

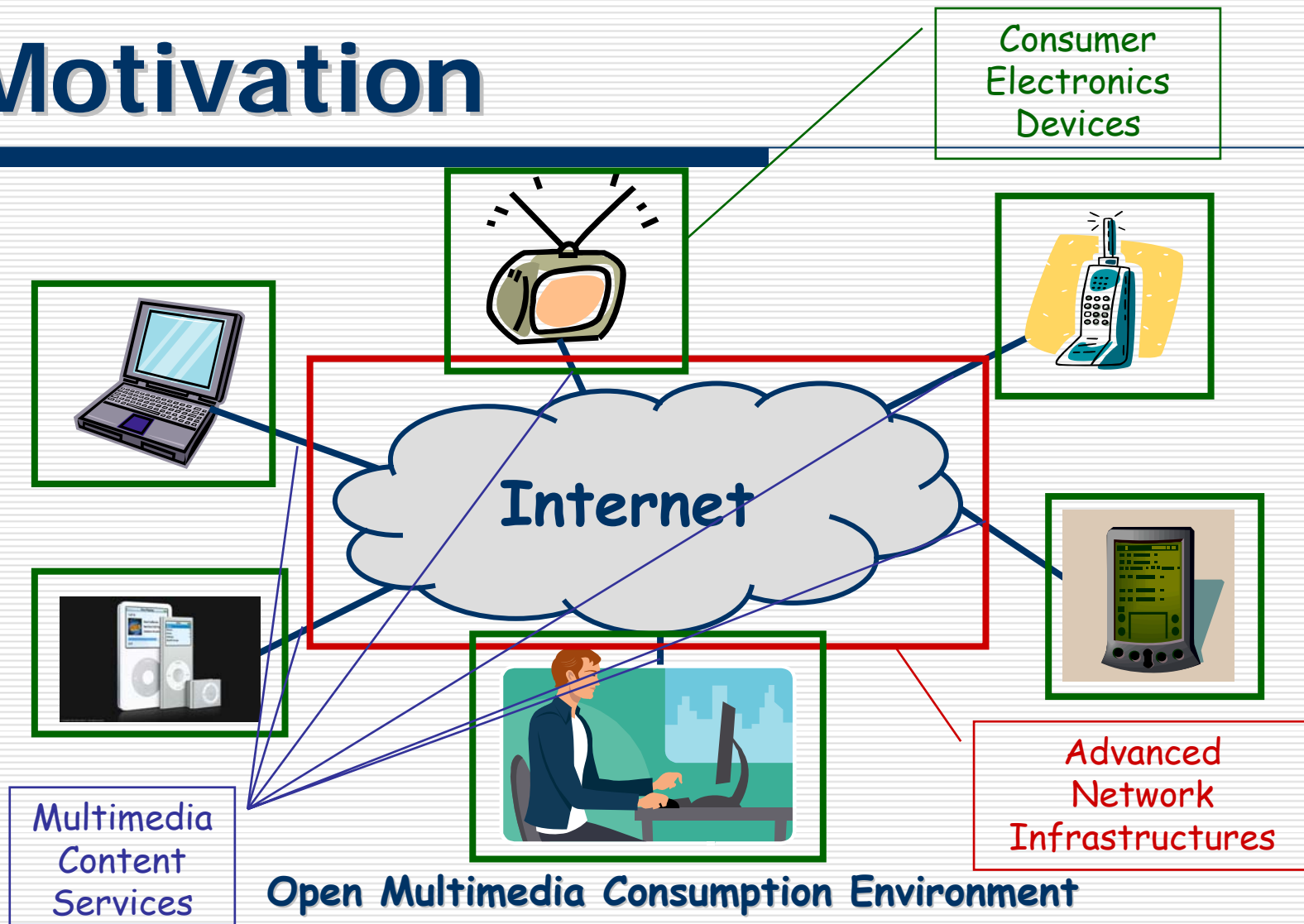
Ontology-Driven Interoperability for MPEG-7

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Motivation



Motivation

- Multimedia Content Services offered by different Vendors should interoperate
- Syntactic Interoperability: Achieved through Standards
 - MPEG-7: The Dominant Standard in Multimedia Content Description
- Semantic Interoperability: Achieved through Domain Knowledge Integration
 - Domain Knowledge usually expressed in the form of Domain Ontologies
 - Enhances the Retrieval Precision [TKDE 07]

Overview

- MPEG-7 Overview
- Domain Knowledge Representation using pure MPEG-7
- Ontology Driven Interoperability for MPEG-7
- MPEG-7 – CIDOC/CRM Alignment
- Semantic Multimedia Content Retrieval & Filtering
- Conclusions
- Open Research Issues

MPEG-7 Overview

Visual Descriptors	Audio Descriptors	
Media Semantics	Textual Annotation	
Structure	Point of View	Relation
Matching Hints	Creation Information	
Media Information	Usage Information	

