MPEG-7 Interoperability & the Semantic Web

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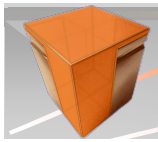
Thanks to
S. Dasiopoulou (ITI), V. Tzouvaras (NTUA)

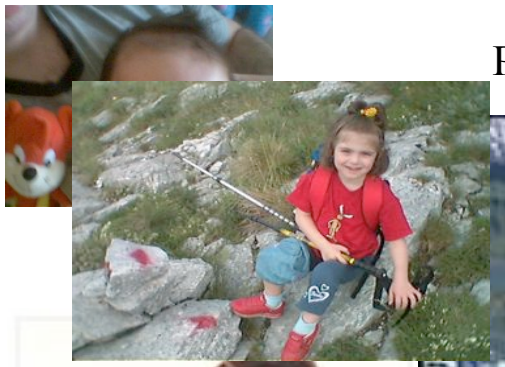
Outline

- MM content annotation
- MPEG-7
- Semantic Web
- Interoperability issues
- MPEG-7 ontologies
- Towards Interoperable Semantic Multimedia Descriptions
- Conclusions



Evolution of Content

- 1-2 exabytes (millions of terabytes) of new information produced world-wide annually
- 80 billion of digital images are captured each year
- Over 1 billion images related to commercial transactions are available through the Internet
- This number is estimated to increase by ten times in the next two years.
- 4 000 new films are produced each year
- 300 000 world-wide available films
- 33 000 television stations and 43 000 radio stations
- 100 billions of hours of audiovisual content



Personal Content

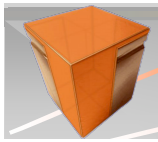
Sport - News

Web
Mobile

Movies

Need for annotation + medatata

"The value of information depends on how easily it can be found, retrieved, accessed, filtered or managed in an active, personalized way"



MM Content Metadata

- Two levels within the annotation context from analysis, search and retrieval perspective
  - conceptual (descriptive, domain specific)
  - media (structural, decomposition specific)

(signal level: feature representation)

(example from http://comm.semanticweb.org/examples)

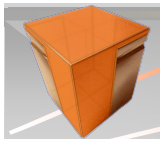
Conceptual and media annotation

Conceptual level

Media level

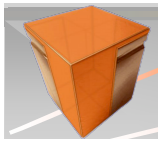
MM Content Metadata

- Domain specific ontologies (Semantic Web) provide the vocabulary & semantics for descriptive-related annotations
- MPEG-7 provides (among others) standardised description tools for media-related annotations
- How can they be combined?
- What happens with **interoperability**?



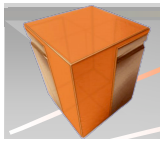
MPEG-7

- MPEG-7: greatest effort towards standardised multimedia content descriptions
  - rich set of broad coverage tools
  - generic schema: usage flexibility
- Interoperability issues
  - XML Schema (lack of precise semantics)
  - ambiguous interpretations
  - incompatibility with proliferating SW technologies



Interoperability Issues in MPEG-7

- XML Schemas define only the structure of well-formed descriptions
  - e.g. MovingRegion DS vs VideoSegment DS
- Multiple representations per semantic notion
  - e.g. an image can be represented using either of StillRegion DS, VideoSegment DS, etc.



```
<Mpeg7>
 <Description xsi:type="ContentEntityType">
  <MultimediaContent xsi:type=„ImageType">
   <Image>
    <SpatialDecomposition>
     <StillRegion id=„SR1">
      <TextAnnotation>
       <KeywordAnnotation xml:lang="en">
        <Keyword>Sky</Keyword>
       </KeywordAnnotation>
      </TextAnnotation>
     </StillRegion>
     <StillRegion id=„SR2">
      <Semantic>
       <Label>
        <Name>Sky</Name>
       <Label>
      </Semantic>
     </StillRegion>
     <StillRegion id=„SR3">
      <Semantic>
       <Definition> <!-- Also TextAnnotation!! -->
        <StructuredAnnotation>
         <WhatObject>
          <Name xml:lang="en">Sky</Name>
         </WhatObject>
        </StructuredAnnotation>
       </Definition>
      </Semantic>
     </StillRegion>
```

Segment 1

Segment 2

Segment 3

How do you formulate a query to get all segments that show „Sky“?

(syntactic interoperability)

What is „Sky“?

No ability to automatically process the information in a machine-understandable manner

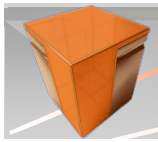
(semantic interoperability)

(example from Semantics in Multimedia Content for Multimedia Use, Steffen Staab, University of Koblenz - Landau, Germany, http://mklab.iti.gr/ist2006)

