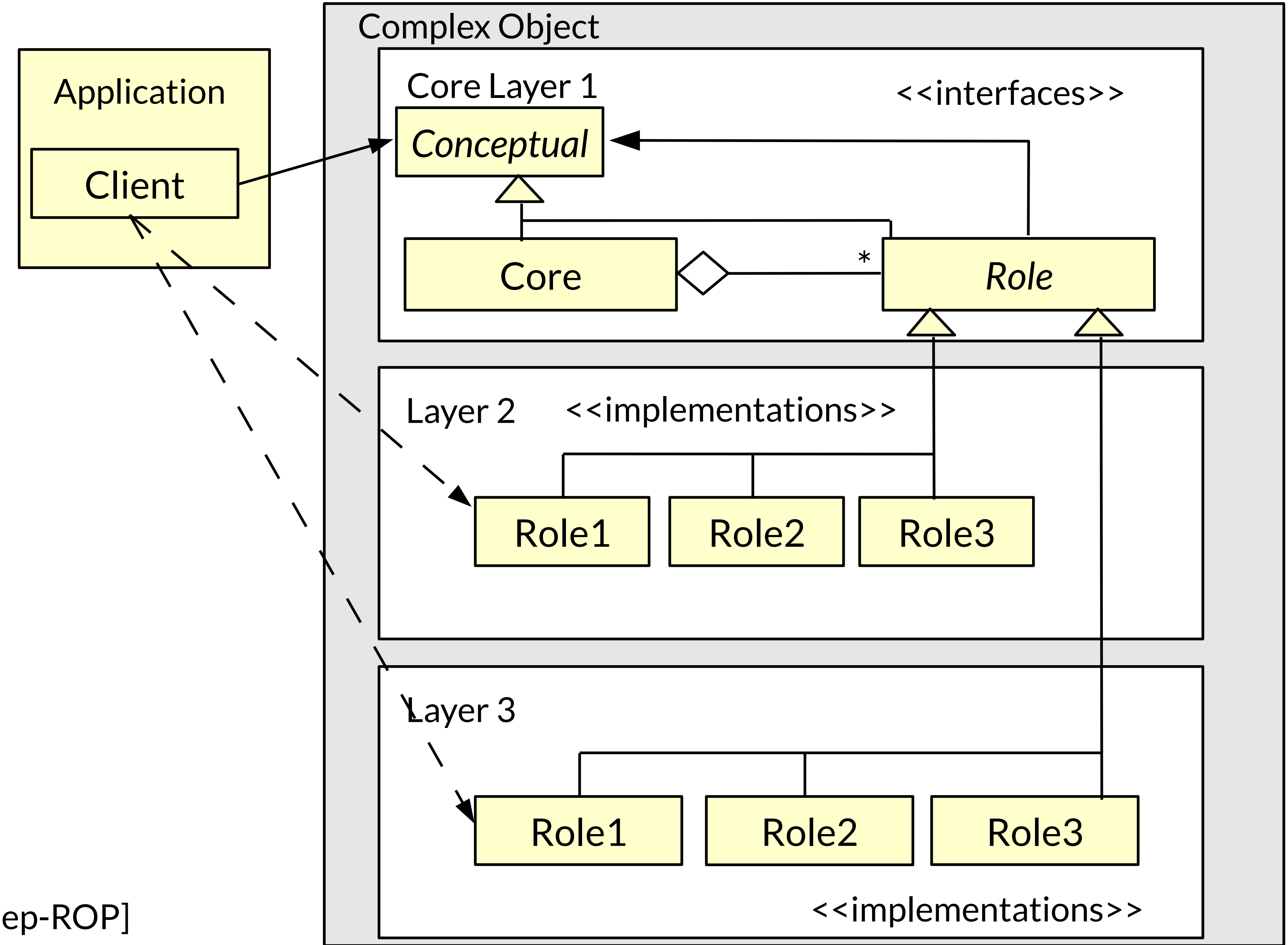


Implementation in Java or C# a) Tool-Material Roles of the Collaboration Layer as Interfaces of Material Classes

- Roles can be realized by mixin inheritance or interface inheritance
- Then, roles of tools are integrated into tools



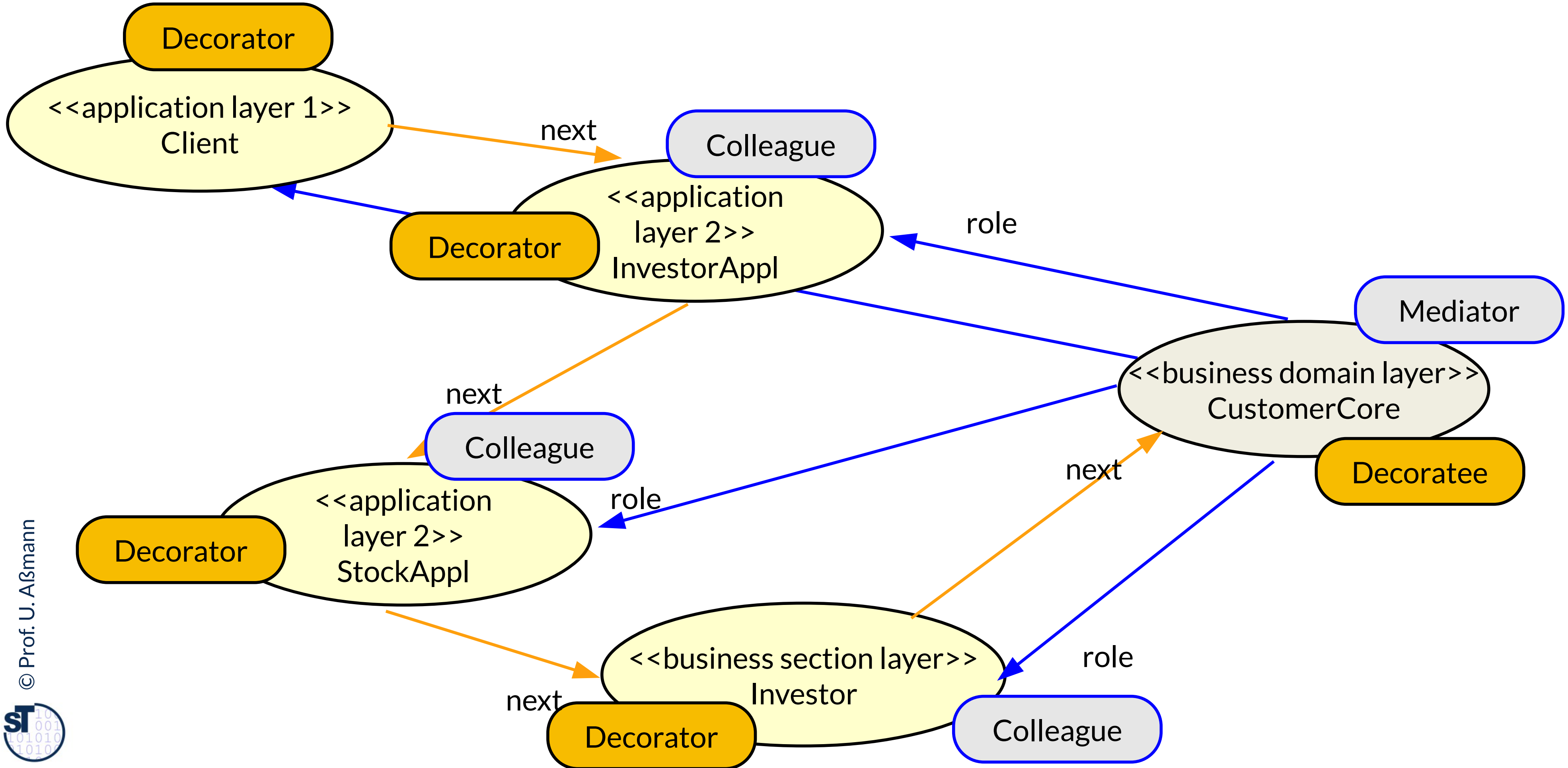
Riehle/Züllighovens Role-Object Pattern (“Deep Roles”)