MPEG-7 Description

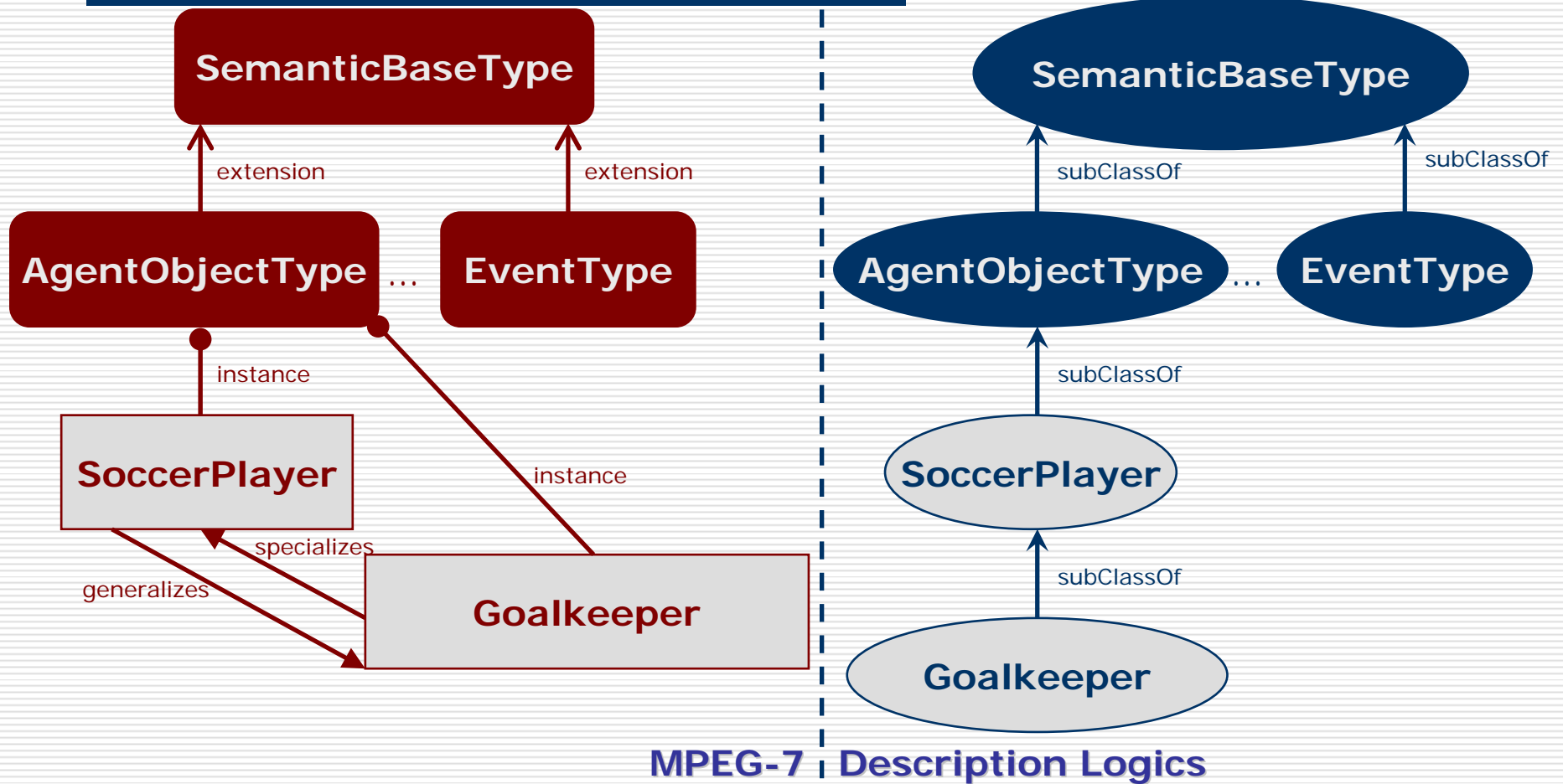
MPEG-7 Semantic Description Capabilities

- MPEG-7 provides general-purpose Semantic Description constructs
- MPEG-7 Semantic Descriptions are represented as collections of Instances of the subtypes of SemanticBaseType
 - ConceptType
 - EventType
 - ObjectType
 - AgentObjectType
 - SemanticTimeType
 - SemanticPlaceType
 - SemanticStateType
- Abstract & Concrete Descriptions are supported
 - AbstractionLevel Element

