Content Management: An Area of Research and a Melting Pot of Approaches from Neighboring Fields.

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Dr. Hans-Werner Sehring, T-Systems Multimedia Solutions GmbH, Germany

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Contents of this Talk.

- Introduction: Content Management state-of-the-art.
- Advanced Content Management Tasks and Requirements.
- Concept-oriented Content Management (CCM).
- Content Modeling.
- CCM System Architecture.
- CCM System Generation.
- Content Visualization.
- Summary.

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INTRODUCTION: CONTENT MANAGEMENT STATE-OF-THE-ART.

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Introduction.
Content Management: an Industrial Branch, not a Research Topic.

- The analysis of the area of **Content Management** and the development of **Content Management Systems** (**CMSs**) is industry-driven.
- Contributions for CMSs are spread over a **range of areas**, including but not limited to:
  - Information systems and databases.
  - Search and retrieval, automatic classification and clustering.
  - Web-based information systems.
  - Semantic web.
  - E-business.
  - Workflow systems.
  - Authoring tools.
- Content management as an area of research has **not matured enough** in order to come up with clear definitions, principles, methodologies, models, patterns, ...
- ⇨ Need for this CONTENT conference.

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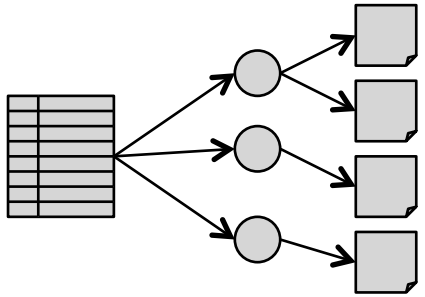
Introduction.
Content Management.

- There is no agreed-upon **notion of content management**.
  - Web content management.
  - Enterprise content management.
- Perhaps not even of **content**.
- We consider a **“many-of-a-kind” scenario** here.
  - Structured content.
  - Services over uniform content.
  - Automatic, template-based rendering.
- We do **not** consider as content management:
  - Singular documents.
  - Unstructured content.
  - Wikis etc.



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Introduction.
Basic Content Management Requirements.

- **Content Creation:**
  - Import and syndication of content.
  - Authoring and modification of content.
  - “Web 1.0”: by dedicated editors; “Web 2.0”: by every user (*user-generated content*).
- **Quality Assurance:**
  - Domain-specific, e.g., following business rules. Legal aspect ⇨ dedicated editors.
  - Technically, e.g., no “broken links”.
- **Distribution:**
  - Rendering of content into documents.
  - Delivery / playout of multimedia documents, e.g., HTML pages.
  - Export of “raw” content.
- Inclusion of **additional services** in delivery:
  query, retrieval, classification, recommendation, e-commerce, tracking, personalization, ...

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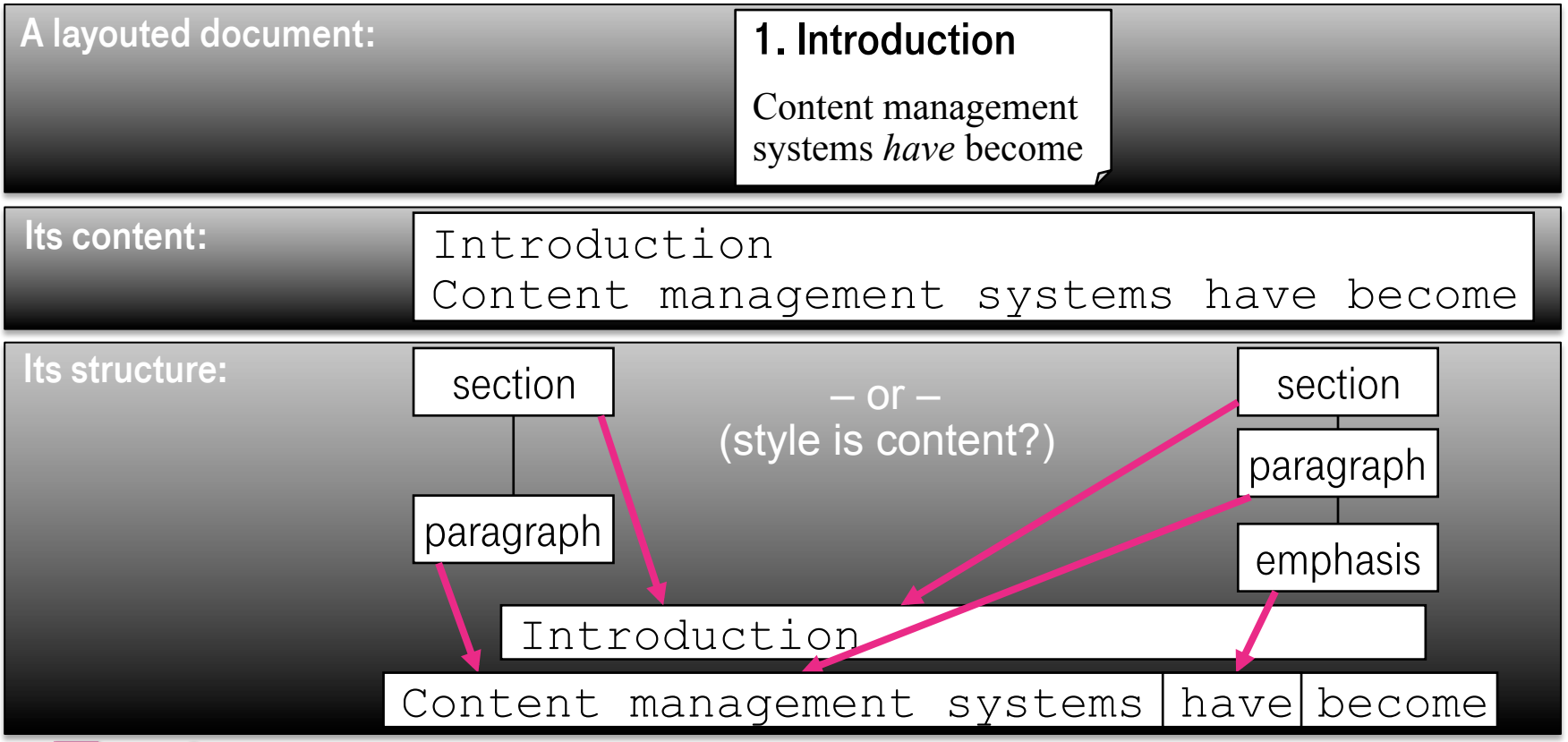
Introduction.
So, What is Content?

- Well known: hierarchy(?) of
  - Data.
  - Information.
  - Knowledge.
- **Content?**
  - Technical definition.
  - Pragmatic definition.
  - Epistemic definition.

Introduction.
Technical View: from Multimedia Documents to Content.

- **An observation:**
  in documents *content*, *structure*, and *layout* can be separated.

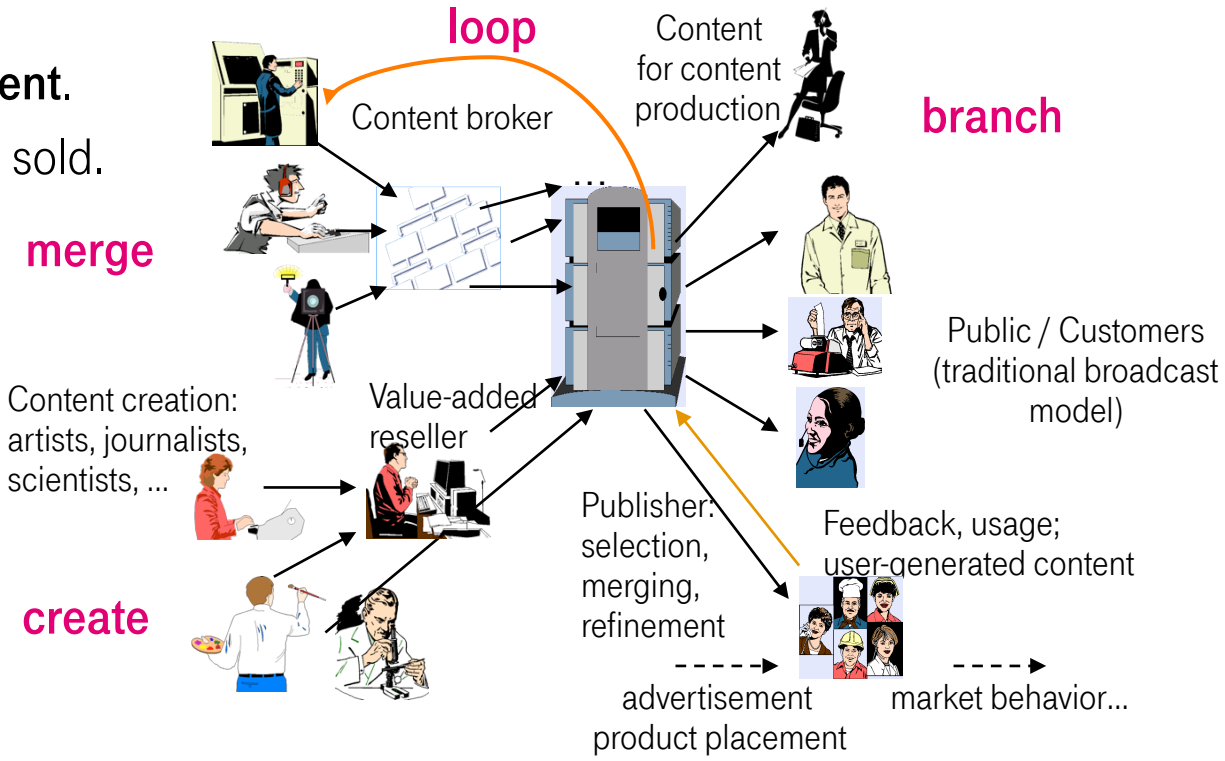
Content is data: media independent, used for document production.