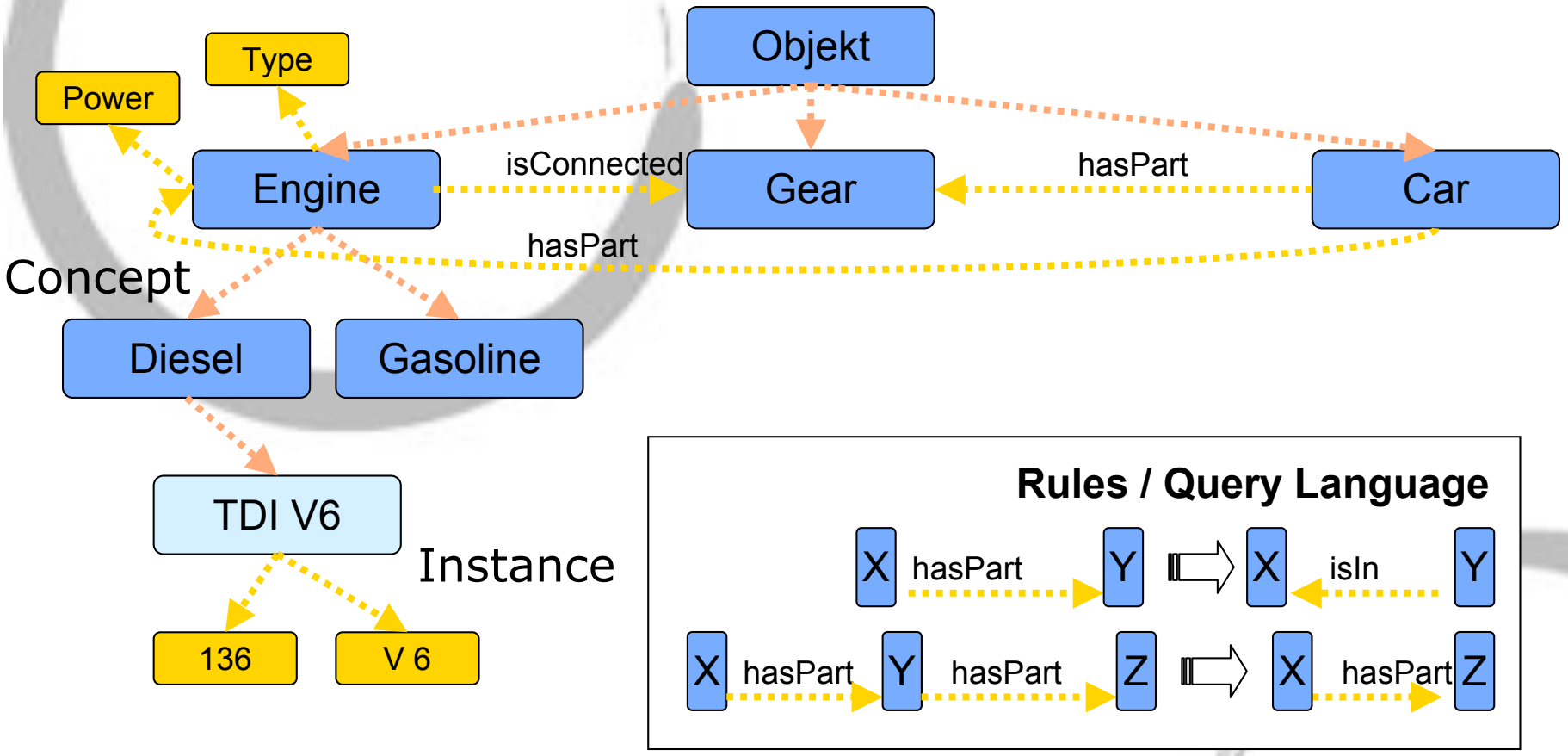
Semantic Web vision

- Technologies to capture, represent, exchange, and share metadata
- Logic-grounded formal semantics
- Explicit, machine processable semantics

⇨ challenge & prerequisite for realistic semantic enabled applications

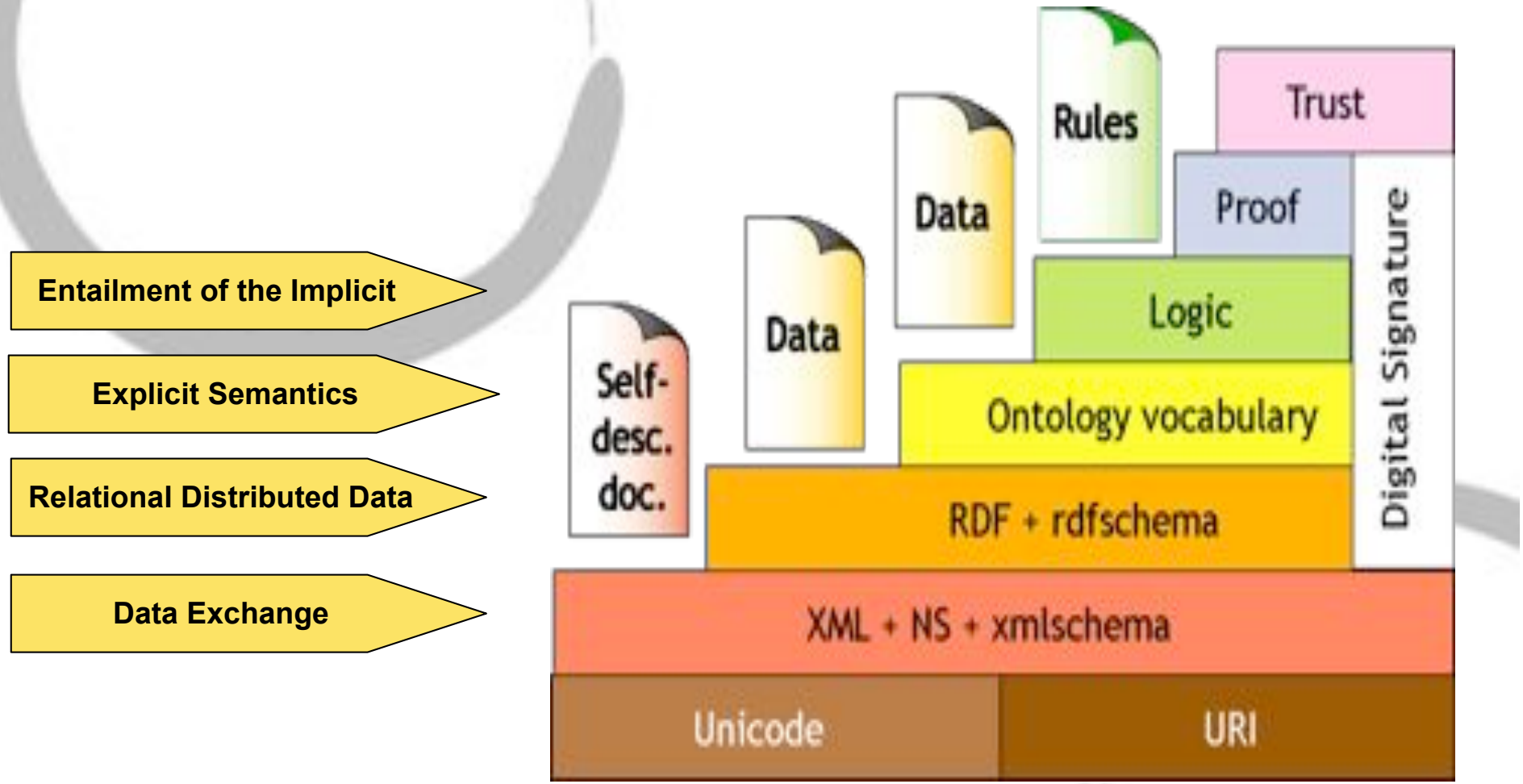


What is an ontology?