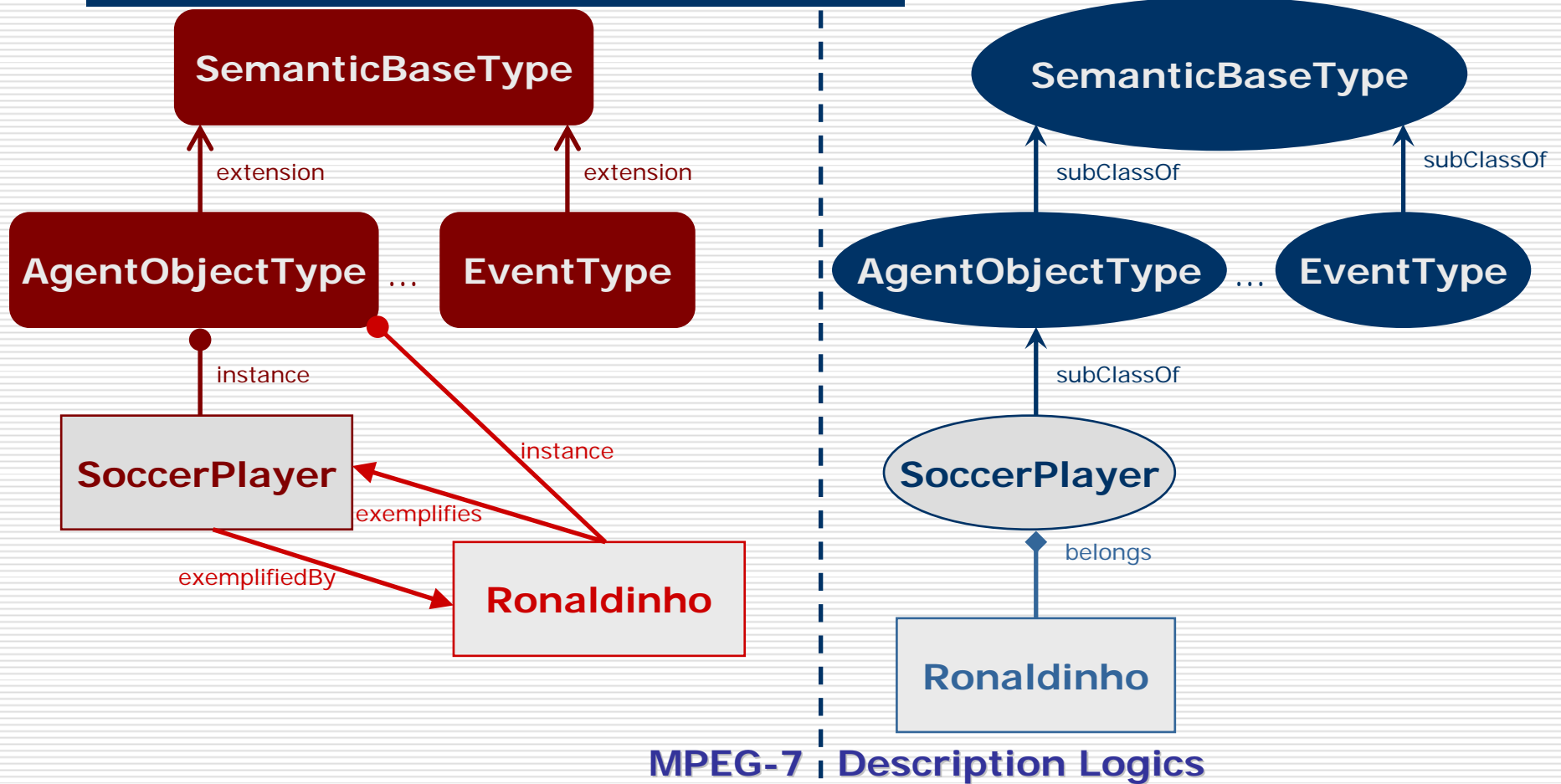
Domain Knowledge Representation using pure MPEG-7

- Domain Specific Classes Represented as MPEG-7 Abstract Semantic Entities [CAiSE 03, MTAP 05]
 - AbstractionLevel.Dimension>0
 - Specializes/Generalizes Relationships form the Class Hierarchies
 - Simple Type Properties: Property Elements
 - Complex Type Properties: Property/PropertyOf Relationships
- Domain Specific Individuals Represented as MPEG-7 Concrete Semantic Entities
 - Exemplifies/ExemplifiedBy Relationships between the Semantic Entities Representing Classes and Individuals