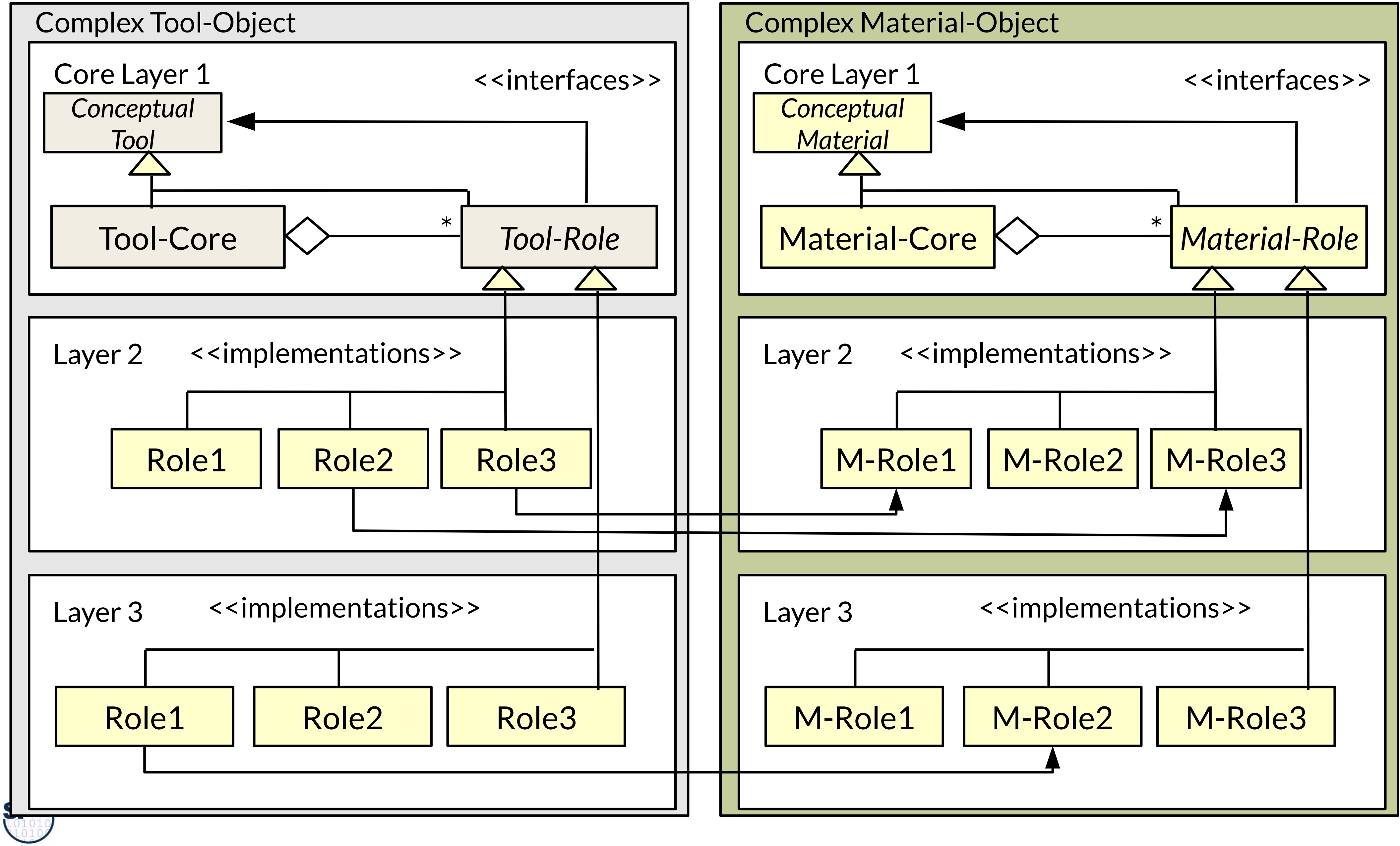
[deep-ROP]

Run-Time Structure: Deep Roles as Decorators of a Core

- At runtime, RoleObjects pass service requests (queries) on to the core
  - RoleObjects can be stacked in a Decorator chain (**deep roles**)
- The core knows all RoleObjects, and distributes requests (Mediator)
  - The core manages the RoleObjects in a *map* that can be dynamically extended



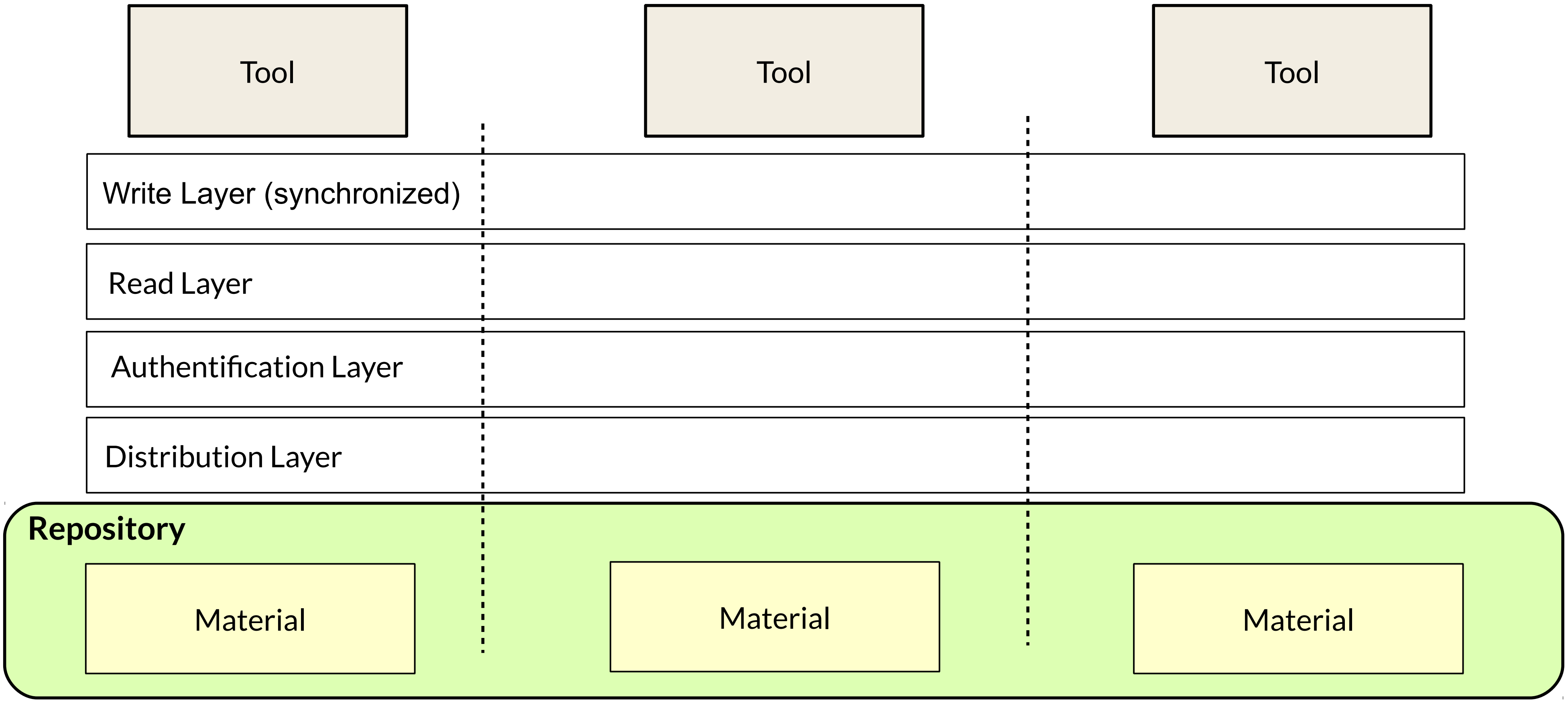
Deep Role-Object Pattern in Tool-Material-Collaboration



6.3.1 Layering of the Access Layers of the Material Objects with Deep Role-Object Pattern

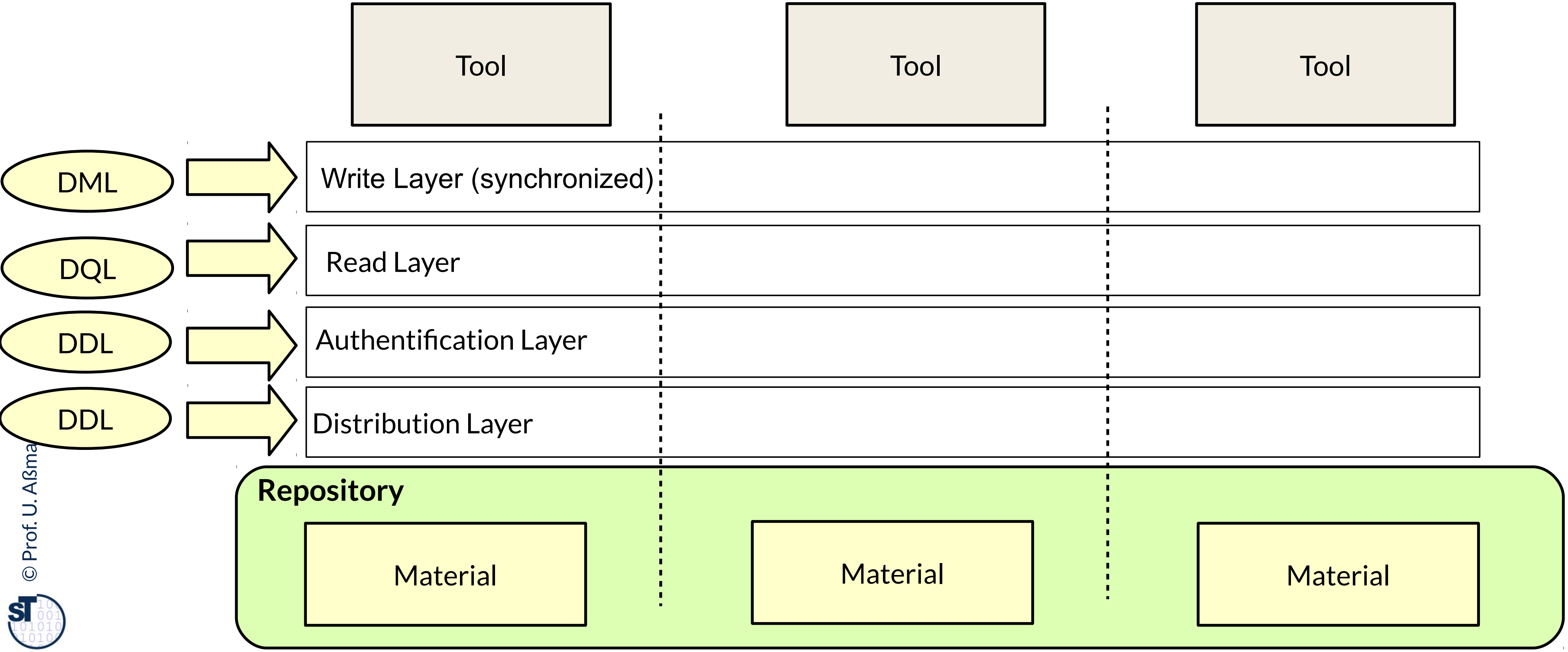
Access Layers of the Repository

- In a TAM-structured repository, Tool-objects access Material-objects through several layers of role objects
  - Every role object treats a specific aspect of the access
  - An Aspect-Material-object-Matrix results