Introduction.
Pragmatic View on Content.

Content is a good, subject to value-adding processes.

- If we see content management as the discipline of **database publishing**: content is data with the purpose of being ...
  - Created in an editorial process.
  - Quality assured.
  - Rendered into a **document**.
  - Published / played out / sold.
  - Syndicated.
  - Perceived.
  - ...



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Introduction.
Epistemic View on Content.

Content is a knowledge structure, concepts as well as evidence.

- Inspired by Ernst Cassirer:
  content is the **meaningful** and **purposeful** representation of entities.
- **Meaningful:** symbol (semiotics: sign) composed of ...
  - Something perceivable.
  - Some concept for a class of (important) perceptions.
- These two are indivisible aspects of content
  (see critics on, e.g., Kant's categories; Ontology vs. Epistemology in philosophy).
- ⇨ not just "typed data".
- **Purposeful:** depending on some context.
  - Perceiver's knowledge.
  - Perceiver's task.
  - Perceiver's location.
  - ...

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Introduction.
Content Management Models.

- In addition to the above models
  - **Content model** (structure, schema).
  - **Layout model**.

  a range of **further models** is required for a complete presence (site, hypermedia, ...):
  - **Navigation model**.
  - Browser / device **capability description**.
  - **User model**.
  - ...
- When models are missing, they are often hardwired into other models, e.g.,
  - Navigation in layout.
  - Capabilities in layout.

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Introduction.
Contemporary Content Management Systems.

- The relevance of content management has brought up a plethora of content management systems (CMSs).
- **Contemporary CMS:** built as information systems following 3-tier architecture.
  - Data layer.
  - Application layer.
  - Presentation layer.
- ⇨ Content is data in databases, playout is “database publishing”.
- Thus implemented as **generic software**.
  - Parameterizable with content structure and templates.
  - Need to carry conceptual model over all layers and into the users perspective.
  - Need for user to interpret data as content.
- There are products with different properties, but basically all are built along these lines.

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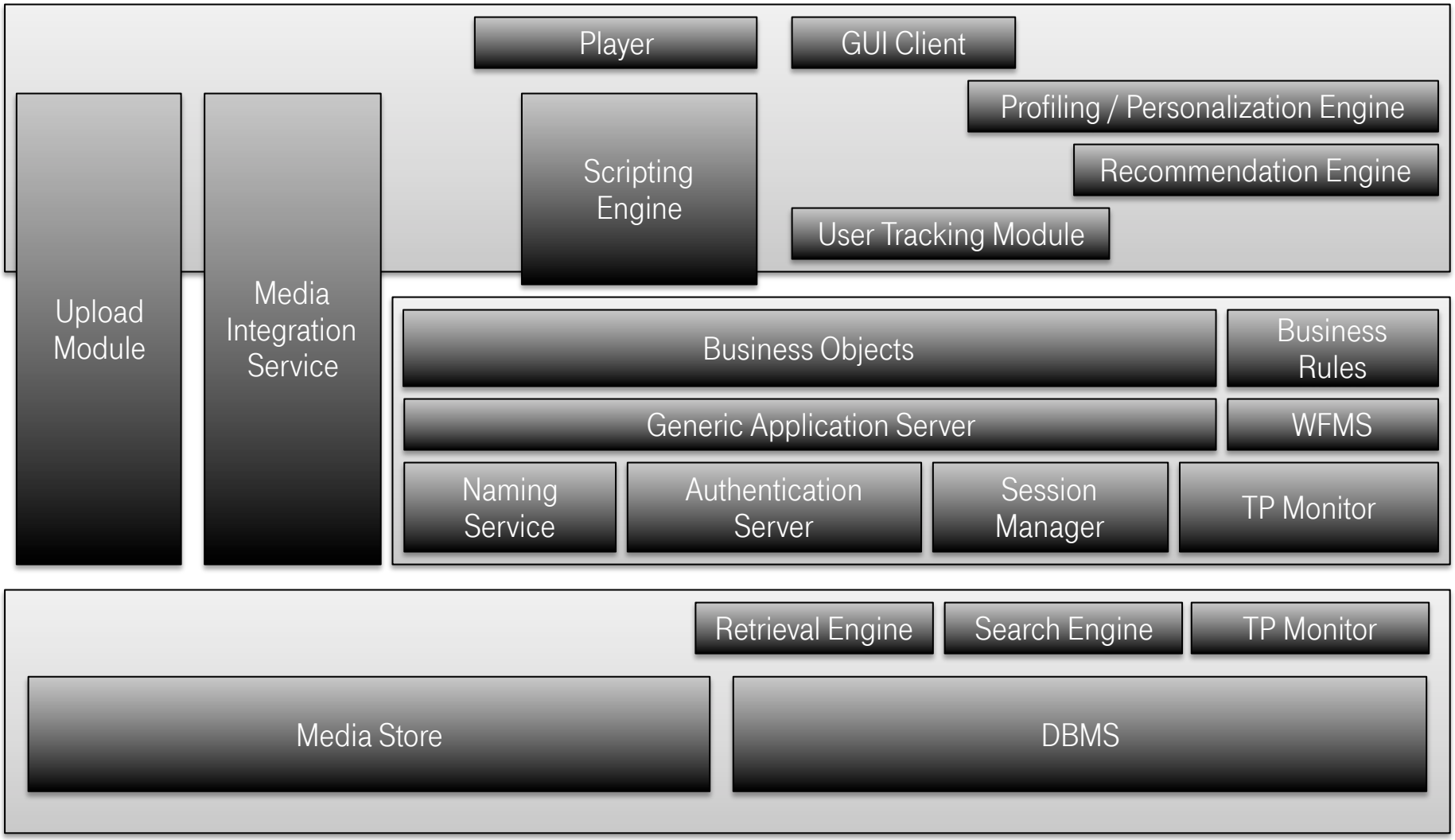
Introduction.
“Conventional” CMS Architecture Diagram.



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Introduction.
A Critique on Contemporary Content Management Systems.

- Contemporary CMSs deliver **pragmatic solutions**, but some problems still **call for more elaborated solutions**.
- **A-priori conception**, separating creation from operation phase.
  - **Software:** no co-evolution with content, built upon solid conception
    ⇨ not able to evolve with new conceptions.
  - **Content:** does hardly survive schema changes (migration!), does not cross organizational borders.
  - **Schema:** introduces standardization (like in DB, IS) within one organization
    ⇨ content syndication means copying content ⇨ no “real” cooperation.
- **Insufficient multi-channel / x-media support:** content is not really reusable on different media (shortening text, simplifying navigation, adapting services, ...).
- **No modality** (consideration of user: preferences, task, environment, ...).
- **Not suited for Web 2.0 applications** (typical problem of commercial CMSs: optimized for massive playout, no “feedback” channel).