Domain Class Representation in MPEG-7



Domain Class Individual Representation in MPEG-7

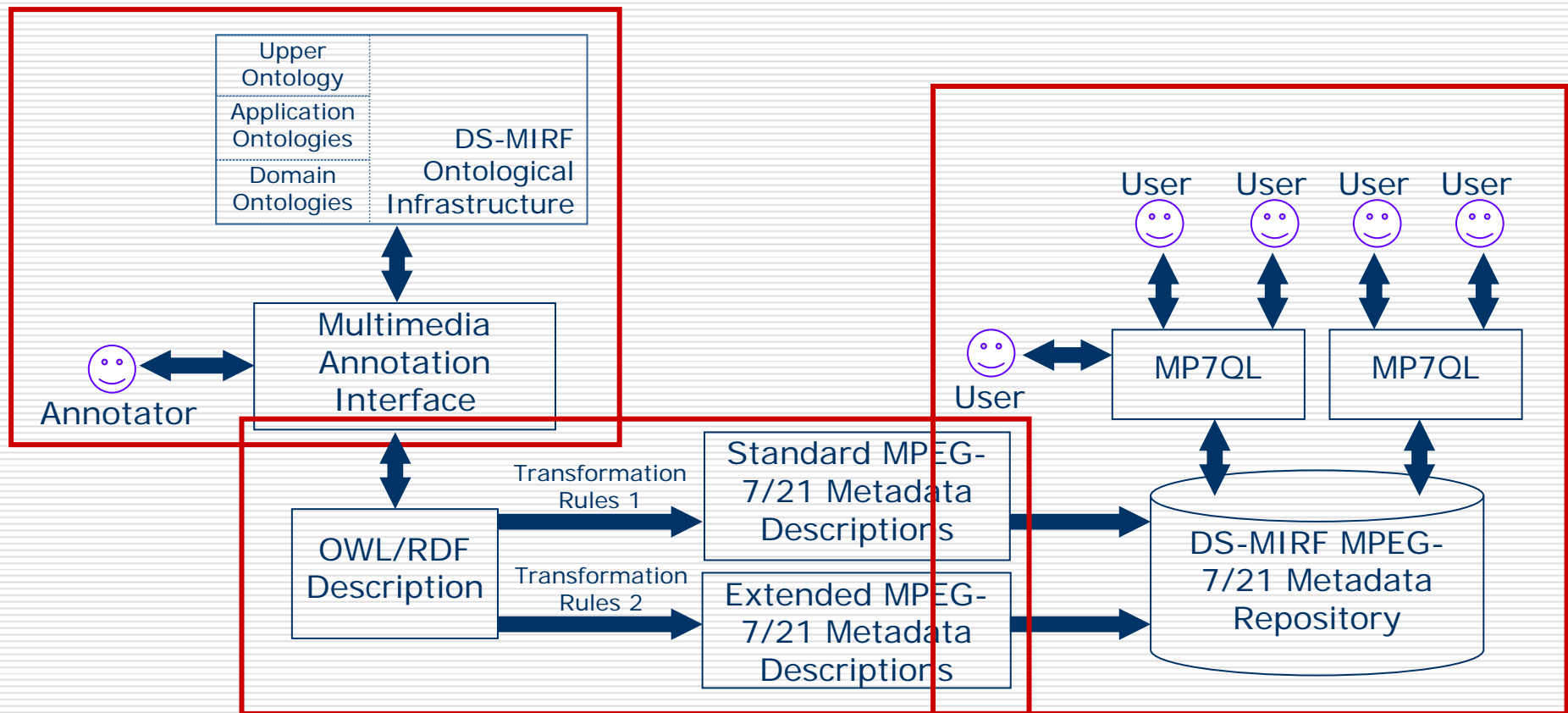


Ontology Driven Interoperability for MPEG-7

- OWL is the Dominant Standard in Ontology Description
 - Several Ontologies expressed in OWL
 - OWL Reasoners have been developed
- Expression of the MPEG-7 Constructs in OWL
 - The Hunter Ontology [SWWS01]
 - The DS-MIRF Upper Ontology [CIVR 04, TKDE 07]
 - The AceMedia Ontology [WIAMIS 05]
 - The UDF Ontology [SemAnnot 05]
- Integration of Domain & Application Knowledge expressed in OWL Ontologies [CAiSE 04, TKDE 07]

Ontology Driven Interoperability for MPEG-7

The DS-MIRF Framework

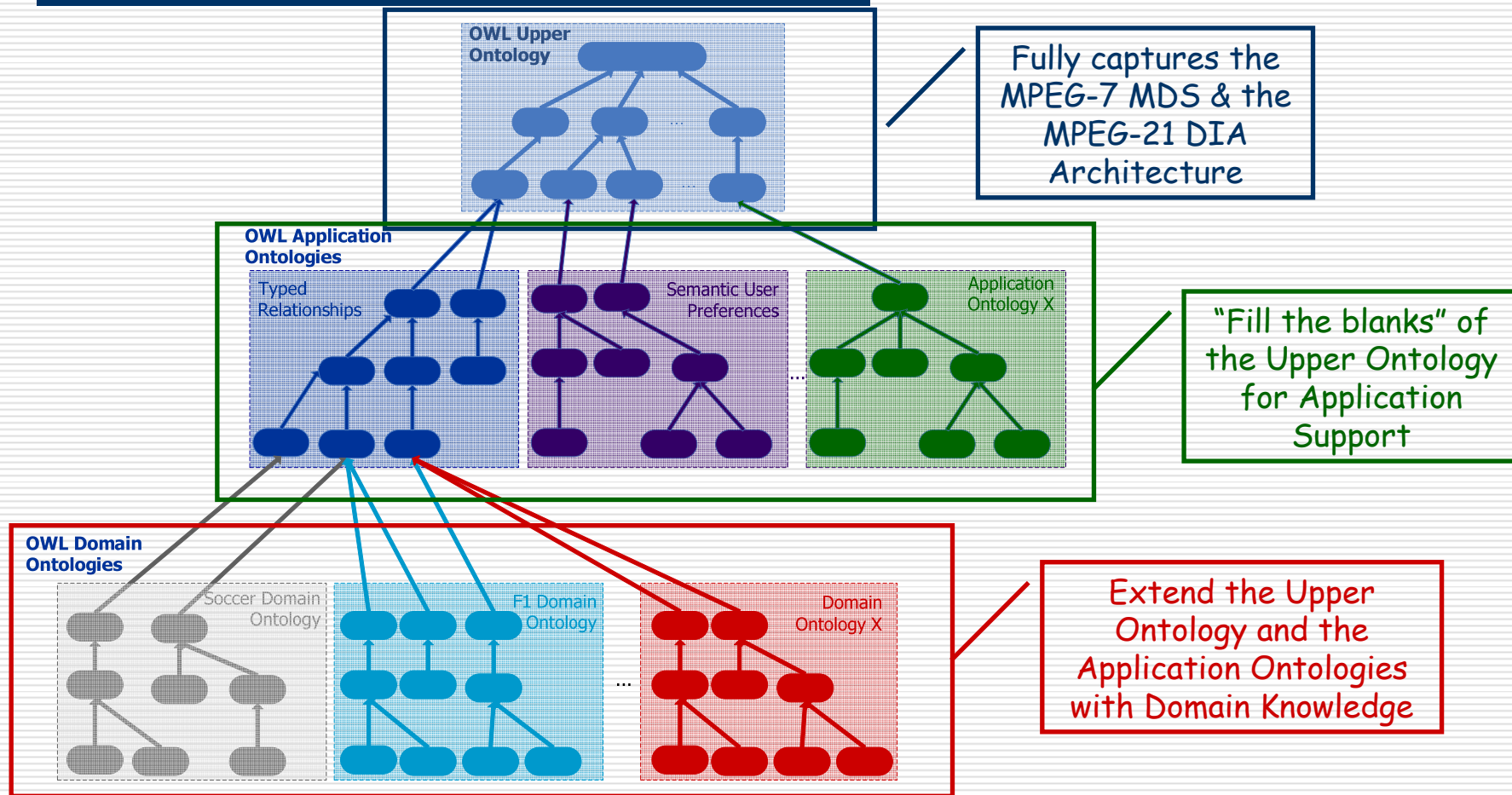


The DS-MIRF Framework

- ❑ The DS-MIRF Ontological Infrastructure
- ❑ Methodology for Domain Ontology Definition/Integration
- ❑ Transformation Rules
- ❑ Methodology for Transforming XML Schemas to OWL-DL