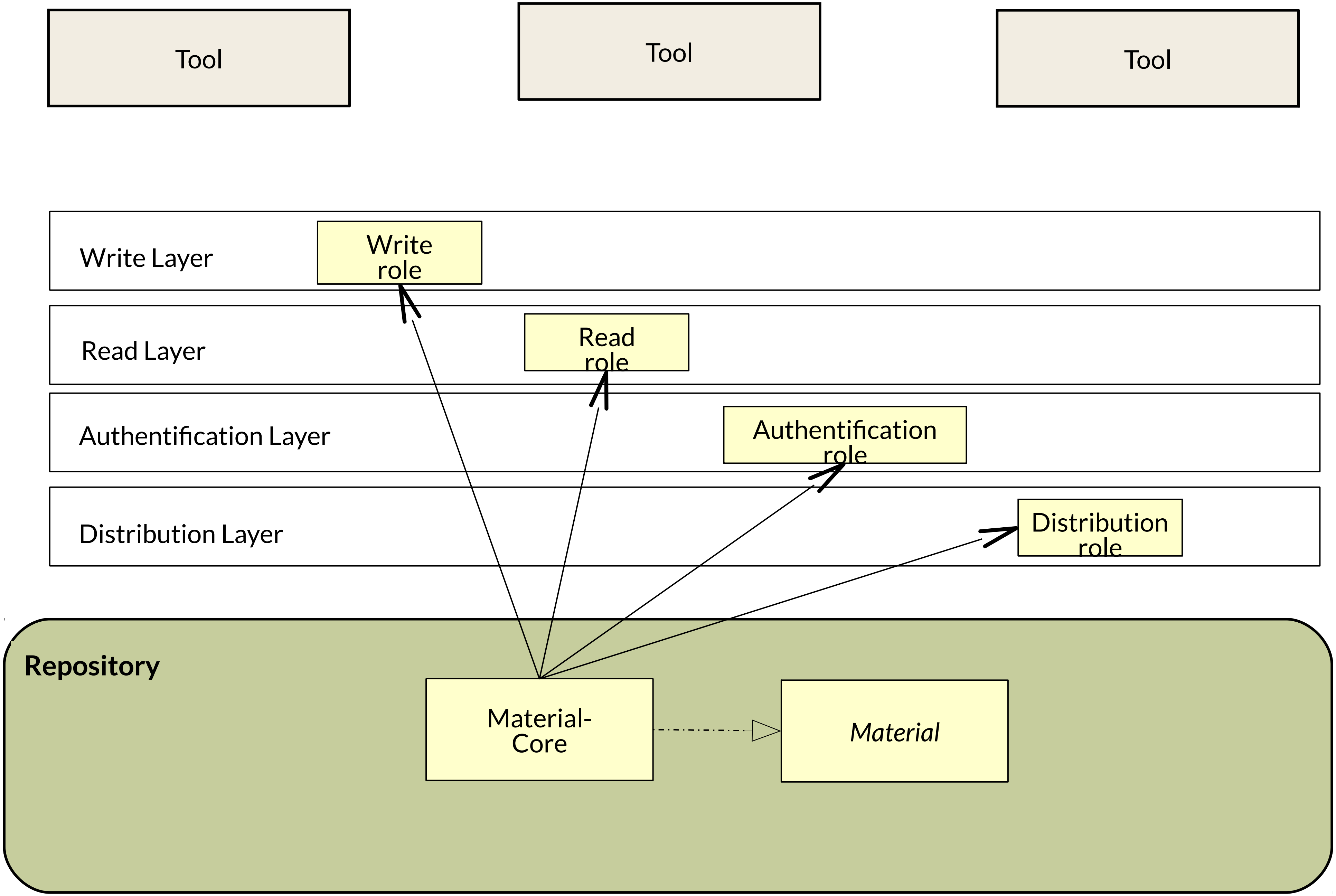


Generation of the Implementation of the Layers from M2

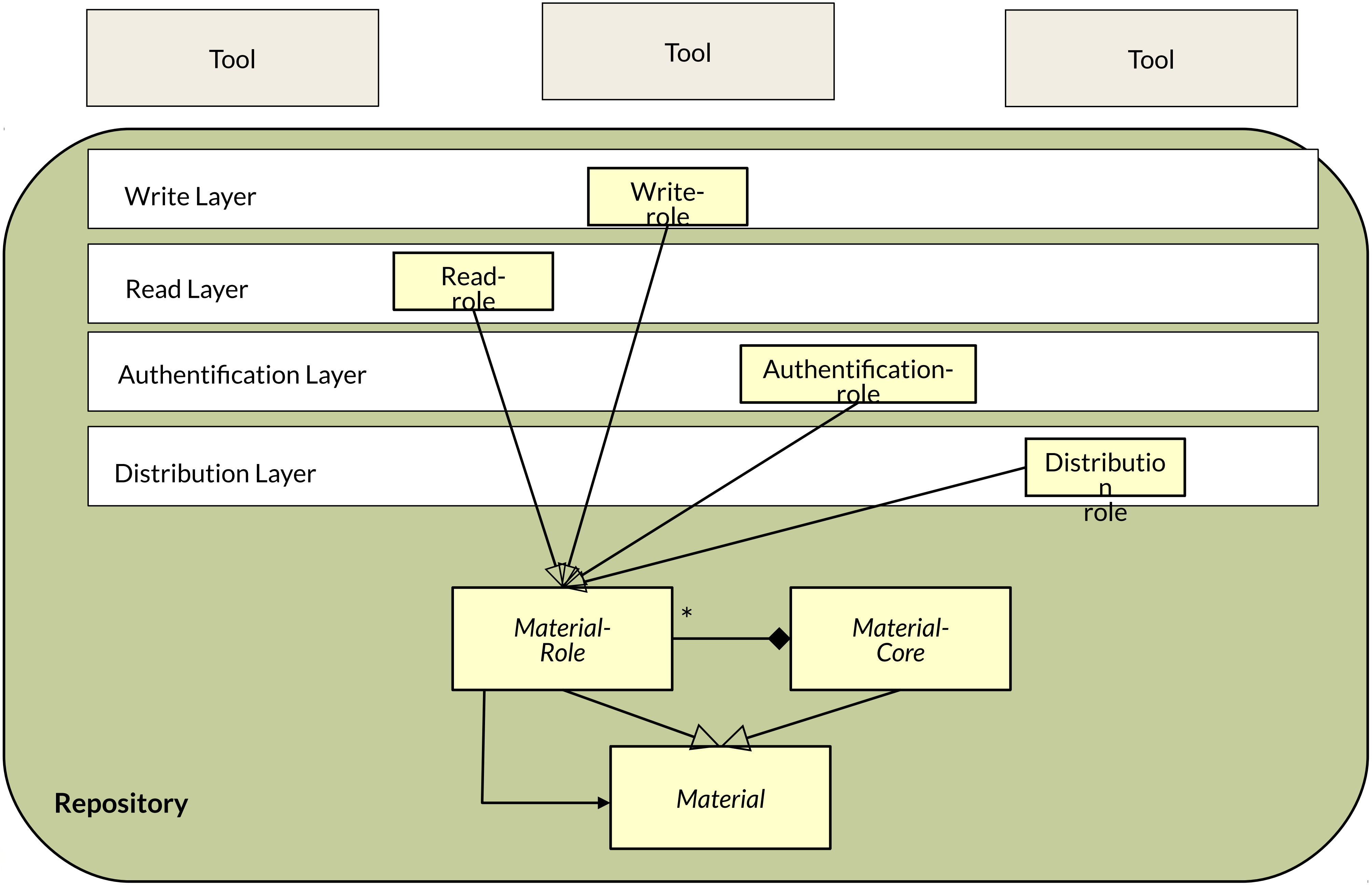
- The implementation of the role objects in the layers can be specified by different languages on M2
  - OCL-constraints can specify constraints in the Read/Write Layers
  - Query languages can be used to generate the Read Layer
  - Transformation languages can be used to generate the Write Layer



Implementation b) Material, realised as Core with Role-Delegatees (object-schizophrene)