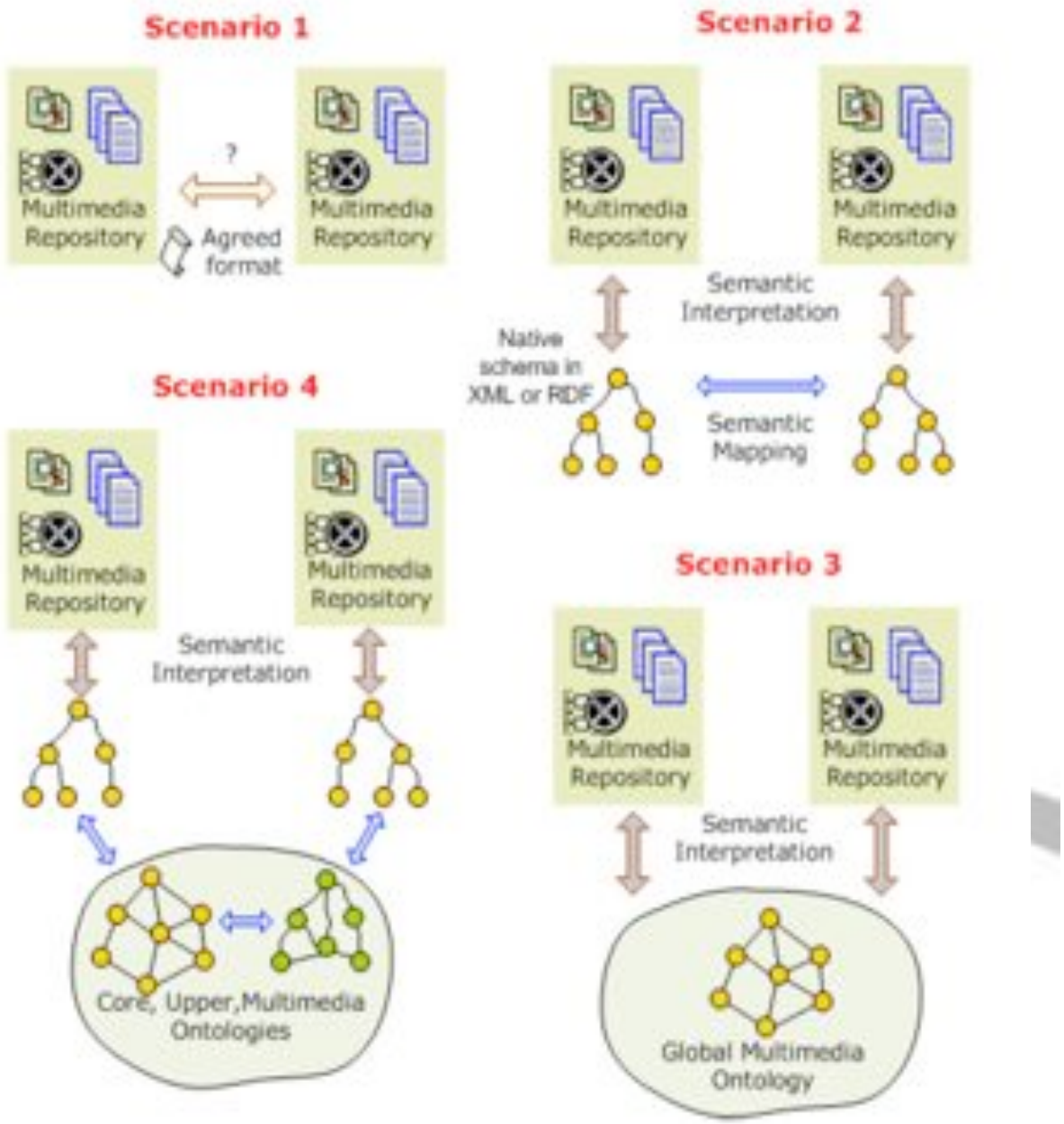


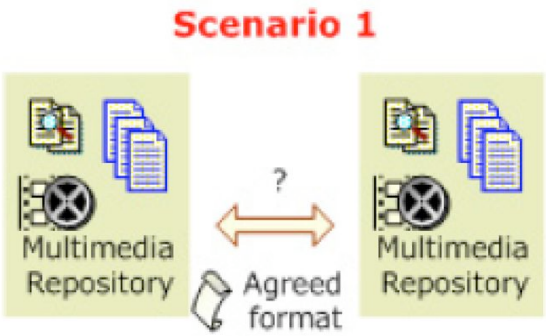
(example from "Semantic Web: ontologies, applications and EU projects", Professor Juergen Angele, http://www.multimine.gr)

Semantic Web Architecture



Multimedia Semantic Interoperability in the SW



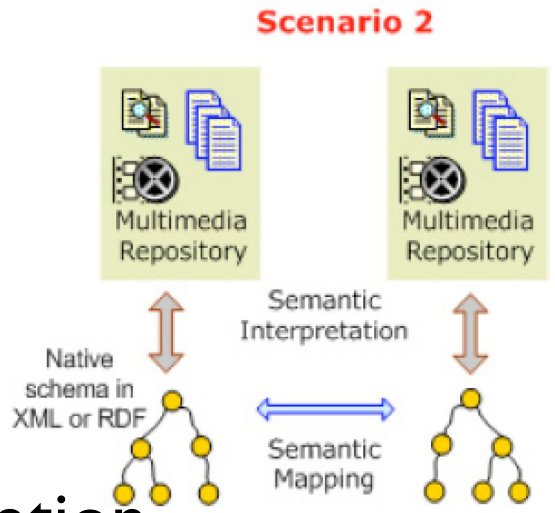


Scenario 1

- Information exchange in predefined format
- XML-based → "meaning" lies in strict conformance to exchanging format
- Achieves interoperability at functional level