The DS-MIRF Framework

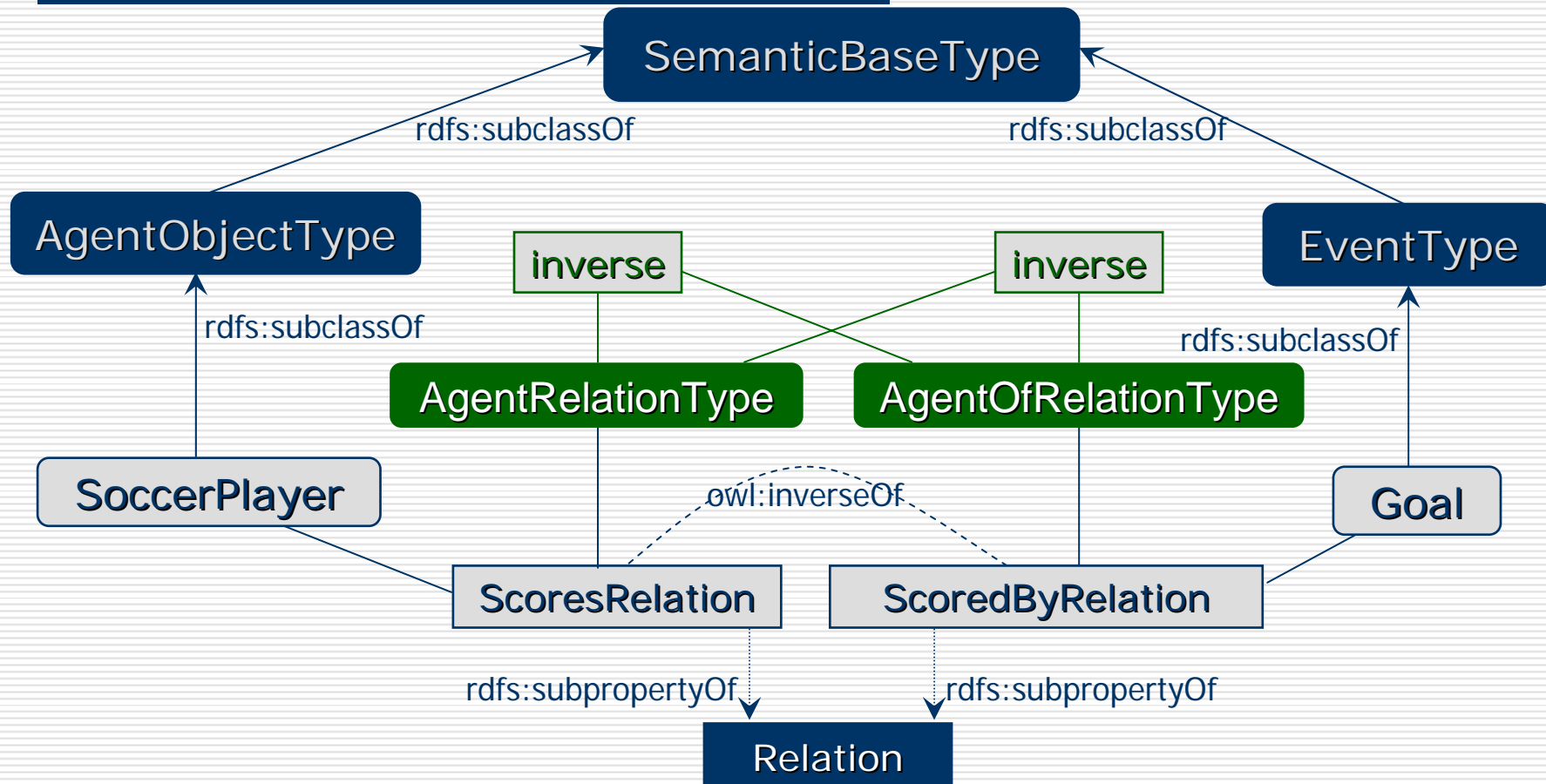
Ontological Infrastructure



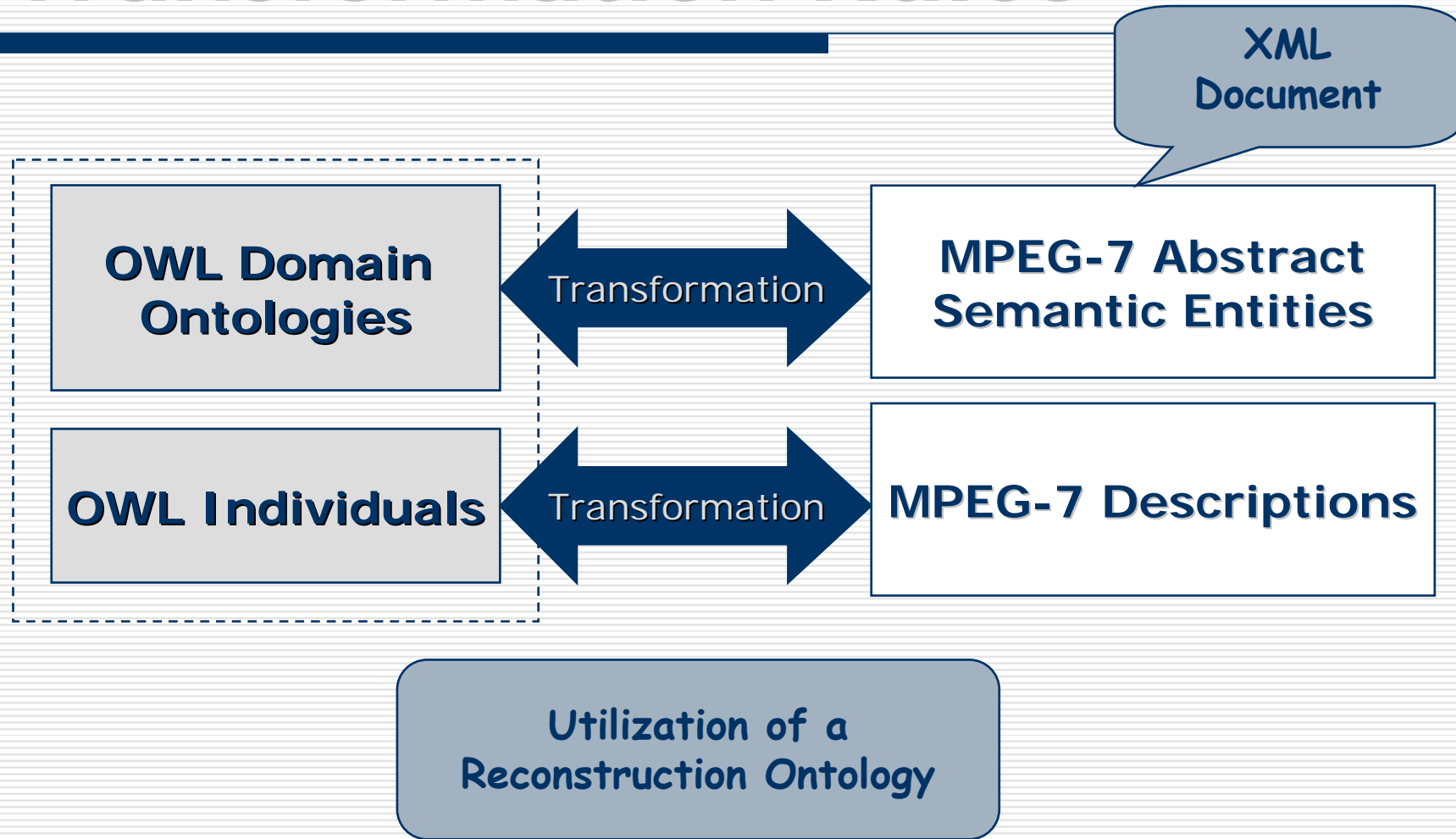
Methodology for Domain Ontology Definition/Integration

- Domain-Specific Entities \Rightarrow OWL Classes
 - Subclasses of the Upper Ontology
Classes that Represent the MPEG-7 Types