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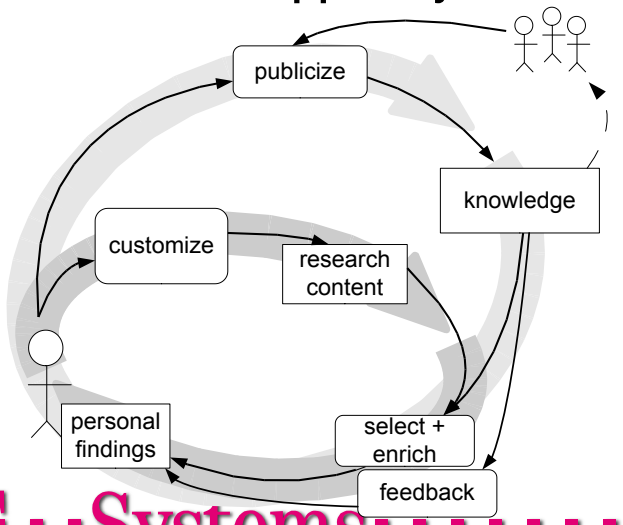
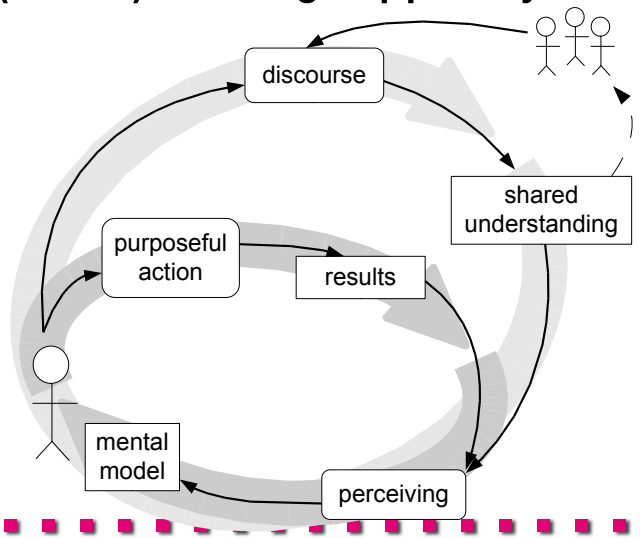
Introduction.
Shortcomings of Contemporary Content Management Systems.

- **Advanced CMS properties:**
  - Models and software evolving with content.
  - Models and software adapting to different modes (of user, devices, ...).
  - Consideration for the different life cycles of content and software.
  - Interrelationship between content model and domain / business model.
- Two CMS application examples:

research support system



(active) learning support system



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ADVANCED CONTENT MANAGEMENT TASKS AND REQUIREMENTS.

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Content Management Tasks and Requirements. Content / Knowledge Management.

- **Entity descriptions**:
  - *Data* often describe real world entities.
  - Claim: the same holds for multimedia *content*.
- **Observation** (see, e.g., Cassirer):
  - Natural sciences describe *things* in *states*.
  - Humanities look at *document-based processes*.
- **Entity representation** (see, e.g., Peirce):
  - Representation of entities by *multimedia content* and
  - Interpretation of content by means of a *conceptual model*.

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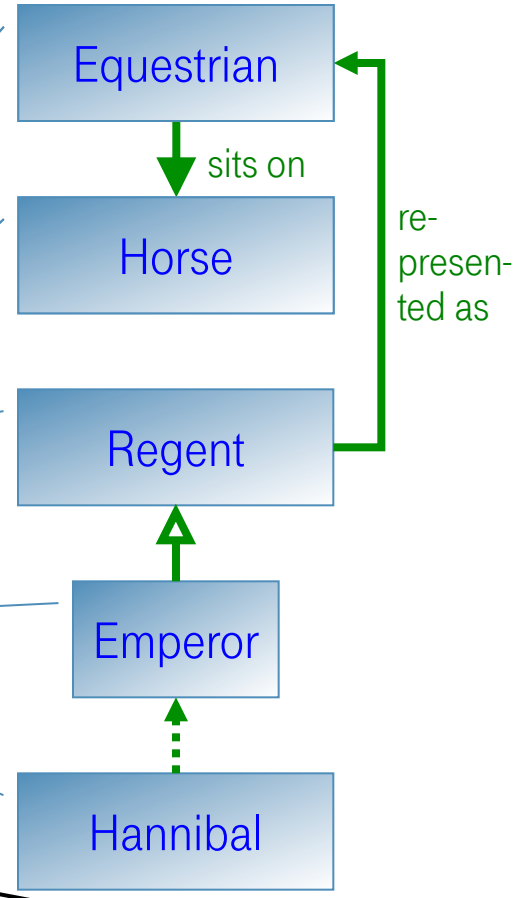
Content Management Tasks and Requirements.
Content Descriptions: Example.



Meta / description data

Web 2.0, Collaborative Tagging

Semantic Web, ontologies; folksonomies

Epistemic structures

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Size	: 491x624
Resolution	: 260dpi

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Size	: 100cm x 50cm
Medium	: Oil on canvas