However: it's syntactic interoperability, ***not*** *semantic interoperability*

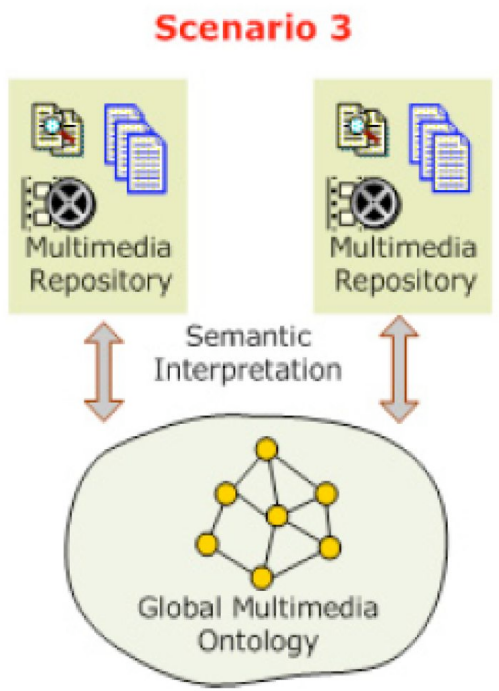
Scenario 2



- Formal representation language
  - machine understandable interpretation
  - Unified Resource Identifiers (URIs)
- Each MM repository adopts its own representation formalism and conceptual schema

⇨ *Automated mapping and reasoning required to achieve information/meaning integration*

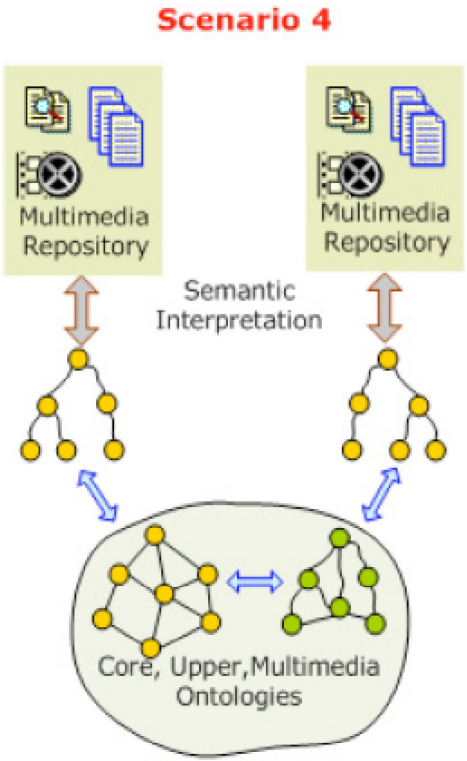
Scenario 3



- "Semantic Version" of scenario 1
- Reference framework: upper multimedia ontologies
  - common understanding for semantic meaning
- All multimedia repositories use the common, upper multimedia ontologies

Requires mutual agreement

Scenario 4

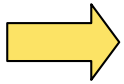


- An attempt to fulfill the SW vision
- Each multimedia repository uses its own ontologies
- Mappings are defined (manually/ automatically) to shared, upper multimedia ontologies

⇨ *inability of semantic technologies to support a satisfactory level of automation, especially for highly expressive semantics*

Semantic Multimedia Descriptions

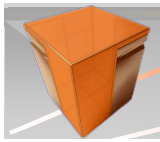
- SW technologies: subject descriptive
- MPEG-7: media descriptive
  - structure (decomposition, localisation)
  - signal descriptors (colour, motion)



Attach formal semantics to MPEG-7 through its ontological representation, overcoming its interoperability issues

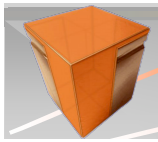
State-of-the-Art in MPEG-7 ontologies

- Different approaches
  - normative semantics allow for individual interpretations of descriptions
- Lack of interoperability at conceptual level
- MPEG-7 ambiguities propagate

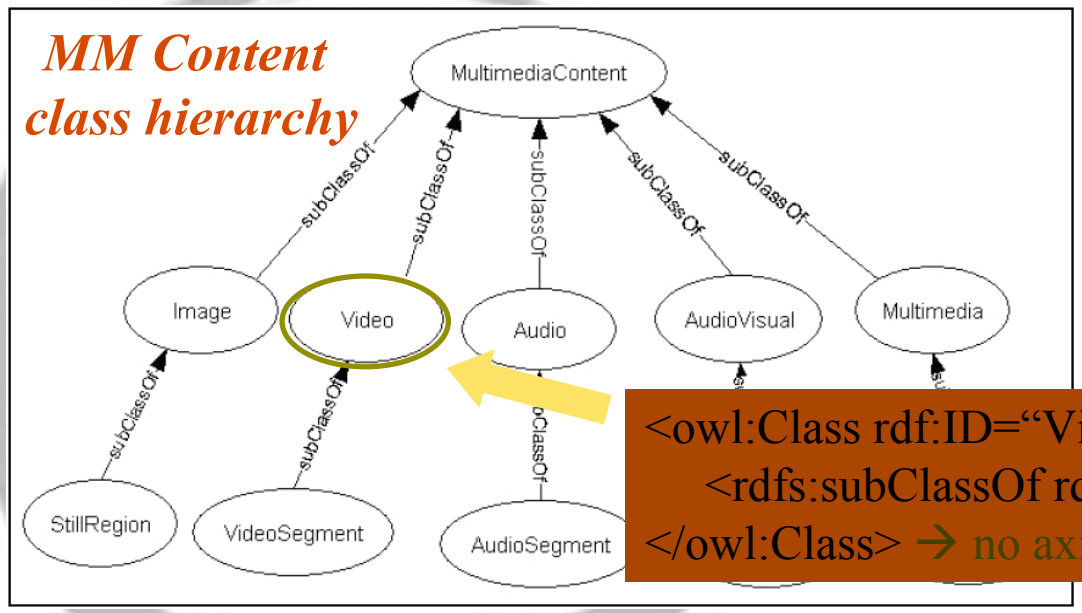


Hunter's (FUSION) approach

- Chronologically the first approach
- Addresses Multimedia DSs plus the Audio and Visual Parts
- Expressed in RDFS (plus OIL constructs), eventually ported to OWL
- Direct translation from the specifications
  - maintains MPEG-7 intended flexibility
  - can be handy for handling part-whole semantics
- Conceptual differences are not addressed