for Semantic Entity Representation
- Non MPEG-7 Features \Rightarrow Properties
- Additional Constraints for Valid Metadata
Production
- Additional Restrictions for the MPEG-7
Relationships

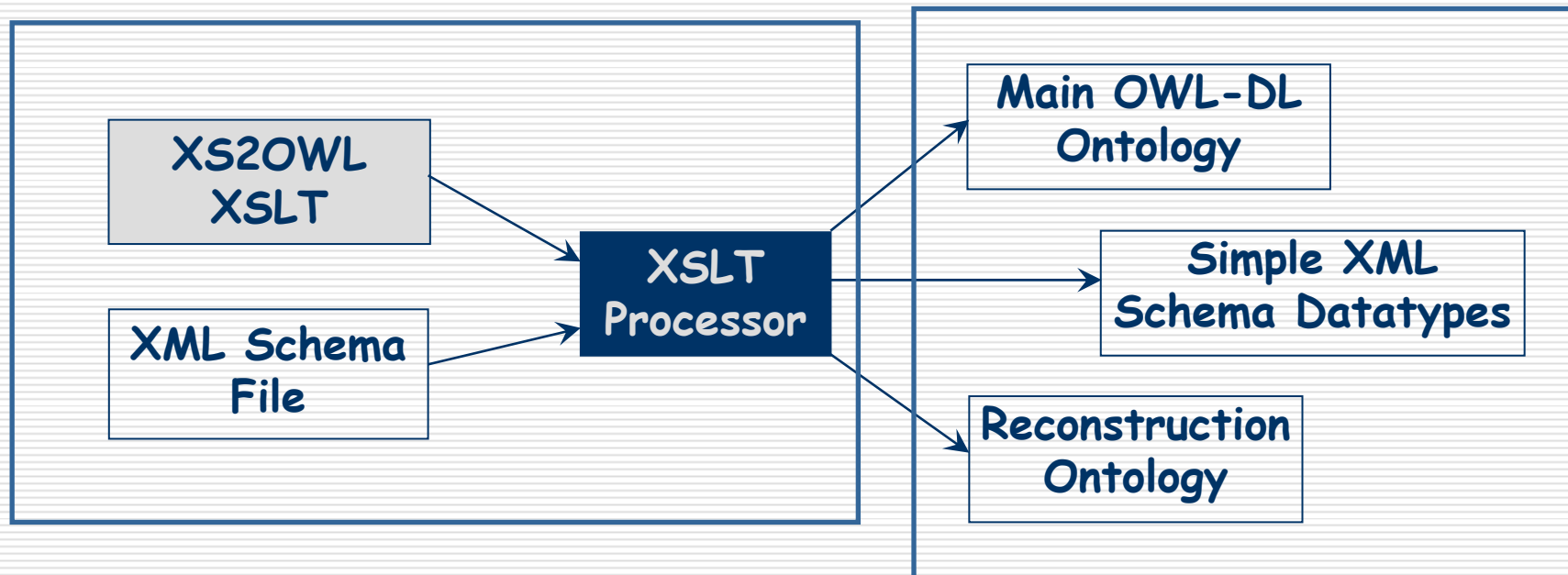
Methodology for Domain Ontology Definition/Integration