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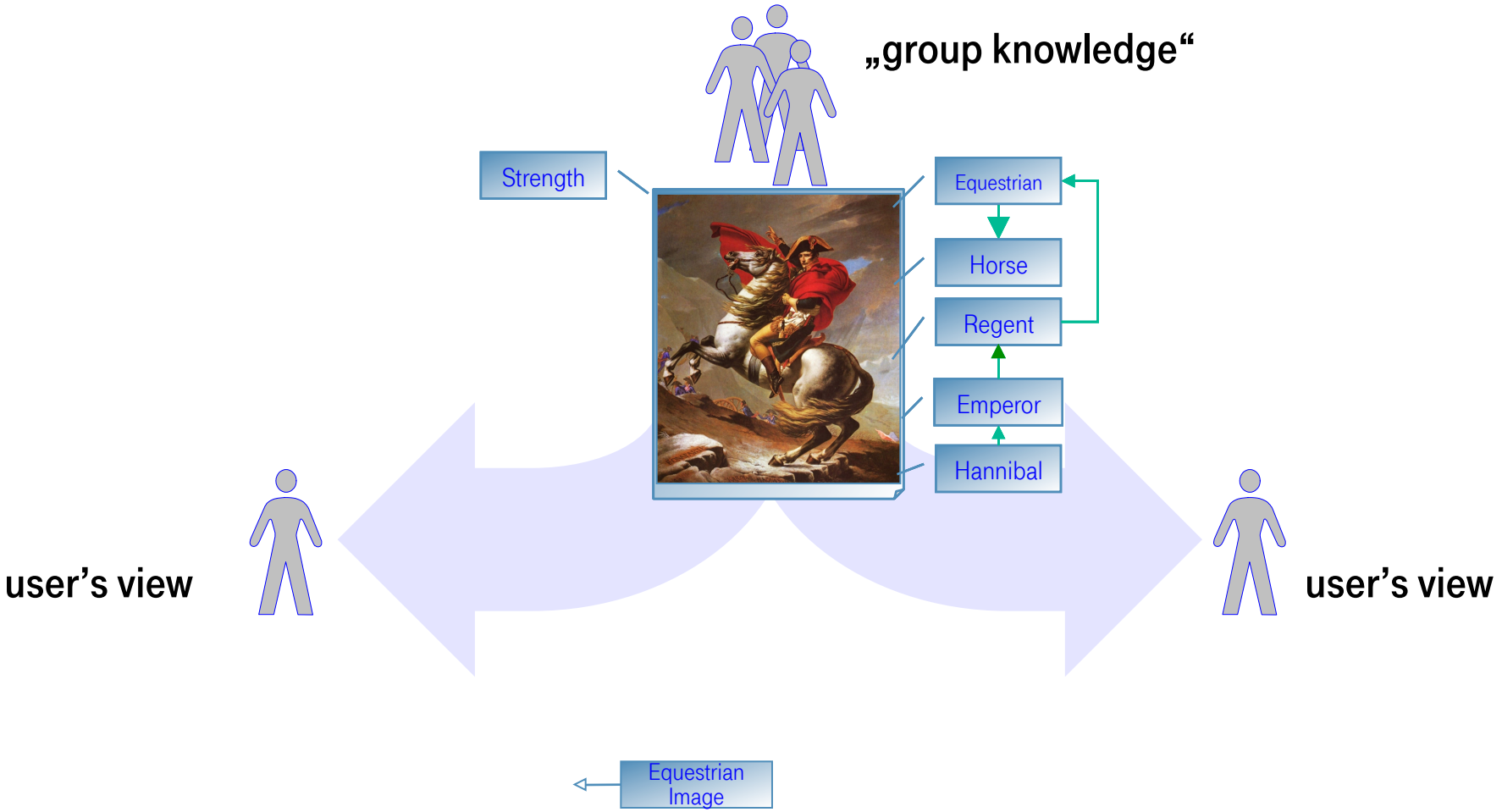
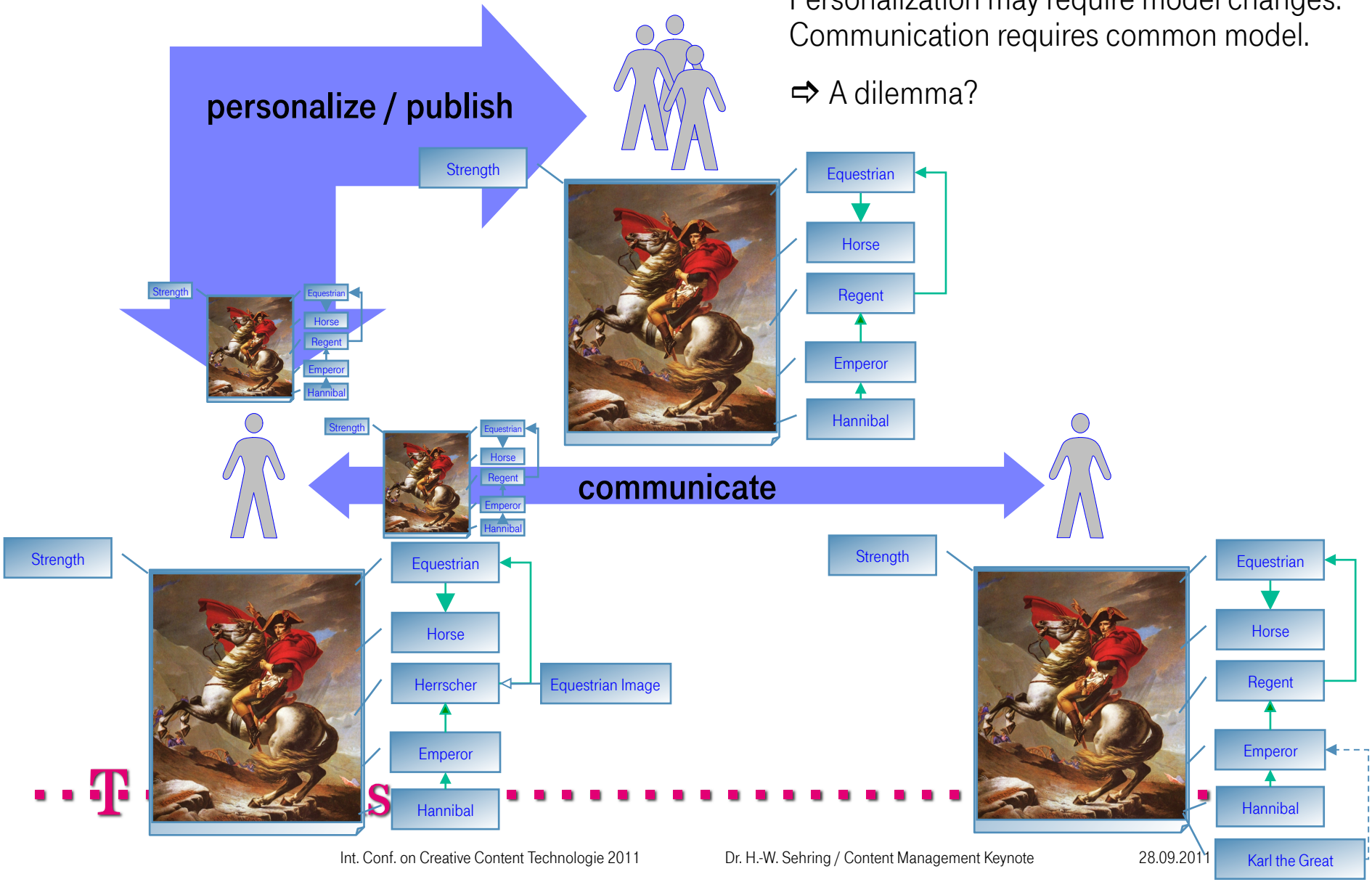
Content Management Tasks and Requirements.
User Adaptivity: Personalization



Content Management Tasks and Requirements.
User Adaptivity: Communication.

Personalization may require model changes.
Communication requires common model.

⇨ A dilemma?



CONCEPT-ORIENTED CONTENT MGMT.

Many aspects joint work with Joachim W. Schmidt.
Some aspects joint work with Sebastian Boßung.

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Concept-oriented Content Management (CCM). Openness and Dynamics of Modeling.

- **Requirements:**
  - Users want to adapt (*personalize*) content to their current working context individually, while
  - existing content is preserved and
  - cooperation between users is maintained.
- **Demand: open** and **dynamic** environments
  - **Openness:** models ...
    - are not limited to predefined concepts and
    - can be changed at any time.
  - **Dynamics:** content management systems ...
    - follow model change without interrupting the domain experts' work and
    - maintain existing contents and communication structures.

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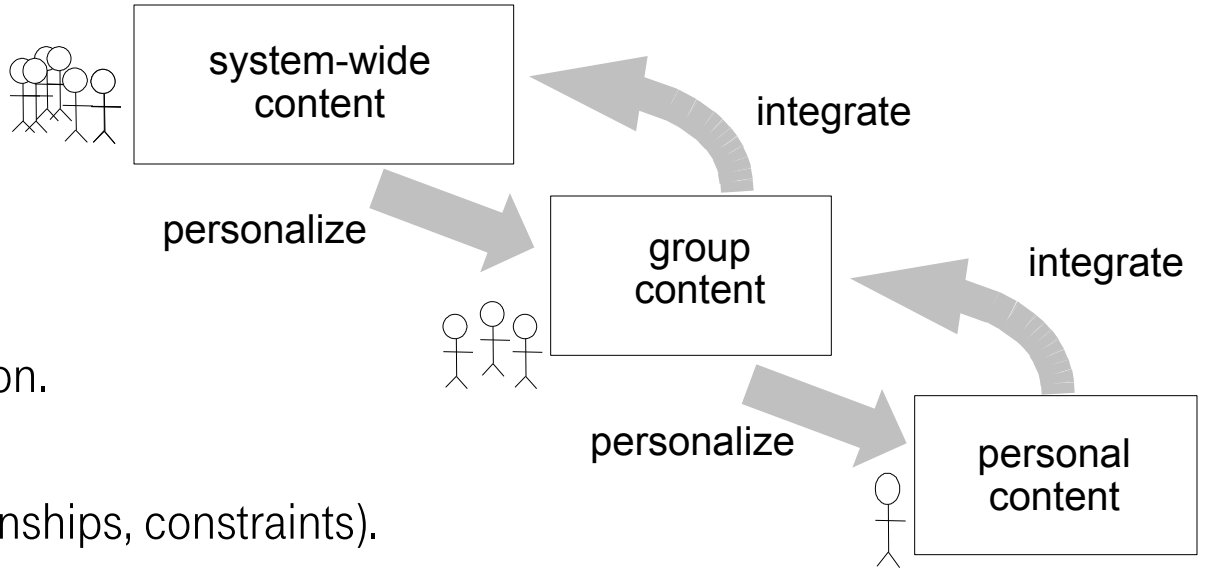
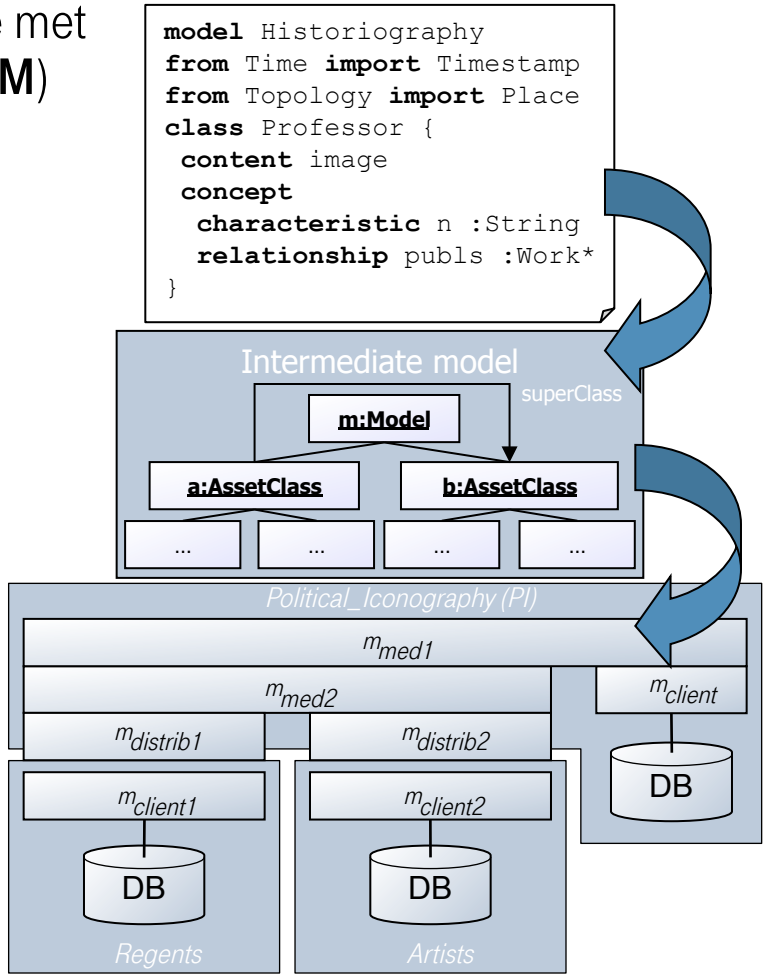
Introduction.
Example for More Demanding CMSs: Orthogonal Personalization.