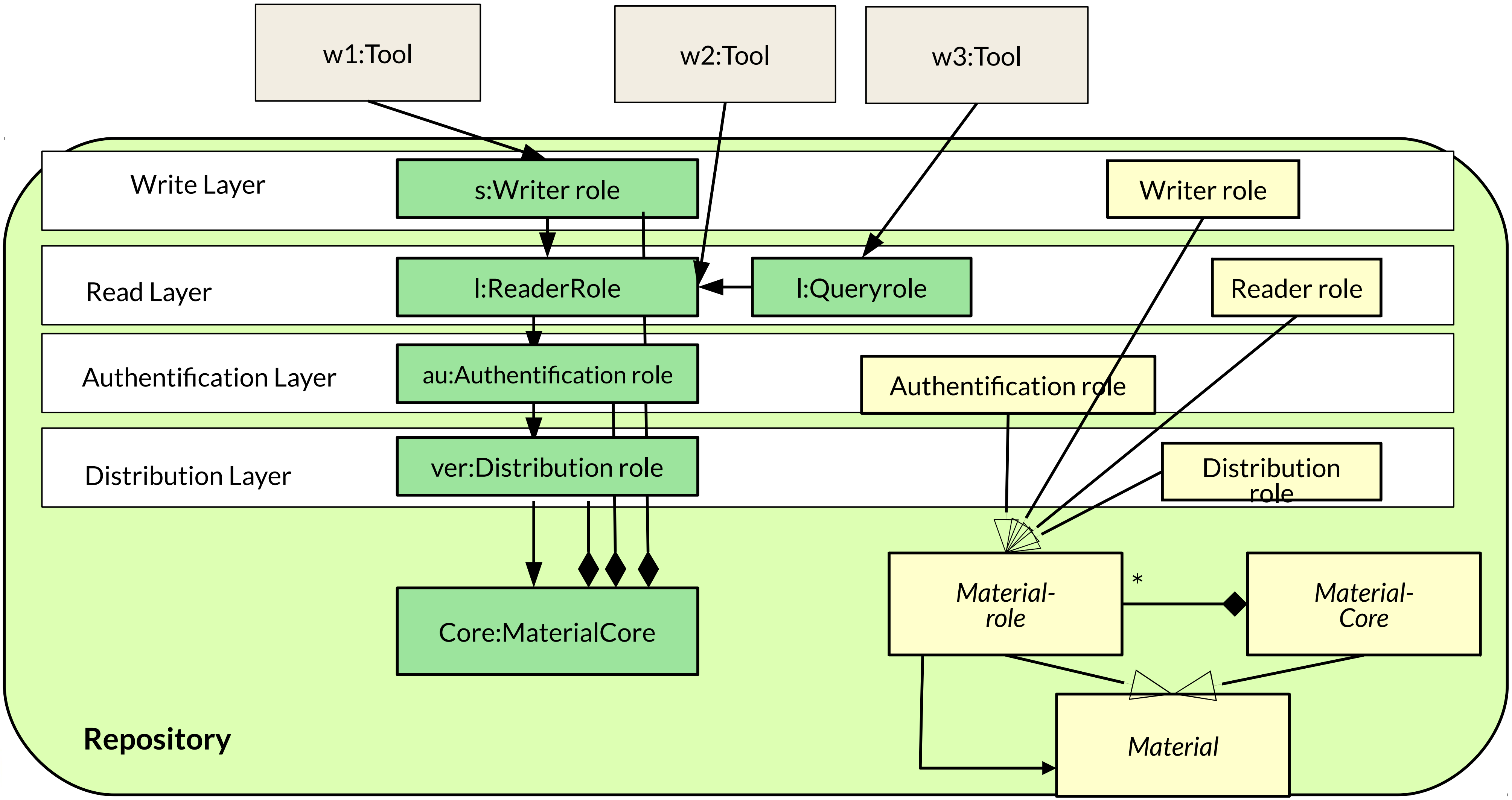


Implementation c) Material Structured with Deep Role-Object-Pattern (non-object-schizophrene)



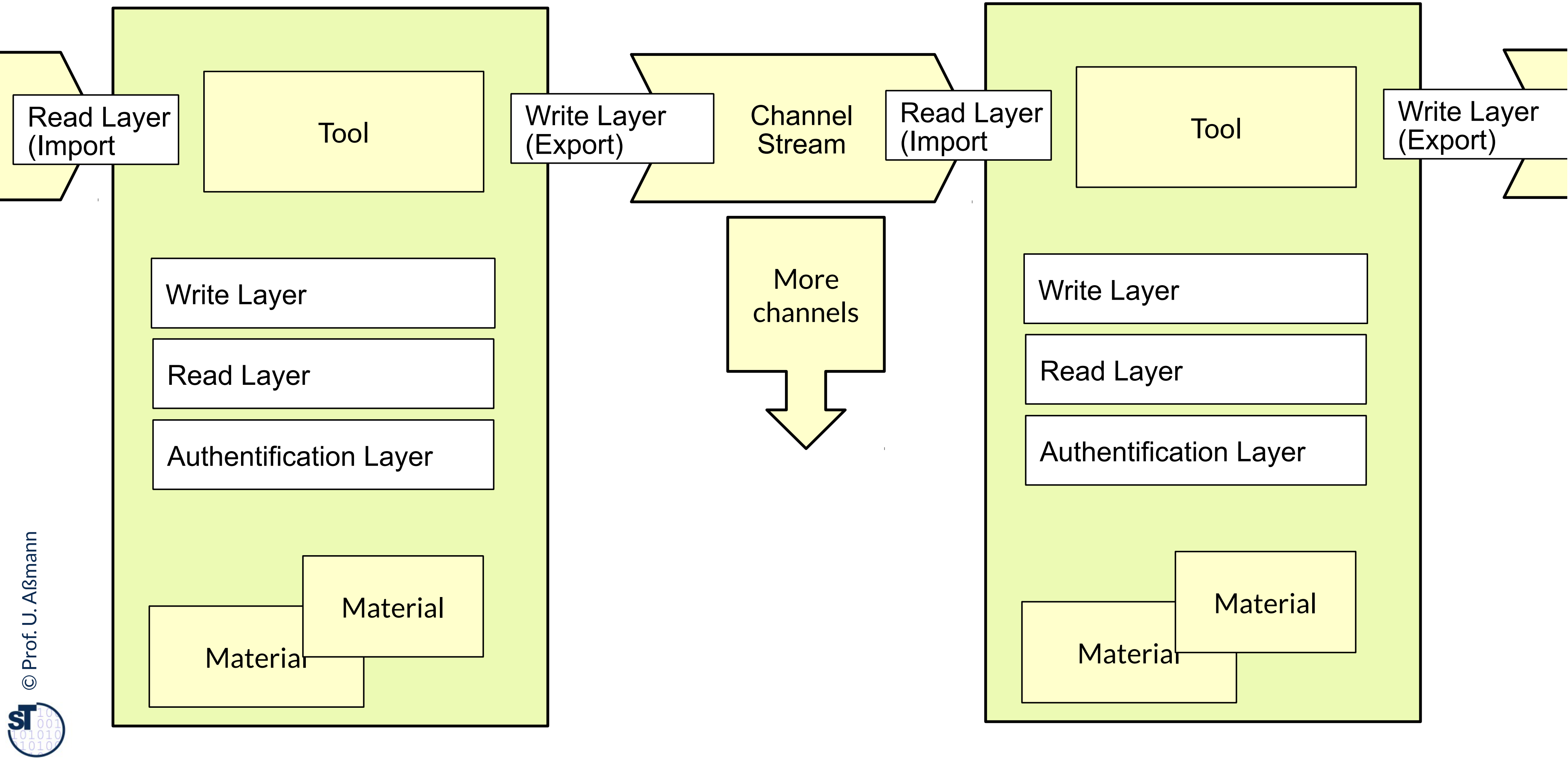
Collaboration of Tool-Objects on a TAM-Repository with Role Objects

- The Role-Object Pattern is a good pattern for implementation of Tools and Materials in Repositories
- Collaboration layers (here only Material Layers are shown)
- Interfaces and implementations of these layers can be generated