Transformation Rules



Methodology for Transforming XML Schemas to OWL-DL



XS2OWL – Direct XML Schema to OWL-DL Transformations

- ❑ Simple XML Schema Datatypes \Rightarrow Datatype Declarations
- ❑ Attributes \Rightarrow Datatype Properties
- ❑ Attribute Groups \Rightarrow Sets of Datatype Properties
- ❑ Elements \Rightarrow Datatype/Object Properties
- ❑ Complex Types \Rightarrow Classes
- ❑ Sequences & Choices \Rightarrow Complex Cardinality Restrictions
- ❑ Model Groups \Rightarrow Sets of Object/Datatype Properties
- ❑ References \Rightarrow Additional Information for Property Definitions

MPEG-7 – CIDOC/CRM

Alignment

- Digital Multimedia Content Services are getting popular ⇒ Digital Libraries should pay attention
- Culture is an important Digital Library Application Domain
- Cultural Information may be expressed in the form of Multimedia Objects
- Multimedia Objects may be of special cultural interest
- MPEG-7 and CIDOC/CRM are the dominant standards in the Multimedia and the Cultural Heritage Domains
- Interoperability between them is important

MPEG-7 – CIDOC/CRM

Alignment

- ❑ Combination of MPEG-7 with CIDOC/CRM under the ABC Ontology [JDIM03]
- ❑ CRM extended with the MPEG-7 Segment Class Hierarchy [MW02]
 - Decomposition properties defined (spatial, temporal decomposition, etc.)
- ❑ Mappings between the MPEG-7 Semantics and the CIDOC/CRM Semantics are carried out in TUC/MUSIC
- ❑ Transformations from CIDOC/CRM Descriptions to MPEG-7 Descriptions
- ❑ Transformations from MPEG-7 Descriptions to CIDOC/CRM Descriptions

Semantic Multimedia Content Retrieval & Filtering

- Powerful Retrieval can be built on top of MPEG-7 Descriptions
 - Several Research Efforts
 - Visual/Audio Descriptors
 - Textual Annotations and/or Media-related Elements
 - Semantic Descriptions
 - Treat some aspects only!
- A Uniform and Transparent MPEG-7 Retrieval and Filtering Framework is needed

Semantic Multimedia Content Retrieval & Filtering

- Use standard XQuery (1.0 & 2.0)
 - No Preference Values
 - Does not take into account the peculiarities of:
 - Visual/Audio Low-level Descriptors
 - Semantic Descriptions
- Use MPEG-7 Filtering and Search Preferences (FASP) as Queries
 - Low-level Descriptors & Semantic Descriptions Absent
 - Not all Media-related Elements Present
 - No Boolean Operators

Semantic Multimedia Content Retrieval & Filtering

I want the multimedia objects where
The family name of a creator is "van Gogh" (preference 100)
The family name of a creator is "Kandinsky" (preference 75)

Not Supported by
XQuery

I want the multimedia objects where
(The title contains "heliotrope" AND the family name of a
creator is "van Gogh") OR (The title contains "composition"
AND the family name of a creator is "Kandinsky")

Not Supported by
the MPEG-7 FASPs

I want the multimedia objects where
A goal is scored (preference 100) OR a penalty kick takes
place (preference 50)

Not Supported by
XQuery

Not Supported by
the MPEG-7 FASPs

- Response to the Limitations: ISO MPEG-7 Query Format Requirements (MP7QF)
- MP7QL [SMAP 06]: Response to MP7QF

The MP7QL Query Language

- Language for Querying MPEG-7 Descriptions
 - Satisfies the MP7QF Requirements
 - Data Model: MPEG-7
 - Expressed in both XML Schema and OWL Syntax
- MP7QL allows:
 - Uniform and Transparent MPEG-7 Retrieval and Filtering
 - Querying every Aspect of an MPEG-7 Multimedia Object Description
 - Explicit Specification of Boolean Operators and Preference Values

The MP7QL Query Language

- The MP7QL Query Output Format is MPEG-7 ⇒ Closure
- The MP7QL queries may utilize the User Preferences and the Usage History as Context
 - Allow for Personalized Multimedia Content Retrieval
- Compatible FASP Model
 - Has the MPEG-7 FASPs as a special case
- An implementation of the MP7QL is under way on top of an XML Native DB

Input Query Format

- Fundamental Element: The MP7QL Query
 - Represented by MPEG7QueryType
- MP7QL Query Formal Description:

Q = [Select] [From] [Where] [OrderBy] [GroupBy]