- **Content personalization:**
  - Values and bindings (content, concepts).
  - includes presentation personalization.
- **Structure personalization:**
  - Schema (attributes, relationships, constraints).
  - Categories (create new, recategorize).
- Implemented through openness and dynamics.



Concept-oriented Content Management (CCM). Contributions.

- The key requirements of openness and dynamics are met by the **Concept-oriented Content Management** (**CCM**) approach by means of its key contributions:
  - **Modeling language**
    - Modeling performed by domain expert.
    - Open for changes.
  - **Model-driven system development**
    - Incremental generation.
    - Fully automatic, without developer intervention.
  - **Software architecture**
    - Component-based.
    - Evolution friendly.



CONTENT MODELING.

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Content Modeling.
Structuring Content.

- CMS services typically require a **content model**.
- In conventional CMSs: proprietary content schemata (mostly = data schema).
- **Requirement:** `1`, `$1`, or `1€` depending on ...
  - Application layer (e.g., computation).
  - Presentation layer (e.g., rendering the currency sign).
- **Better:** rich central model from which all layers are deduced.
  - While providing openness.
  - While providing dynamics.
- **Compare:** domain modeling.

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Content Modeling.
CCM Modeling Language.

- **Definition language** for classes and instances:

```
model Political_Iconography
from Regents import Regent
class EquestrianImage refines RegentImage {
 content image :Image
 concept
   characteristic creation :java.util.Calendar
   relationship   regents  :Regent*
   constraint     hasHorse icons >= {horse}
}; class EquestrianImage
let bonaparteCrossesAlps := create EquestrianImage {
  regents := { Napoleon } …
}
```

- **Query- and manipulation language**: instance lookup, creation, manipulation, and deletion.

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Content Modeling.
Model Relationships.

- Combinations of models for base domains, models as revisions, and personalized variants.

```
model Political_Iconography
from Regents import Regent
from Artists import Artist
class RegentImage {
 content image :Image
 concept
  characteristic title :java.lang.String
  relationship regents :Regent*
  relationship artist  :Artist }
```

```
model Regents
class Regent
class Monarch refines Regent
class King refines Monarch
…
```

```
model My_Political_Iconography
from Political_Iconography
     import RegentImage
from Humanities import Epoch
class RegentImage {
 concept
  relationship epoch :Epoch
  constraint eqEpoch epoch=artist.epoch }
```

```
model Artists
from Humanities import Epoch
class Artist {
 concept
  relationship epoch :Epoch
}
class Painter refines Artist
…
```

Content Modeling.
The Minimalistic Meta Modeling Language (M3L).

- The CCM Modeling Language is implemented and has been used in various projects.
- A new approach is to use the **Minimalistic Meta Modeling Language** (**M3L**) for open dynamic content modeling.
- M3L ...
  - Was originally designed for software engineering purposes, in particular model-driven development.
    - Model validation.
    - Model-to-model transformations.
    - Model-to-code transformations.
- Presented for the first time on CONTENT 2011: **M3L for content modeling**.
- M3L addresses several issues more directly than the CCM Modeling Language, in particular contexts and modality.

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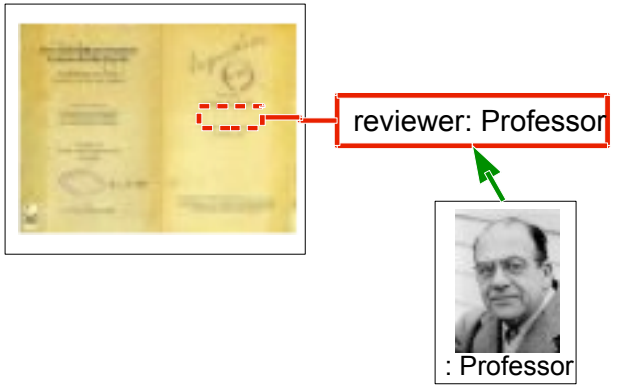
Content Modeling.
Asset Schema Inference Process (ASIP).

- **Bootstrapping:** CCM requires an initial model as a starting point for the open dynamic modeling process.
- **Required:** systematic support for domain experts in finding suitable models.
  - Usually, some **modeling expert** (analyst) is consulted.
  - Due to dynamics requirement, such a modeling expert **cannot be employed** in CCM.
  - Domain experts are not modeling experts.
  - But: experts can “tell their story” by **providing examples**.
- Start with **content expressions:**
  - Content abstractions and applications: assigned names and bound values.
  - Semantic types (concepts): no inner structure.



- Free-form entity descriptions are used as samples; later they become instances of classes.

Joint work with Joachim W. Schmidt, Sebastian Boßung, and Henner Carl.

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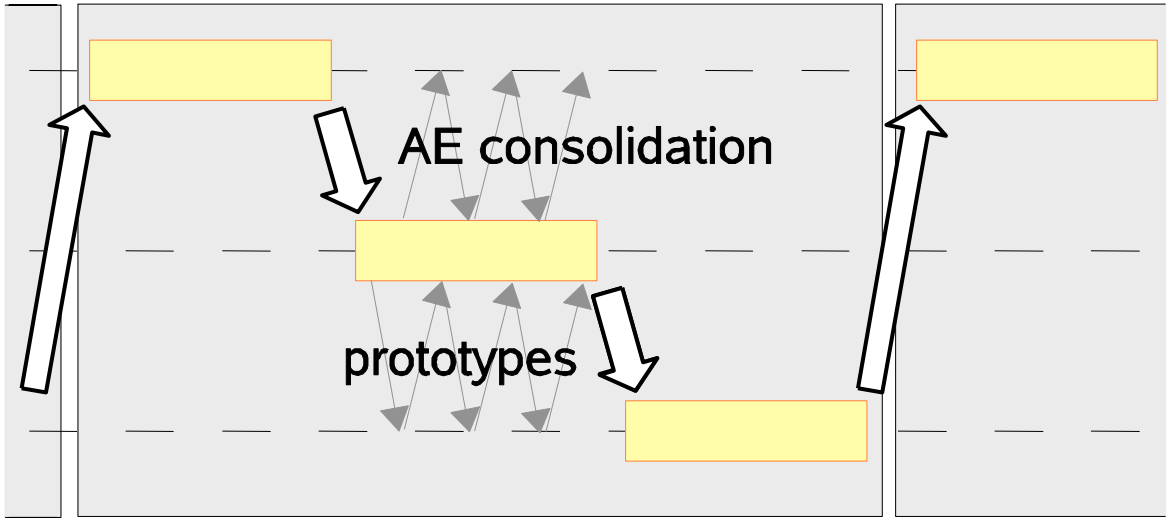
Content Modeling.
Agile CCMS Development.

- **Agility:**
  - Modeling process based on the possibility to generate CCMSs dynamically.
  - Domain experts review their models based on experiences with an operational CCMS.
  - If changes to the model are required, another iteration of the process is started.
  - Entity descriptions created within the CCMS can be used as samples for the next iteration of the process.

Create content instances.

Construct schema.

Generate CCMS.



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CCMS ARCHITECTURE.

CCMS Architecture.
Modules and Components.

- Software and content need to be decoupled in the lifecycle of a CMS.
- In CCMSs, this is achieved by separating two levels of reuse:
  - Content.
  - Code.
- The architecture reflects this in its two **main building blocks**:
  - **Components**.
  - **Modules**.
- Components allow content reuse: varying functionality over same code base.
- Modules allow code reuse: base functionality that can be combined in various ways.