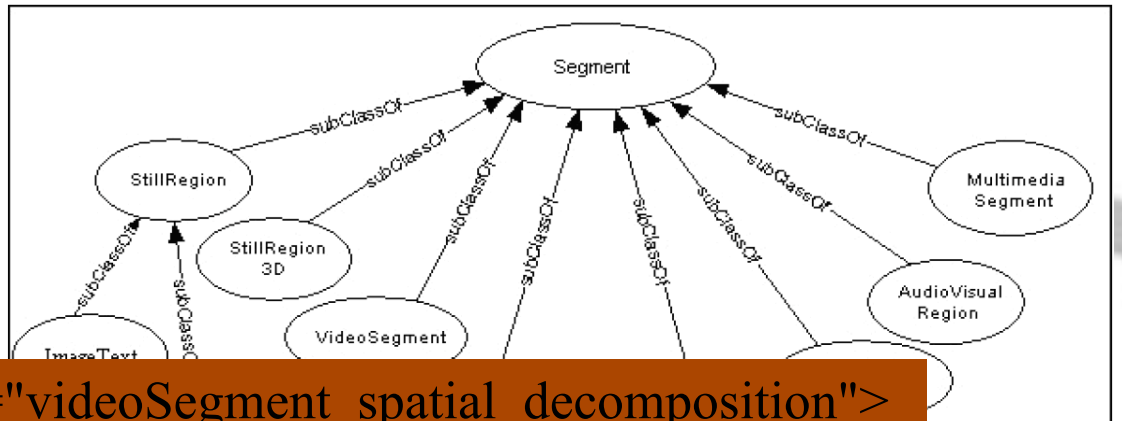


MM Content class hierarchy




```
<owl:Class rdf:ID="Video">
    <rdfs:subClassOf rdf:resource="#MultimediaContent"/>
</owl:Class>
```
→ no axiomatised definition

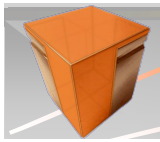
Decomposition relations defined per multimedia content/segment pair




```
<owl:ObjectProperty rdf:ID="videoSegment_spatial_decomposition">
        <rdfs:subPropertyOf rdf:resource="#spatial_decomposition"/>
        <rdfs:domain rdf:resource="#VideoSegment"/>
        <rdfs:range rdf:resource="#MovingRegion"/>
</owl:ObjectProperty>
```

The aceMedia approach

- Extends the Hunter approach
- RDFS ontology
  - expressivity restricted to subclass and domain/range
- Introduction of additional concepts not included in MPEG-7 to account for notions semantically distinct in humans (e.g. video frame)
- Two ontologies
  - MSO (MPEG-7 Multimedia Description Scheme)
  - VDO (MPEG-7 Visual Part)



Multimedia Content class hierarchy

Segment class hierarchy

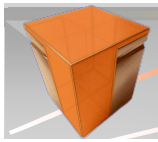
Additional Concepts

Additional Properties

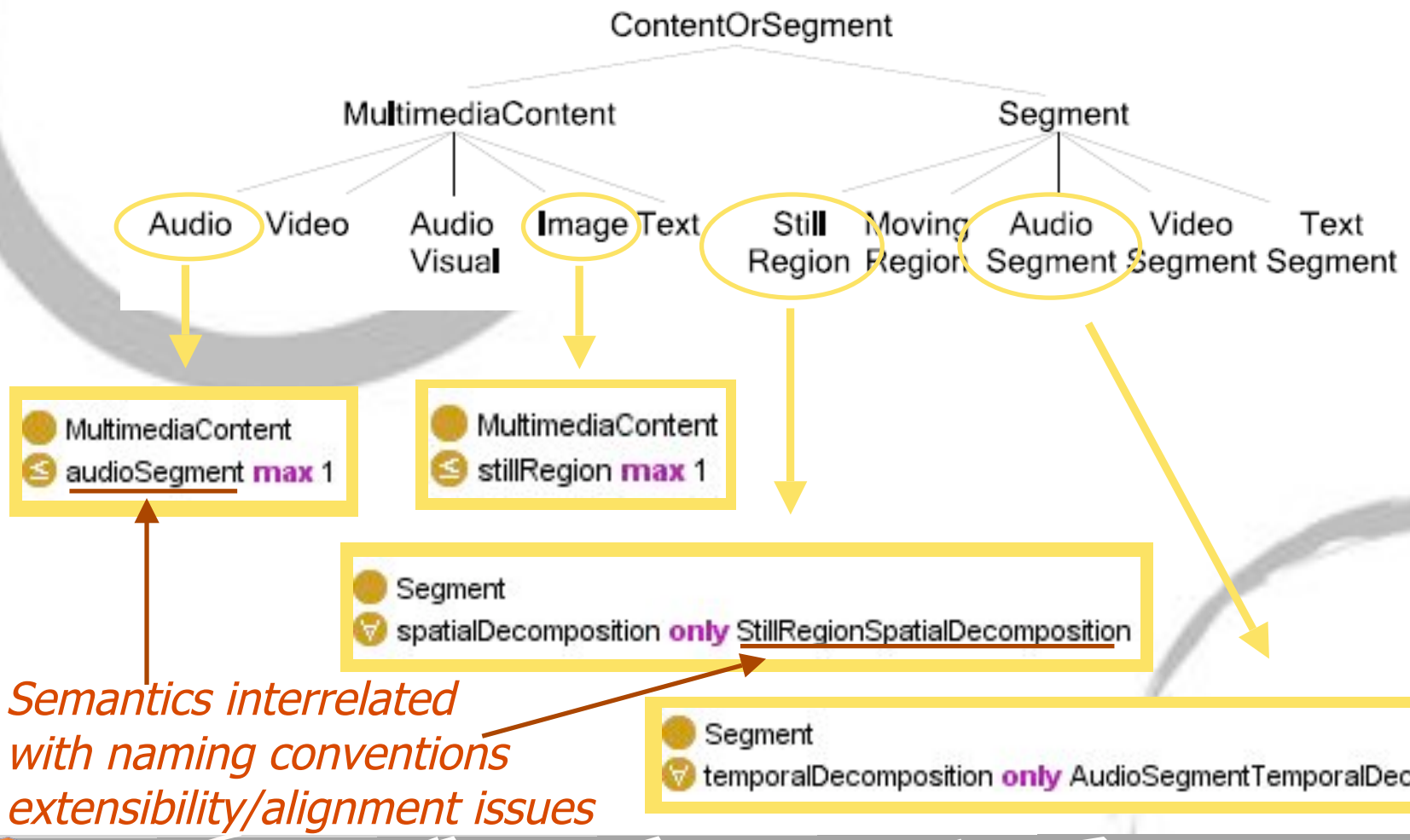
- hasStartFrame
- hasEndFrame
- hasFrameIndex