Features to be included in the Query Results

Search Domain Specification

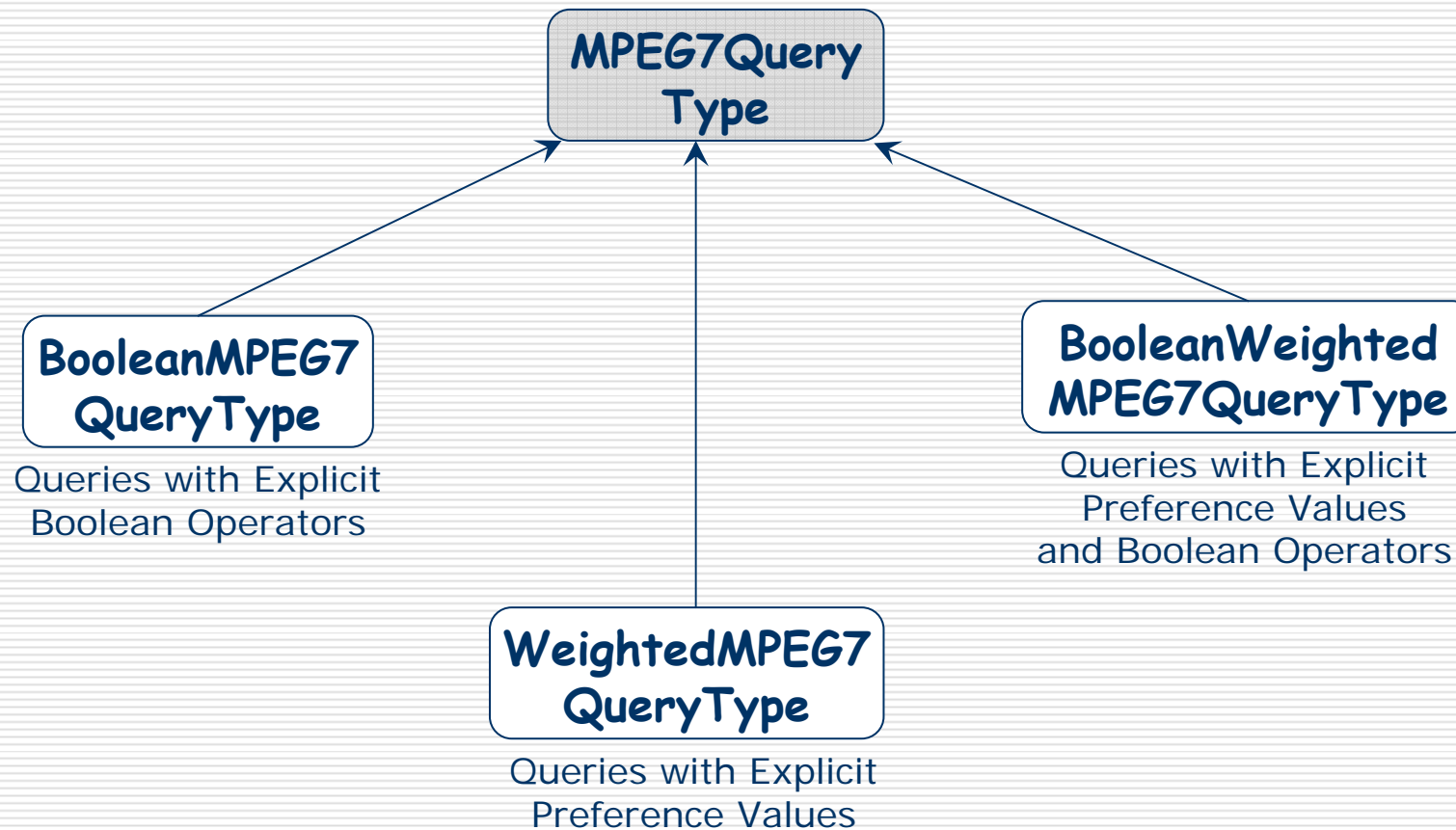
Specification of Conditions

Ordering Criteria

Grouping Criteria

The MP7QL Query Language

Input Query Format



Input Query Format – Examples

I want the Title, the Label and the URI of the Images, max 60 Result Items, 15 per page, Ordered according to their titles where
(The title contains "heliotrope" AND the family name of a creator is "van Gogh") OR (The title contains "composition" AND the family name of a creator is "Kandinsky")

I want the Title, the Media Format and the URI of the Videos, max 50 Result Items, Grouped according to the Media Format where
A goal is scored by Barcelona (preference 100) or a penalty kick against Real takes place (preference 50)

I want the Title and the URI of the Images and Videos where
(The title contains "soccer") AND (A goal is scored by AEK (preference 100) OR (A goal is scored against Olympiakos (preference 95) OR (AEK is awarded a penalty kick) (preference 90))

I want the Label of the Semantic Entities that
Represent an Italian Painter

Conclusions

- Interoperability is needed in the Open Multimedia Consumption Environment formed in the Internet
 - Syntactic Interoperability Achieved through the use of MPEG-7
 - Semantic Interoperability Achieved through Domain Knowledge Integration
 - Domain Knowledge can be represented using pure MPEG-7
 - OWL Ontology Driven Interoperability for MPEG-7
- MPEG-7 – CIDOC/CRM Alignment
- Semantic Multimedia Content Retrieval & Filtering

Open Research Issues

- Integration with Top-Level Ontologies (SUMO, DOLCE, ...)
- Semantic Multimedia Content Service Personalization
- Automation of the Semantic Multimedia Content Annotation
- Experimentation & Testing in Real-World Applications (eLearning, Culture etc.)

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