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CCMS Architecture. Components.

- ADL model relationships support a range of operations. The two most commonly used ones,
  - Domain reuse.
  - Personalization.
- map to two specific ways of component combinations:
  - **Application structure**.
  - **Organizational structure**.
- Components cooperate along these two dimensions.
- Other model relationships are addressed by one of these architectural means, e.g.,
  - Revisions in the organization structure.
  - Rights Management in the cooperation structure.

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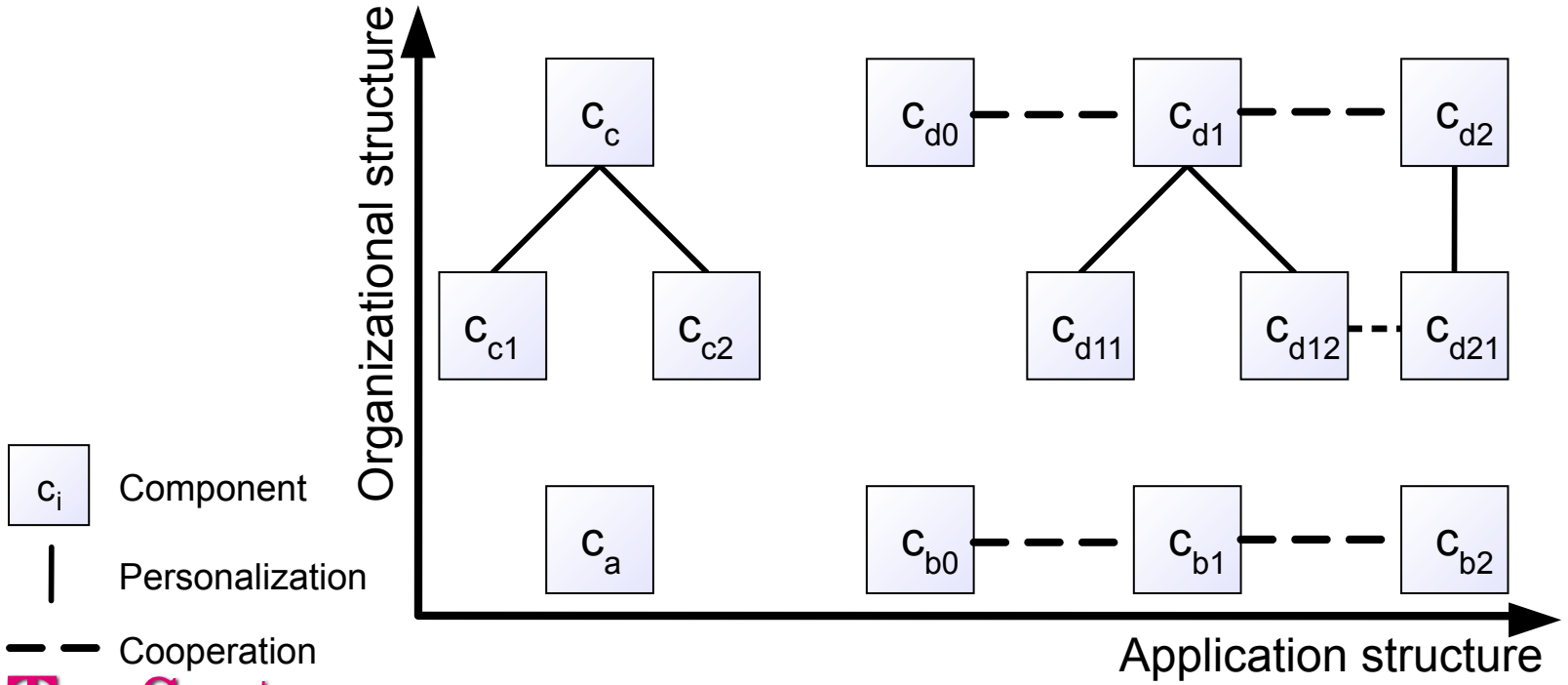
CCMS Architecture.
CCM Component Architecture.

- A CCMS consist of components.
  - One component for each domain model.
  - Cooperation of domains for openness.
  - Personalization of domains for dynamics.



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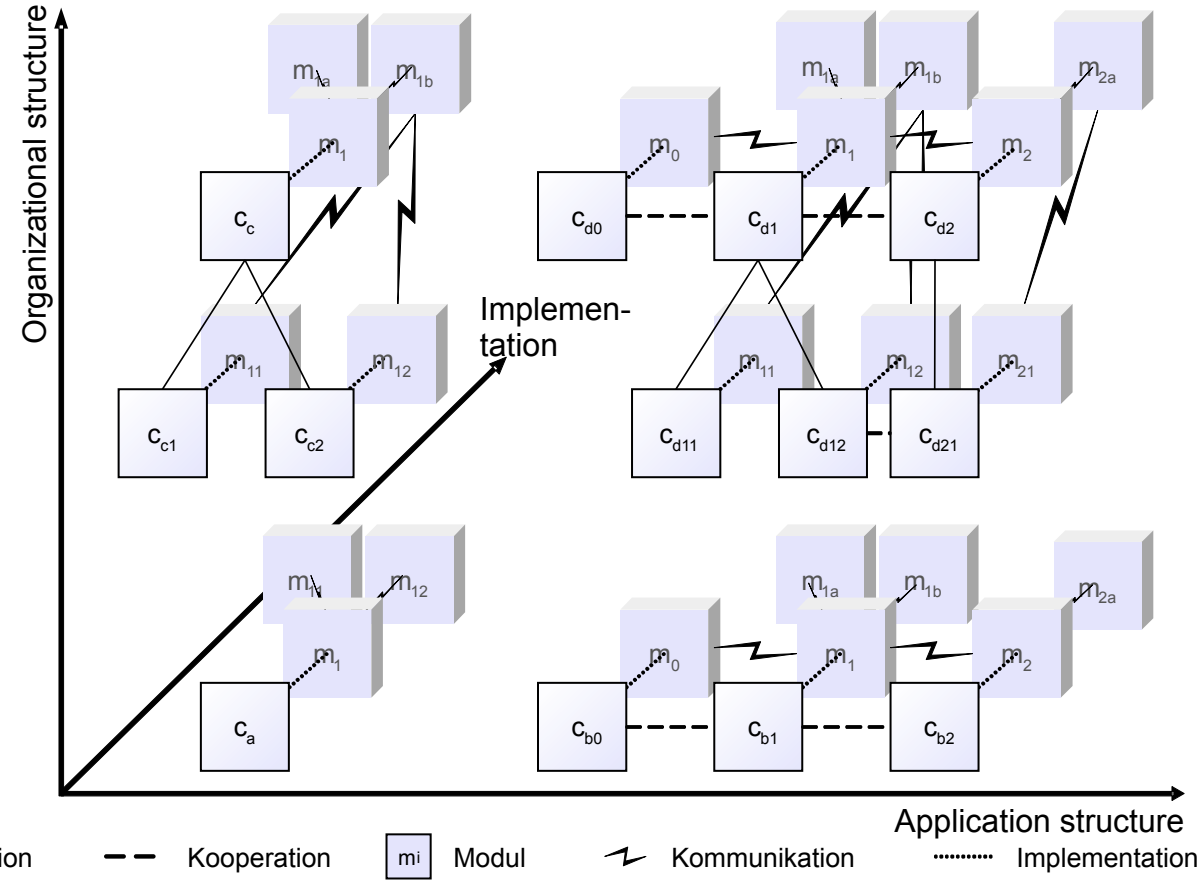
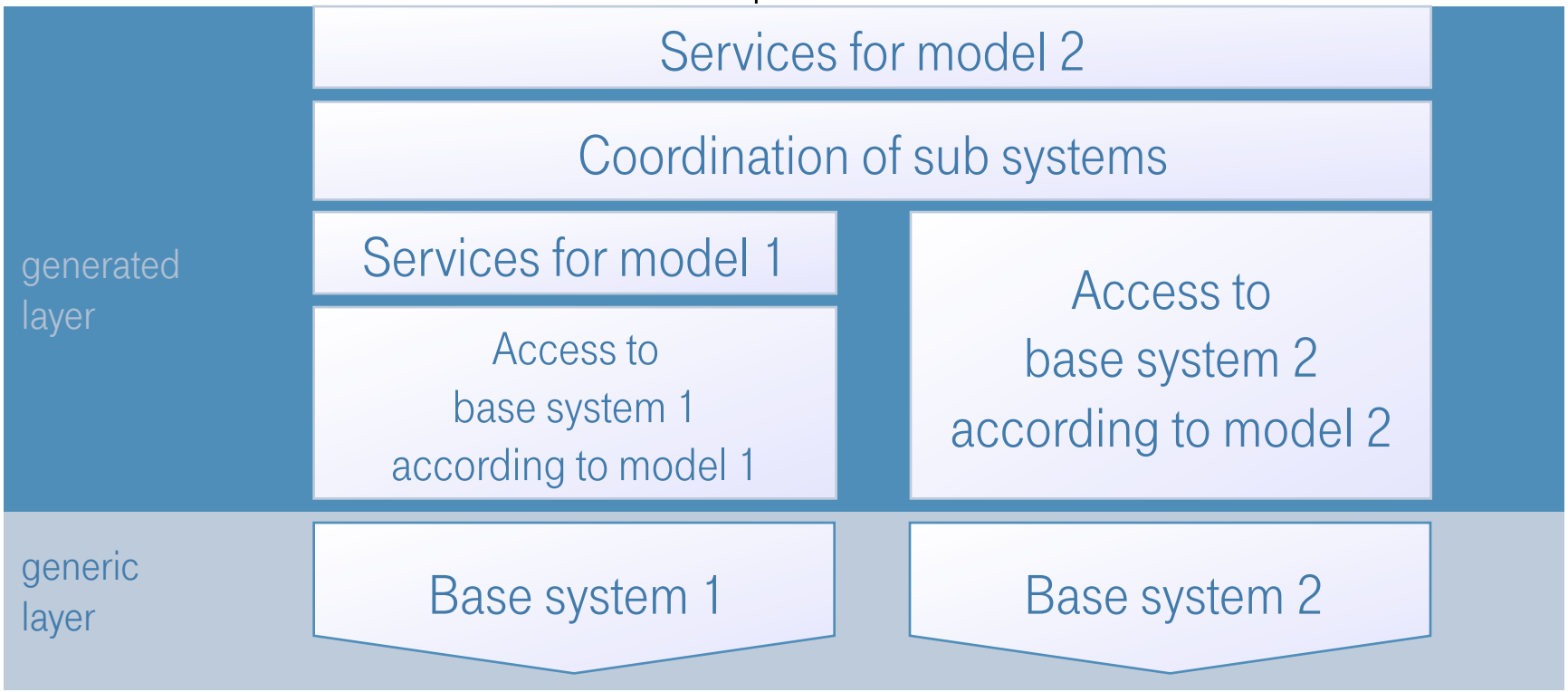
CCMS Architecture.
CCM Fine-grained Architecture: Modules.