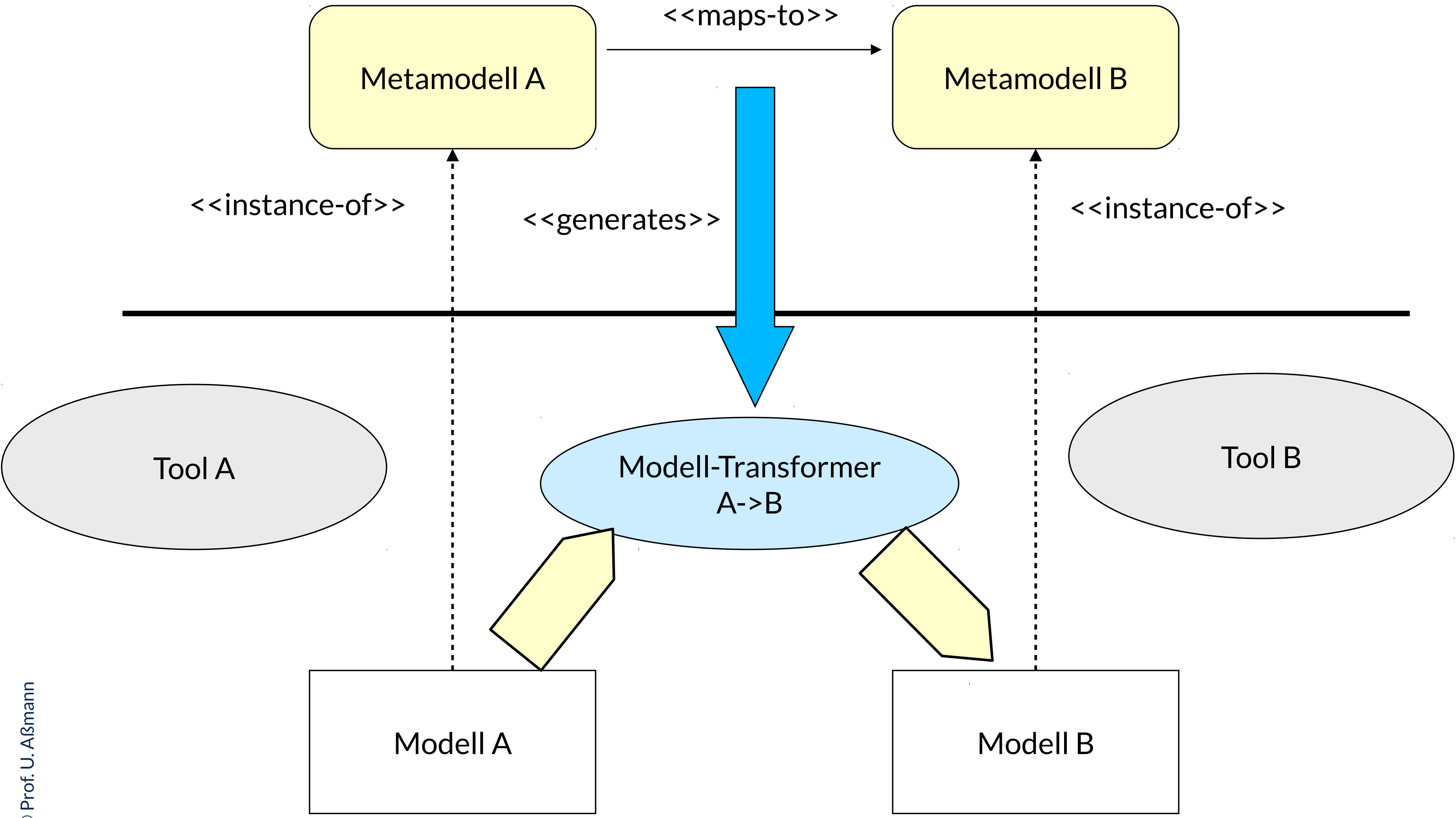


TAM for Stream-Based Tool-Architectures

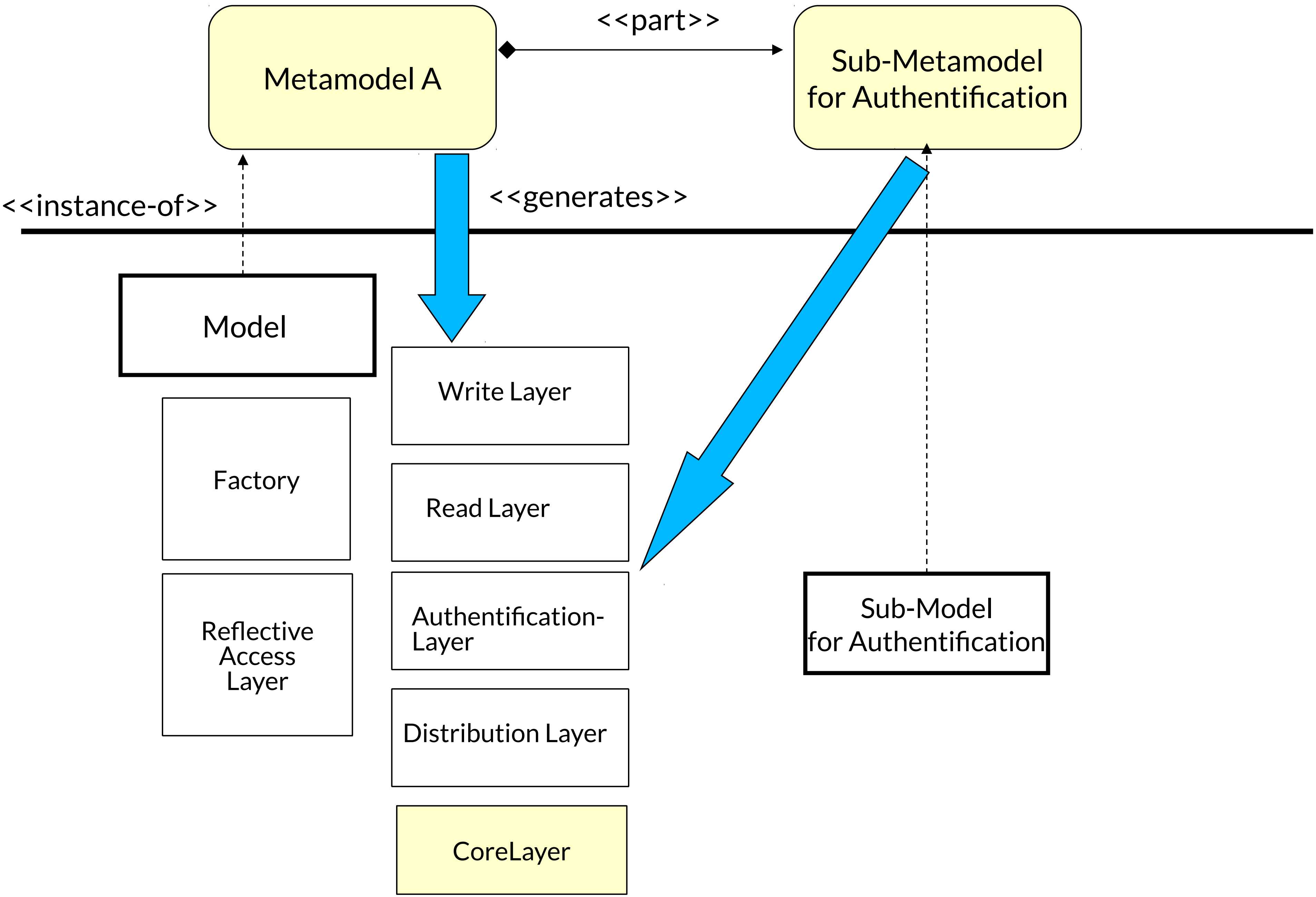
- Is Tool embedded into a stream-based architecture, it has separate Read- und Write Layers for the input and output channels.
- One stream-based Tool alone is not distributed – the Distribution Layer vanishes.



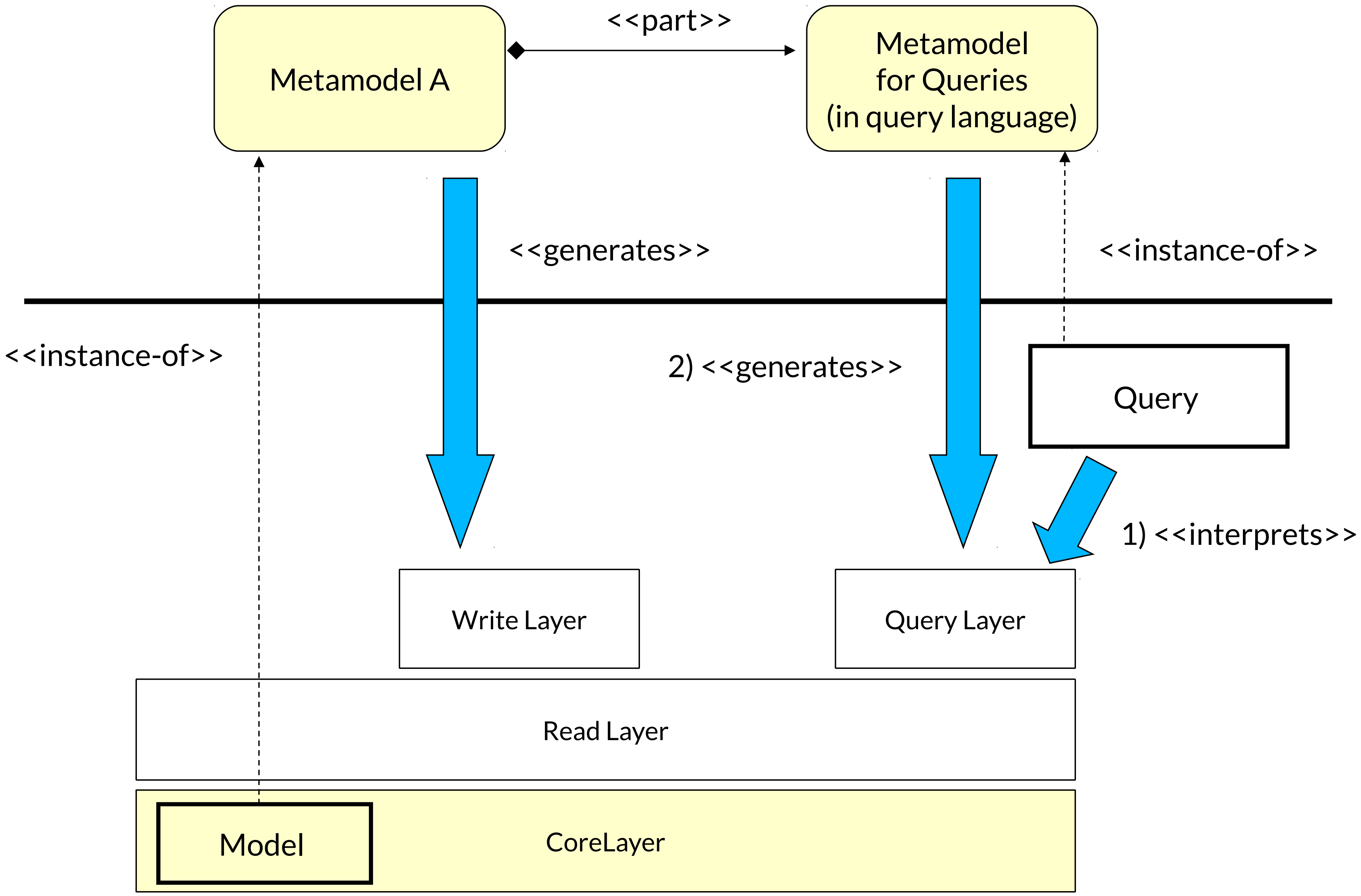
Generation of Model Transformer from Metamodel Mapping