The SmartWeb approach

- OWL DL ontology covering the Content Description and Content Management DSs
- MultimediaContent and Segment classes are defined as disjoint
- Definition of properties for the representation of decomposition description tools
- Semantics “hidden” in the employed linguistic terms to a large extend

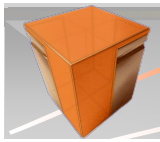


Multimedia Content & Segment class hierarchies



The BOEMIE approach

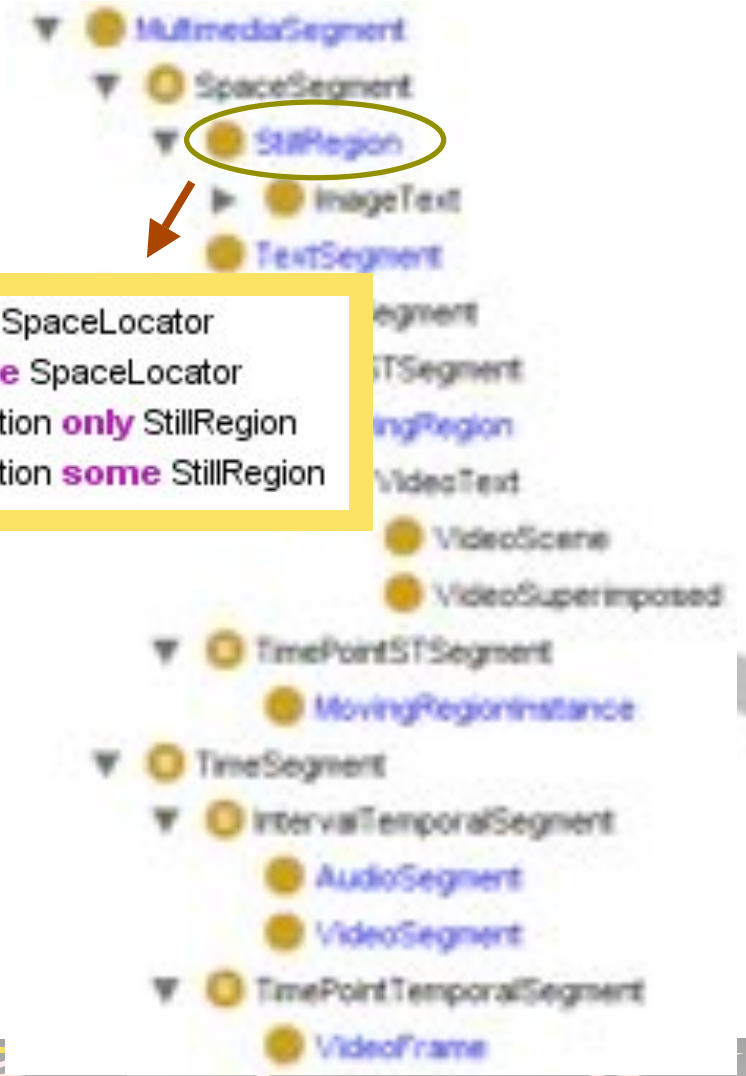
- Goal: cleaner, explicit conceptualisation
- OWL DL
- Identification of different types of MM content
  - discrimination between single & composite
- Identification of respective segment types
  - grouped based on the applicable decomposition dimension (spatial, temporal, spatiotemporal)
- MM content types are defined using the decomposition relations in conjunction with the applicable segment types
- Two ontologies (MCO & MDO)



Multimedia Content & Segment Locator class hierarchy

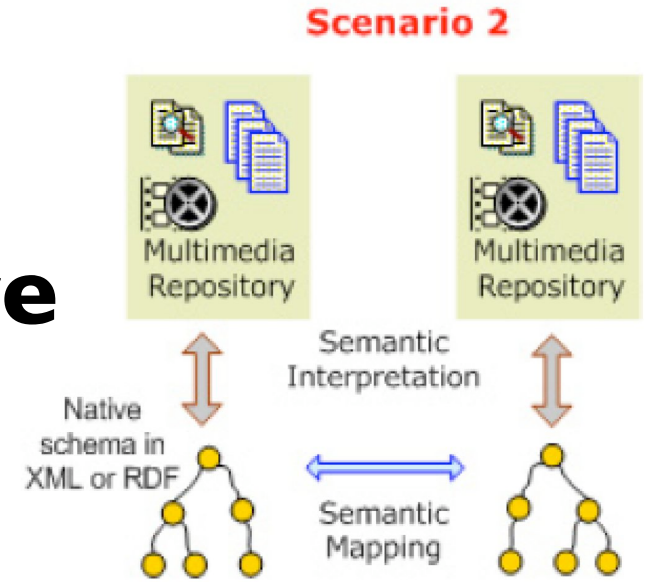
hasMediaDecomposition **only** StillRegion
hasMediaDecomposition **some** StillRegion

Inferred Multimedia Segment class hierarchy



hasSegmentLocator **only** SpaceLocator
hasSegmentLocator **some** SpaceLocator
segmentSpaceDecomposition **only** StillRegion
segmentSpaceDecomposition **some** StillRegion

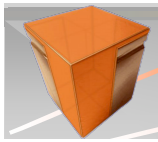
Ontology Infrastructure



- Integration of multimedia and domain specific ontologies using upper level ontologies
  - DOLCE (aceMedia, SmartWeb)
  - SUMO (SmartWeb)
  - ABC (Fusion)
- Examples of Scenario 2
  - upper ontologies serve as reference for the domain specific ontologies
  - provide means for linking to multimedia ones, ***not upper multimedia reference framework***