- Modules are software artifacts generated for a content model at hand.
- The combination of module instances within one component determines the CCMS's behavior.
- Dynamic reconfiguration at runtime for dynamics by:
  - *Separation of Concerns* through module kinds with certain functionality.
  - Uniform module API.
  - Stateless modules.



CCMS Architecture.
Central Architectural Building Block for Incremental Generation.

- Central building block of the CCMS architecture: *Mediator*
  - **Wrapper** → components for the adaption of instances
  - **Mediator** → coordination of other components



CCMS GENERATION.

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CCMS Generation.
Compiler Framework.

- Modeling openness requires adequate software support, prohibits generic software.
- Modeling dynamics requires dynamic software evolution, prohibits manual intervention.

- **A dilemma?**

- CCMS architecture enables software evolution.
- Software generation to allow dynamic software evolution.
- Based on ideas from MDSD.
- But: not arbitrary functionality, but software fulfilling standard requirements for CCMSs w.r.t. a particular content model.

- ⇨ **Solution:** standardized functionality (generated) for individual models.
- Basis for all CCMS: **compiler framework**.

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CCMS Generation.
CCM Model Compiler Framework.

- CCM model compilers follow established compiler construction principles.
- **Generalizations** of compiler construction:
  - Factor out commonalities into a **framework** extendable by **recognizers** and **generators**.
  - Access to multiple related models from **repositories** / **dictionaries** instead of “includes”.
- **Extensions** of compiler concepts:
  - Complex **abstract syntax tree** decoration.
  - Rich **symbol tables**.
  - Coordination of various **generators** (backends) contributing artifacts.

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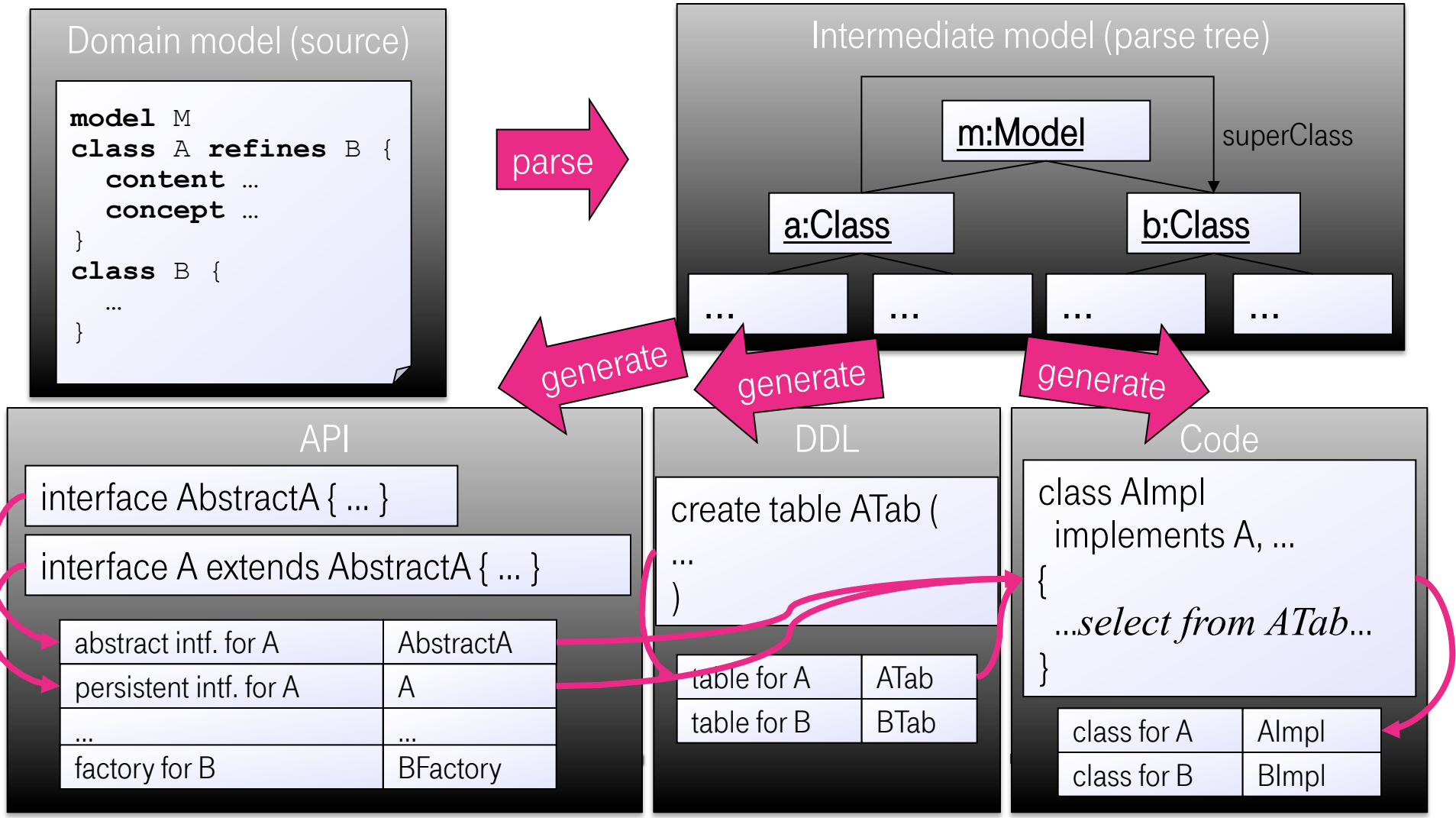
CCMS Generation.
CCM Model Compilation Process.

- Compilation process overview (example):



CONTENT VISUALIZATION

Content Visualization.
Open Dynamic Content Presentation.

- Openness requires rich, well-designed visualizations.
  Dynamics requires adaptable visualization
  (adaptive visualization not possible because of human preferences/needs).
- Generated UIs do usually not meet users' needs.

- **A dilemma?**

- ⇨ **Solution: Apply CCM principles to visualization**.
  - Represent UIs by open models.
  - Provide initial UI definitions with domain models.
  - Users can reuse and personalize UI definitions.
  - Software is generated from the definitions dynamically.