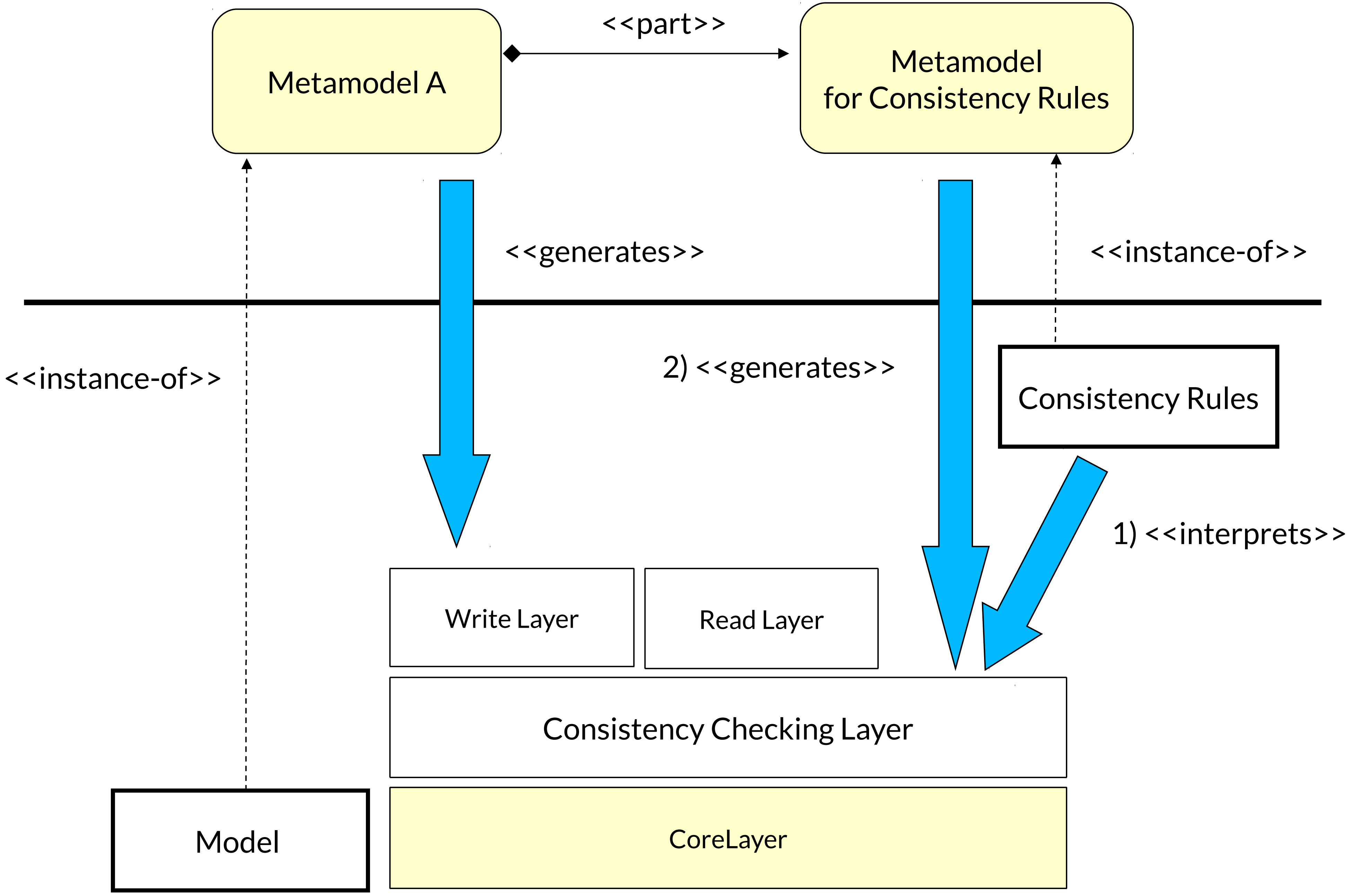
Generation of Access Layers from Metamodels



Generation of Query Layer from Metamodel



Generation of Administrative Layer



6.4 Examples for Repositories on M0 and M1

Repositories can be used in different scenarios:

- Temporary for a Tool
- Persistent for a Tool
- Persistent for several Tools
- Persistent for entire company

Repositories can store object nets (M0), models (M1) and metamodels (M2)

Historical Examples for Repositories

Name	Characteristics
IBM Repository Manager	Repository für the IBM development process AD/Cycle, open architecture, team oriented
PCTE Object Management System	The repository of the first metamodel-based IDE in a techncial space, the PCTE environment
Pirol	View-based repository of TU Berlin (for token modeling) www.objectteams.org/publications/Diplom_Florian_Hacker.pdf

Company-Wide Repositories

Name	Characteristics
WebSphere Repository Database of IBM	Administration tools for Enterprise Applications
SAP R/3-System	Repository for Enterprise Applications, with R/3-Data-Dictionary for Metadata (relational schema)
SAP NetWeaver Master Data Management (MDM)	Distributed Repository for Enterprise Applications

Quelle: Habermann, H.-J., Leymann, F.: Repository - eine Einführung; Oldenbourg Verlag 1993

Metamodel-Driven Repositories

Name	Characteristics
Eclipse EMF	Metalanguage EMOF; similar to MDR
Netbeans Metadata Repository (MDR)	Metalanguage MOF; Load of several metamodels possible möglich; Generation of typed access interfaces and reflective access interfaces; mapping to database and file system possible
ModelBus	Metalanguage MOF; Distributed repository für MOF-based models
Hibernate	Persistence module for object-oriented programs (Java) with object-relational mapper (ORM); mapping of Java-objects to relations and different SQL-databases

File-Based Repositories

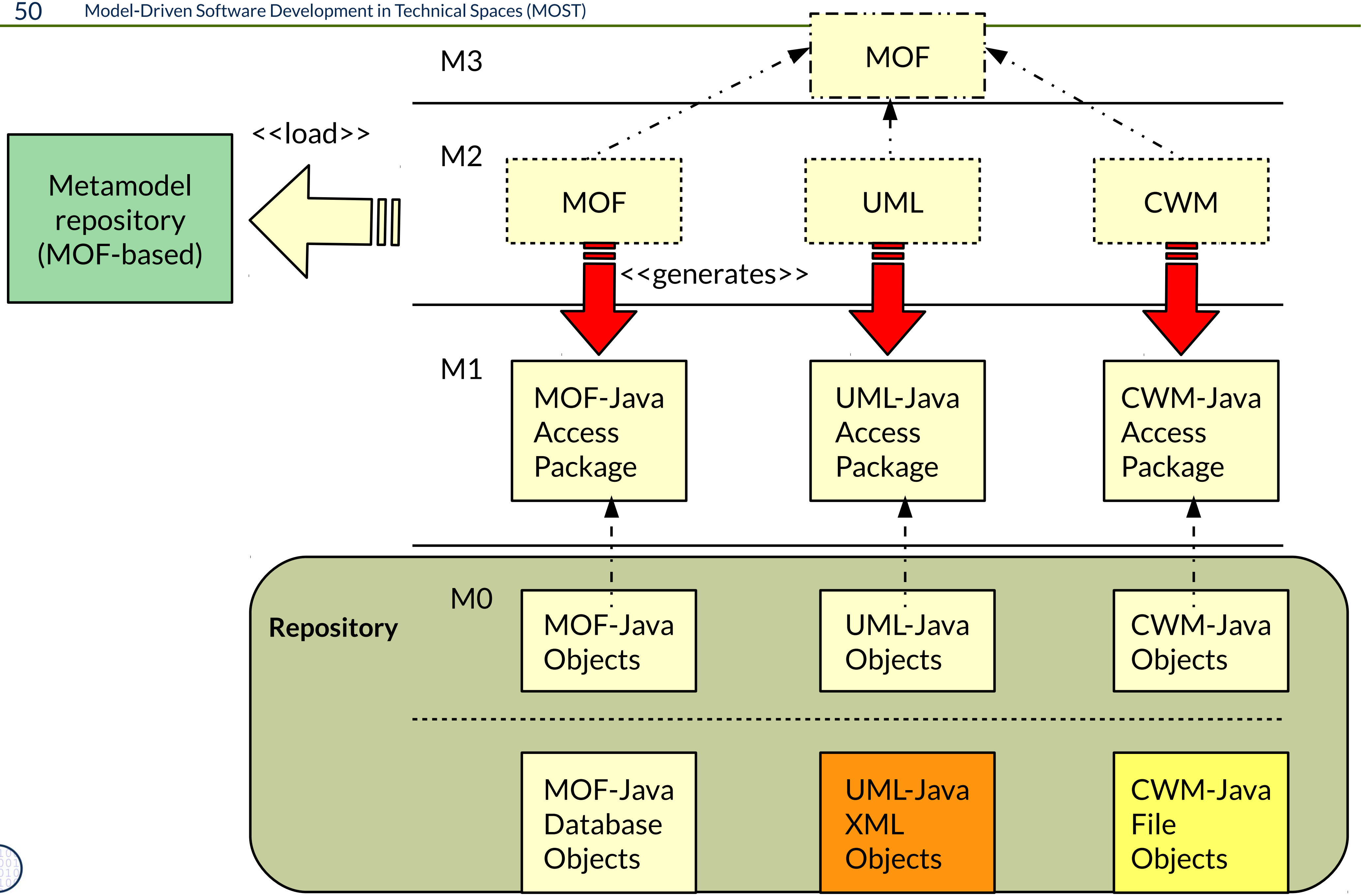
Name	Characteristics
Microsoft Sharepoint	Web-filesystem-based repository
WebDAV	Web protocol for distributed document management
Subversion, git	Version management systems on files and directories, usable from specific clients and browser
DropBox, GoogleDocs	Cloud-based file system