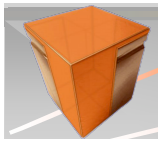
Garcia's and Celma's approach

- Automatic translation of entire MPEG-7 based on a generic XML Schema to OWL mapping
- The MM DS, the Audio and Visual Parts have been evaluated against the manually created Hunter's ontology
- OWL Full ontology
  - limits practical applicability (tool support, sound automated inference)

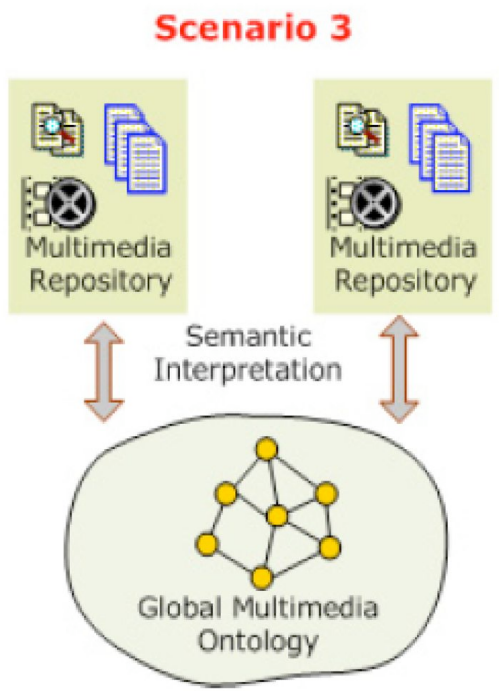


The DS-MIRF approach

- Methodology for the complete MPEG-7 translation into OWL DL
- Focus on the Semantic DS
- Intended to serve *as a core multimedia ontology*
  - domain specific ontologies attachment through subclass/subproperty relations



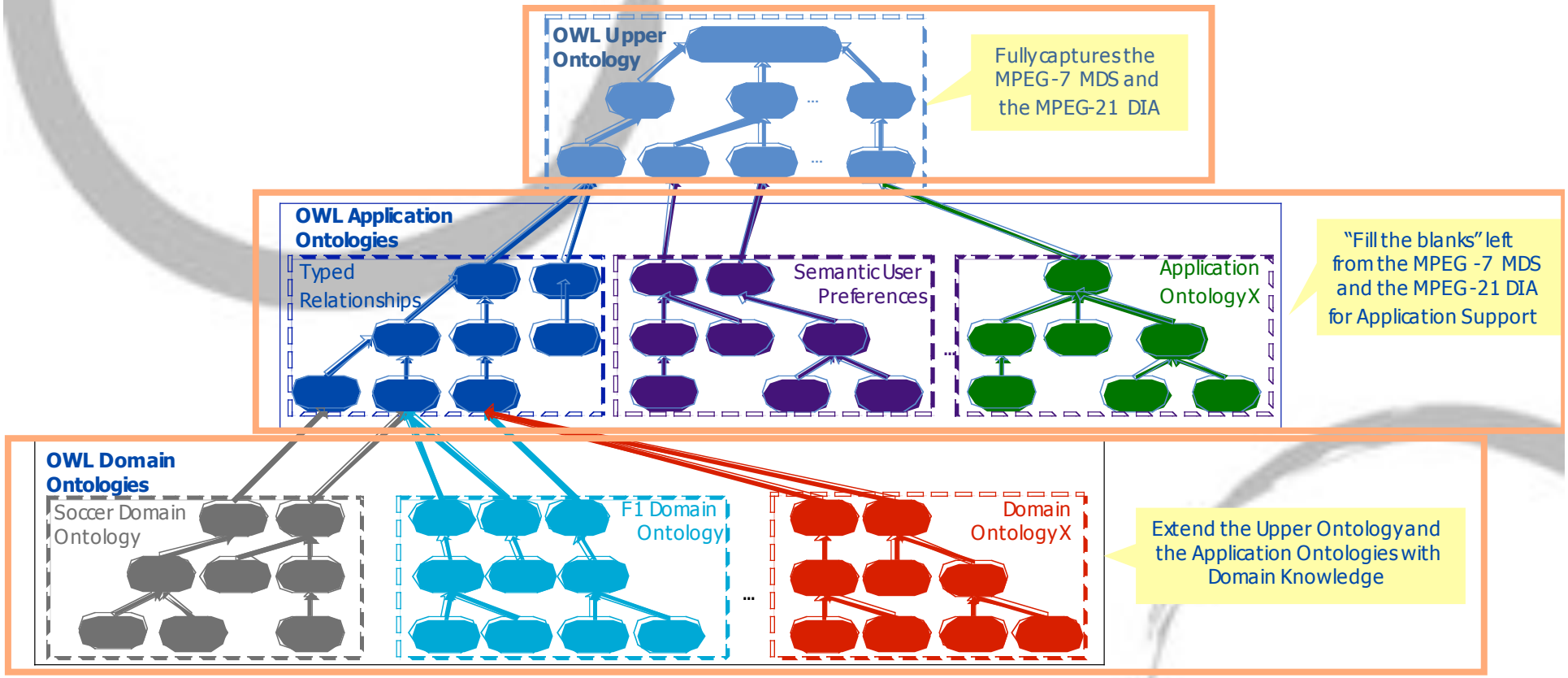
Ontology Infrastructure



- Approaches within Scenario 3 using MPEG-7 as the reference multimedia ontology
- MPEG-7 as upper ontology for both multimedia and domain specific ontologies
  - verbose to adapt (media oriented)
  - MPEG-7 conceptual ambiguities aren't resolved making infeasible the definition of mappings from individual mm ontologies

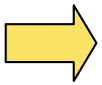
The DS-MIRF Ontological Infrastructure

(example from http://www.w3.org/2005/Incubator/mmsem/meetings/f2f-athens/2006-12-08-Tsinaraki-MMOntology.ppt)