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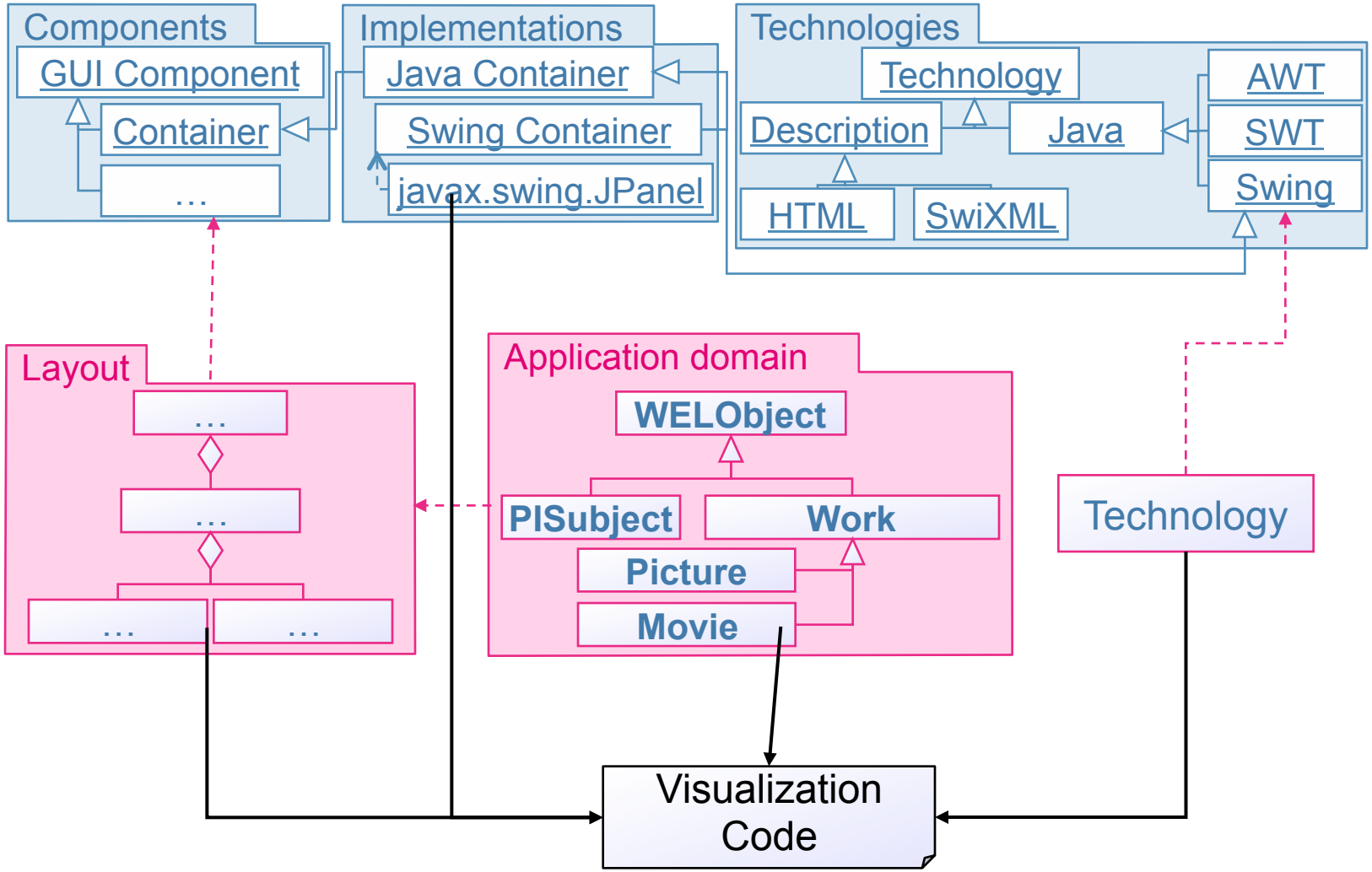
Content Visualization.
Models for Visualizations.

Visualization environment

Domain expert

(CCM) Compiler



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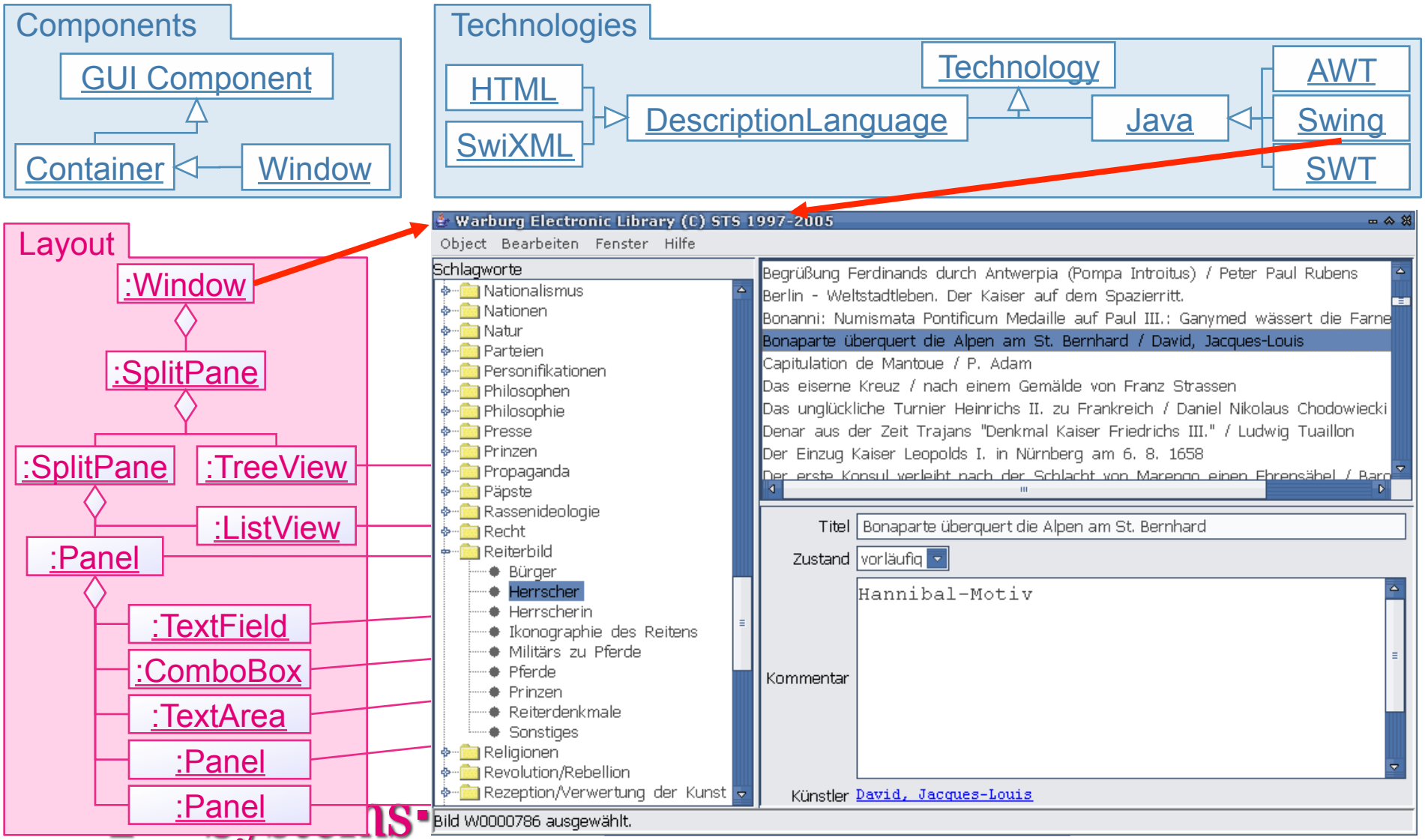
Content Visualization.
Example: Rich Client for a Digital Library.



SUMMARY.

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Summary.

- Content Management is a **vital industry**.
- Contemporary content management systems address requirements **in a pragmatic way**.
  - Solving the practical problems successfully.
  - Do not scale well to more recent challenges.
- Advanced content management tasks call for **more elaborated support** that in turn calls for a solid conceptual basis, including work on:
  - Modeling.
  - Architectures.
  - (Model-driven) software engineering.
  - Visualization.
- To this end, content management needs to be recognized as a **field in its own rights**.
- **Concept-oriented Content Management** has proven successful.
- Much, much more work needed.

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THANK YOU!

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