- No metamodels, but only simple metadata

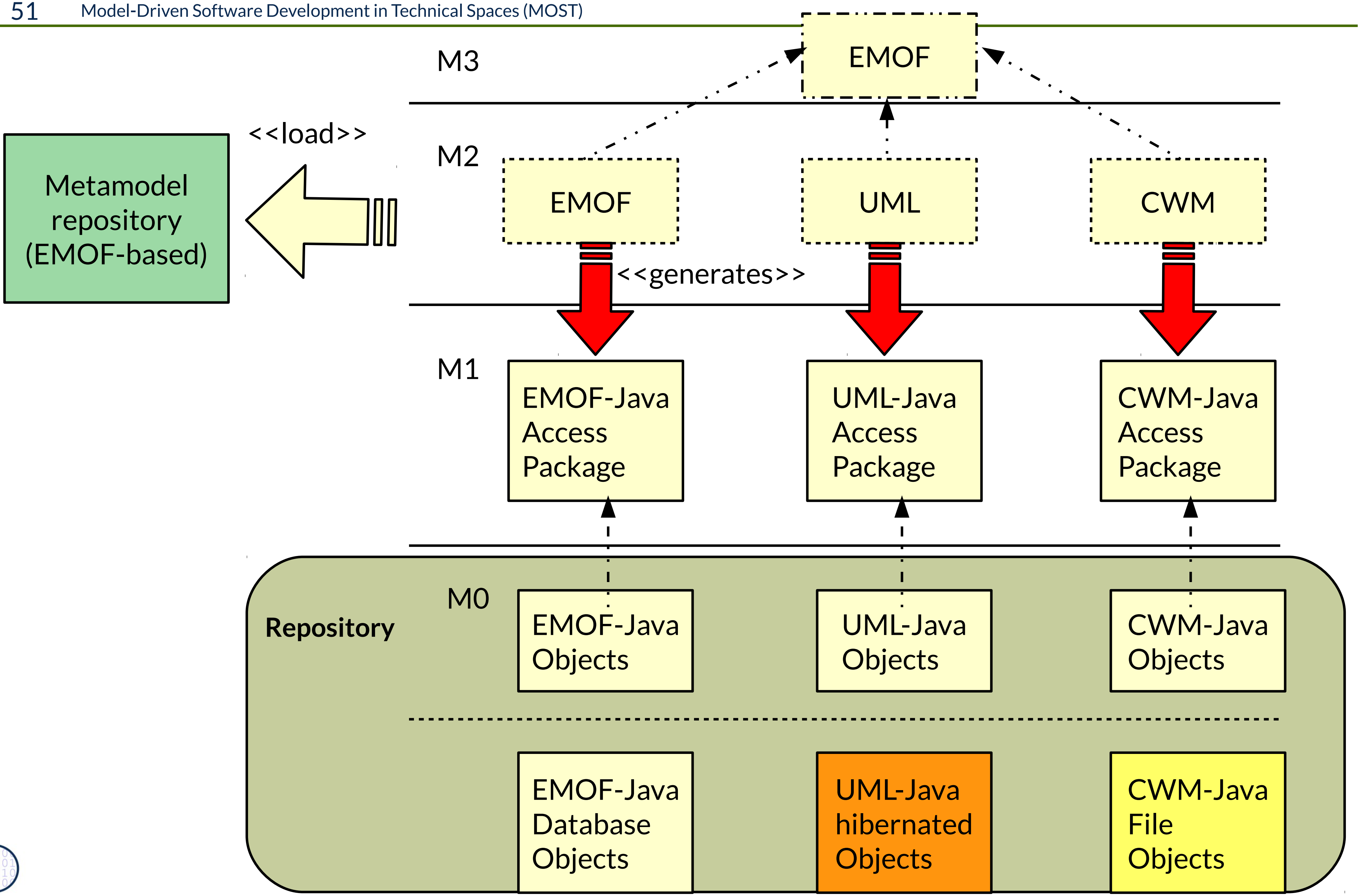
Netbeans MDR

- MDR is a metamodel-driven persistent repository for the IDE Netbeans (<5.5) with metalanguage MOF https://www.openhub.net/p/8317
- Martin Matula. (martin.matula@sun.com). NetBeans Metadata Repository.
  - https://netbeans-uml-extender-plugin.googlecode.com/files/MDR-whitepaper.pdf
  - https://netbeans.org/download/5_5/javadoc/org-netbeans-api-mdr/overview-summary.html
- Storing MOF-metamodels (metadata repository), also models (model repository), and object-nets (graphs)
- Advantages:
  - May be used distributedly, company-wide
  - Generation of Java-access interfaces via JMI (MOF-Java mapping)
  - Generation of reflective access interfaces (weak typing)
  - Generation of observation interfaces
  - Transparent storage in main memory, filesystem or database
  - Exchange format XMI (MOF-XML mapping)

Netbeans MDR



Eclipse EMF (based on EMOF)

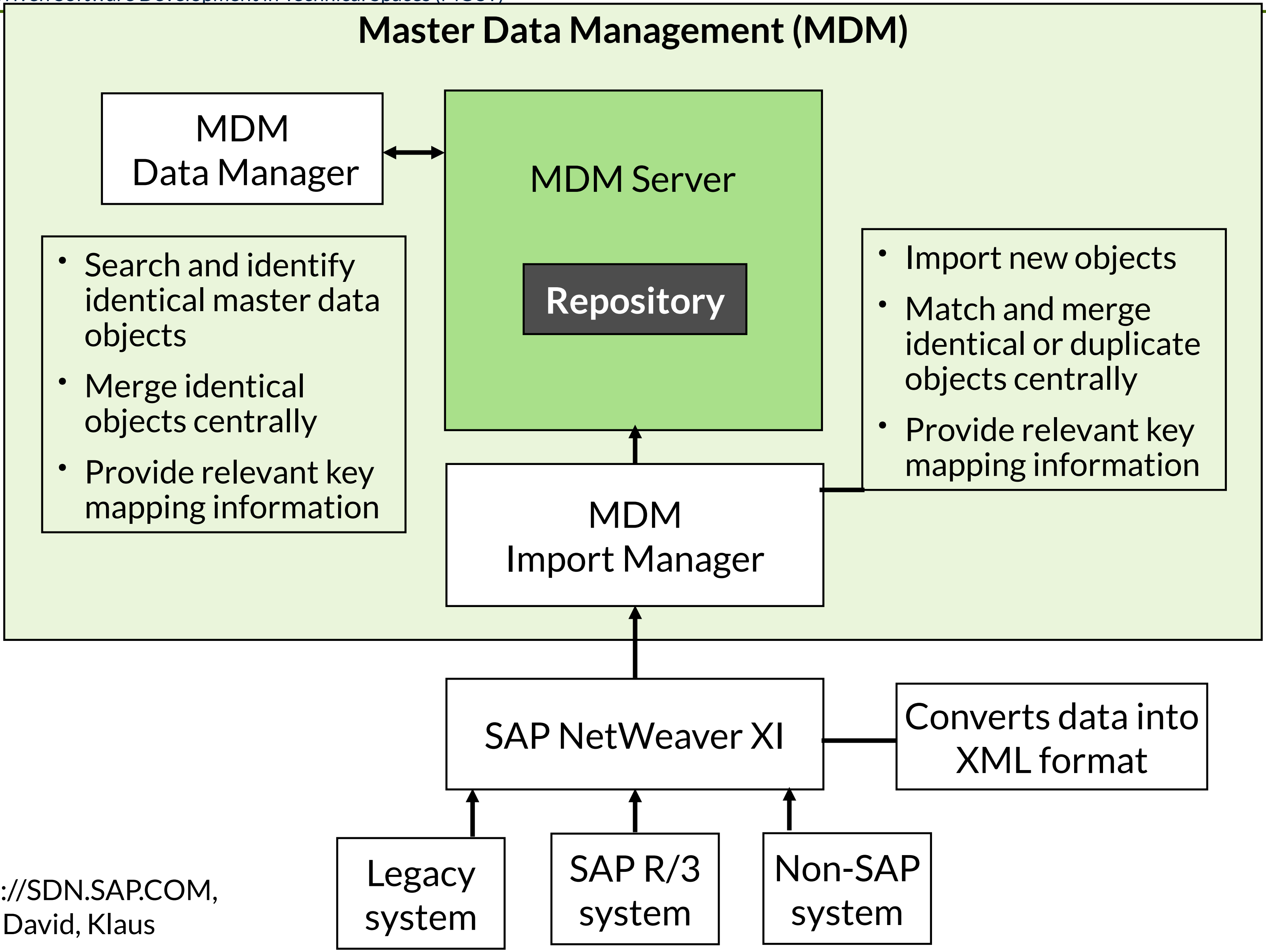


6.4.2 Master Data Management (MDM)

MDM

- Company-wide distributed federated repository
  - Consistent (by transactions) or non-consistent
  - http://en.wikipedia.org/wiki/Master_Data_Management
- Often stems of IT mergers of companies and must be “merged” and “consolidated”