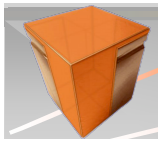


The Core Ontology for Multimedia (COMM) initiative

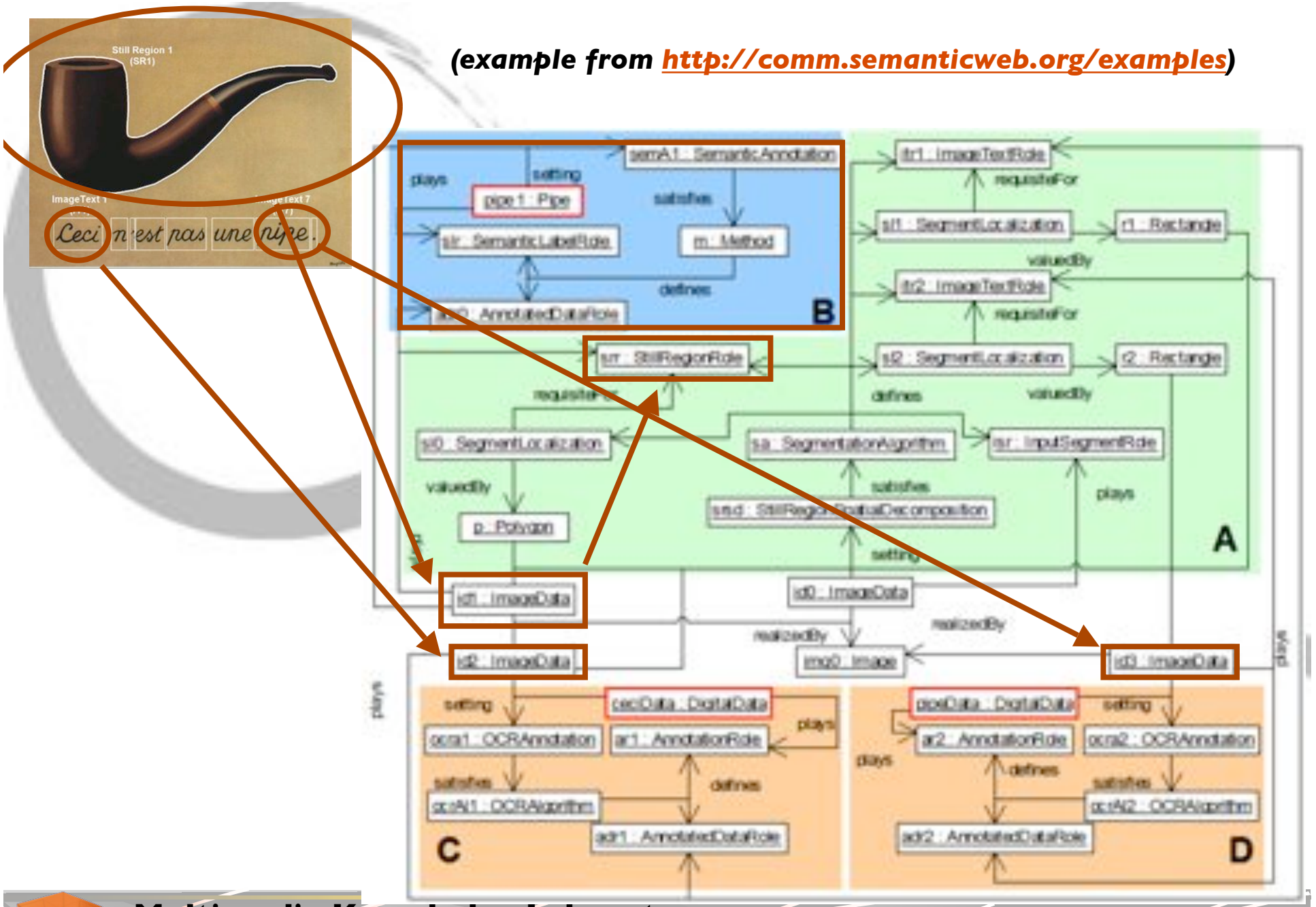
- Extends the Descriptions & Situations (D&S) and Ontology of Information Objects (OIO) design patterns
- Models at semiotic level the aspects involved
  - aims to conceptualise the conceptualisation process itself



The axiomatisation does not cover the media related representations (i.e. the design patterns don't propagate to the MPEG-7 concept/properties subtrees)

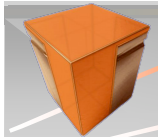


(example from http://comm.semanticweb.org/examples)



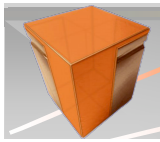
The Core Ontology for Multimedia (COMM) initiative (cont'd)

- Does not resolve interoperability issues
  - two multimedia repositories using the COMM in combination with the FUSION and SmartWeb approaches respectively cannot exchange meaning
- Systematic exploration towards a conceptual schema for structuring semantically different multimedia related aspects



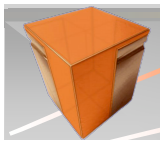
Towards Interoperable Semantic Multimedia Descriptions

- MPEG-7 (multimedia) ontologies
  - explicit semantics
  - Semantic Web compliant
- Possible solution: manual definition of mappings
  - relatively straightforward with upper ontologies
  - hardly possible when considering conceptual differences in the individual multimedia ontologies



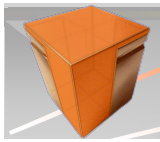
Common Multimedia Ontology Framework

- Multimedia ontologies harmonisation
- Collaborative specification of aspects involved in multimedia description
- Definition of "minimum set" for a multimedia ontology to be used as a basis for all multimedia related applications to build on and extend



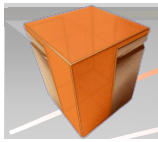
W3c Multimedia Semantics Incubator Group (XG)

- Mission: *show how metadata interoperability can be achieved by using the Semantic Web technologies to integrate existing multimedia metadata standards*
- Selection of use cases demonstrating common interoperability problems
- Possible solutions roadmap



Conclusion

- MPEG-7 is the greatest effort towards standardised multimedia descriptions
- The Semantic Web provides the means to represent, exchange and process semantics of information
- Explicit, unambiguous MPEG-7 semantics (rich axiomatisation)
  - definition of semantics mappings
  - automated inference services
- Upper multimedia ontologies (conceptual clarity)
  - reference framework for multimedia related aspects
  - Modularity & extensibility



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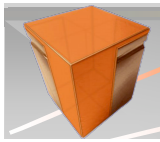
7. http://comm.semanticweb.org/



Thank you!

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