Ex.: SAP NetWeaver MDM



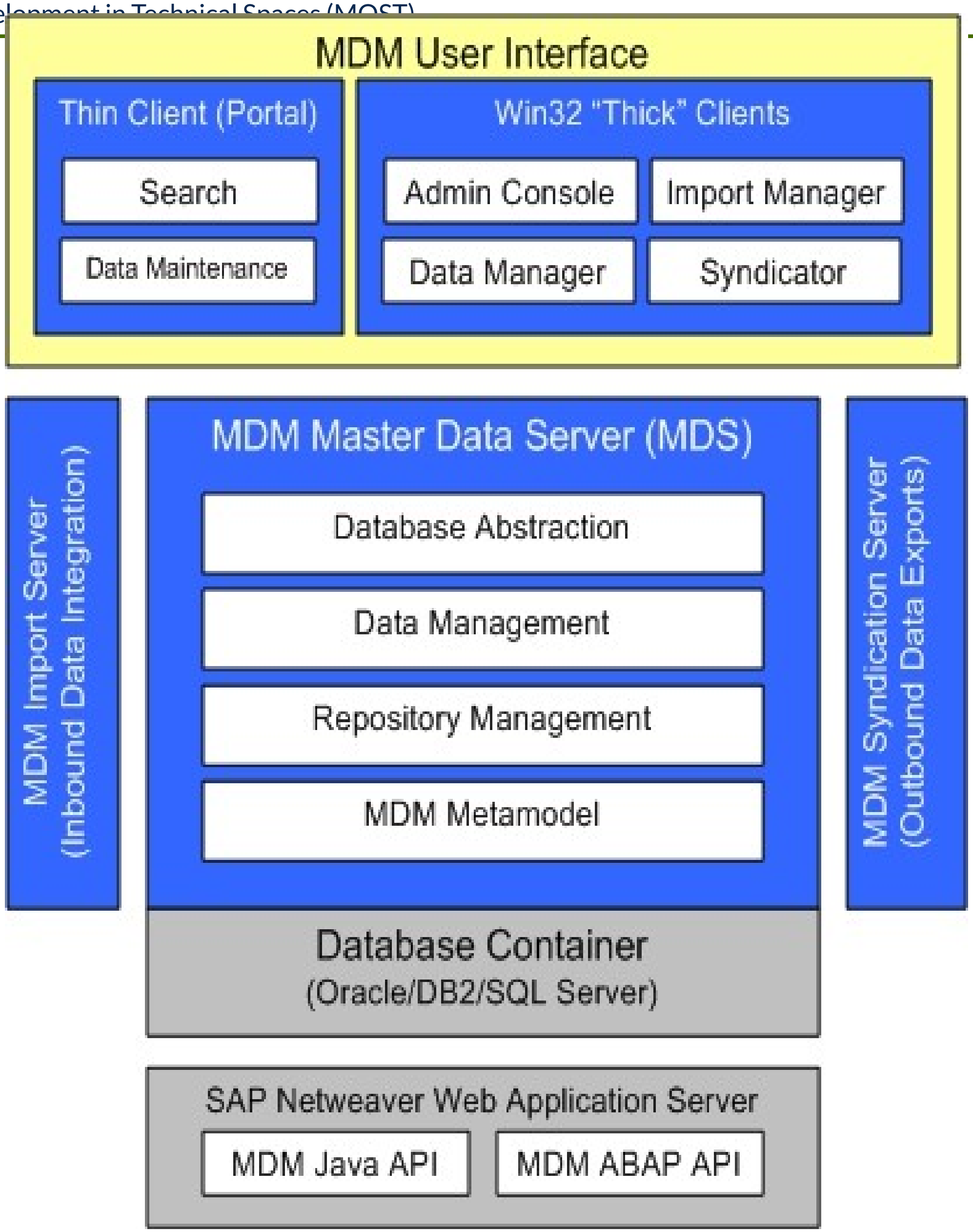
- Search and identify identical master data objects
- Merge identical objects centrally
- Provide relevant key mapping information

- Import new objects
- Match and merge identical or duplicate objects centrally
- Provide relevant key mapping information

Converts data into XML format

Quelle:
URL: http://SDN.SAP.COM,
Artikel of David, Klaus

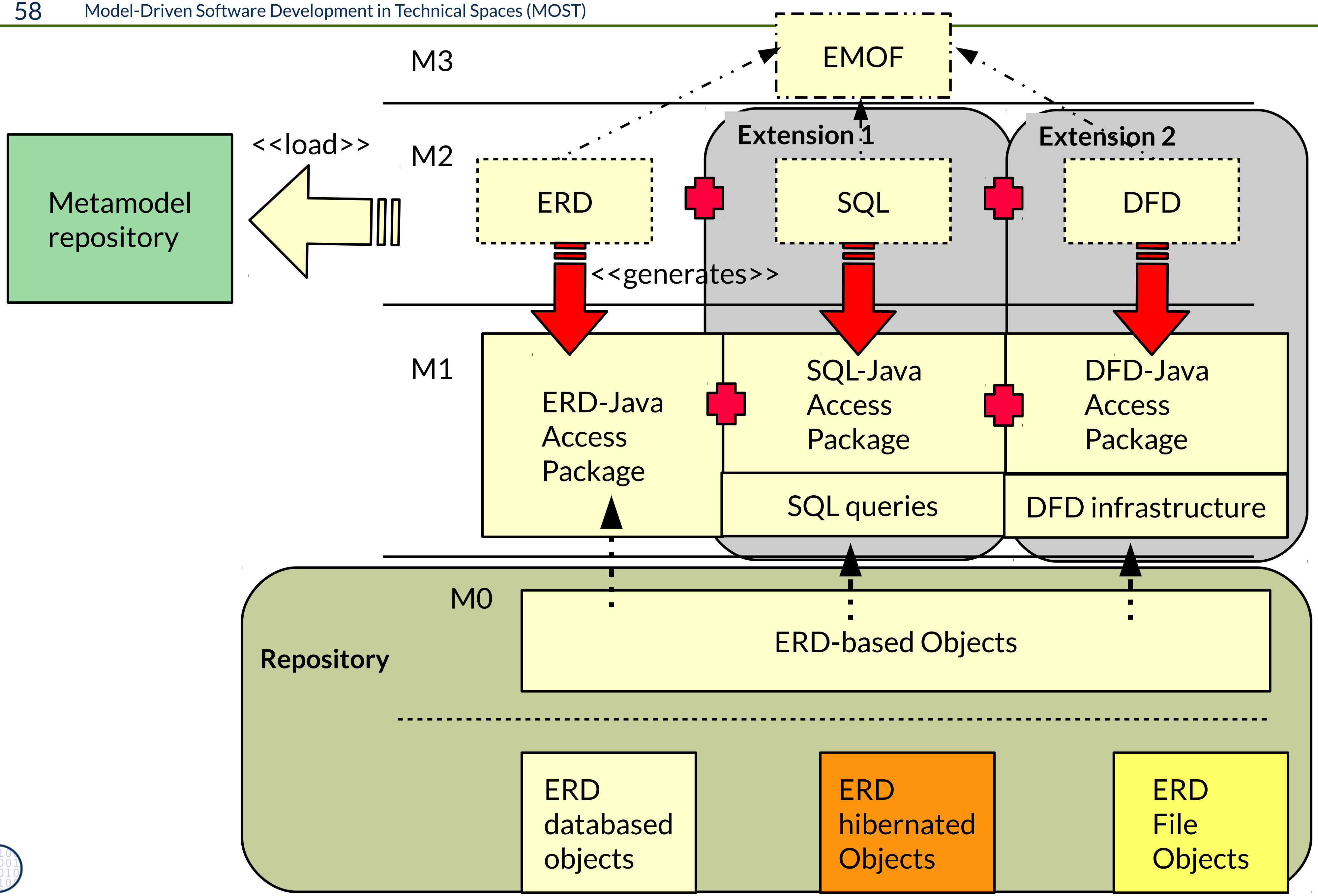
http://searchsap.techtarget.com/resources/SAP-MDM-software



http://searchsap.techtarget.com/generic/0,295582,sid21_gci1232140,00.html

6.5 Extension of Repositories by Metamodel Extension

Extension of Metamodel-Driven Repositories



Why are Metamodel-Driven Repositories Important for MDSD Tools?

Simple extension and composition of typed repositories on M0, M1, M2

- In a metamodel-driven repository, loading of new metamodels extends the access interfaces
  - load the new metamodel
  - generate new typed access interfaces (and code) for access, query, consistency, etc
  - load new code by dynamic class loading
  - run the new code, allocate new extended objects

For an embedded DSL, a repository as extension of the repository of the GPL

For an IDE or MDSD Tool, repositories are created by composition of base techniques and base languages

The End

- Explain the structure of a metamodel-driven repository.
- Why can objects of M0, M1 and M2 be stored in such a repository?
- Explain the structure of a MOF-based repository.
- Explain how the interface of an access role (read, write) of the material in the repository can be generated from a metamodel
- Why is an Observer interface for materials important?