

Semantic Web

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Talk overview

■ Three generations of the Web

- Problems with the current 2nd generation
- The Semantic Web: a vision of the 3rd generation

■ Semantic Web technology

- XML, RDF
- DAML+OIL tutorial

■ 2nd generation multimedia

- Cuypers

■ Towards 3rd generation multimedia

The Web in three generations

- 1 Hand-coded (HTML) Web content
 - easy access through uniform interface
 - huge authoring and maintenance effort
 - hard to deal with dynamically changing content
- 2 Automated on-the fly content generation
 - based on templates filled with database content
 - later extended with XML document transformations
- 3 Automated processing of content
 - The Semantic Web (SW)

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SW application areas

- Search engines
- Browsing on-line stores (B2C)
- Service description and integration (B2B)
- Tailored multimedia information

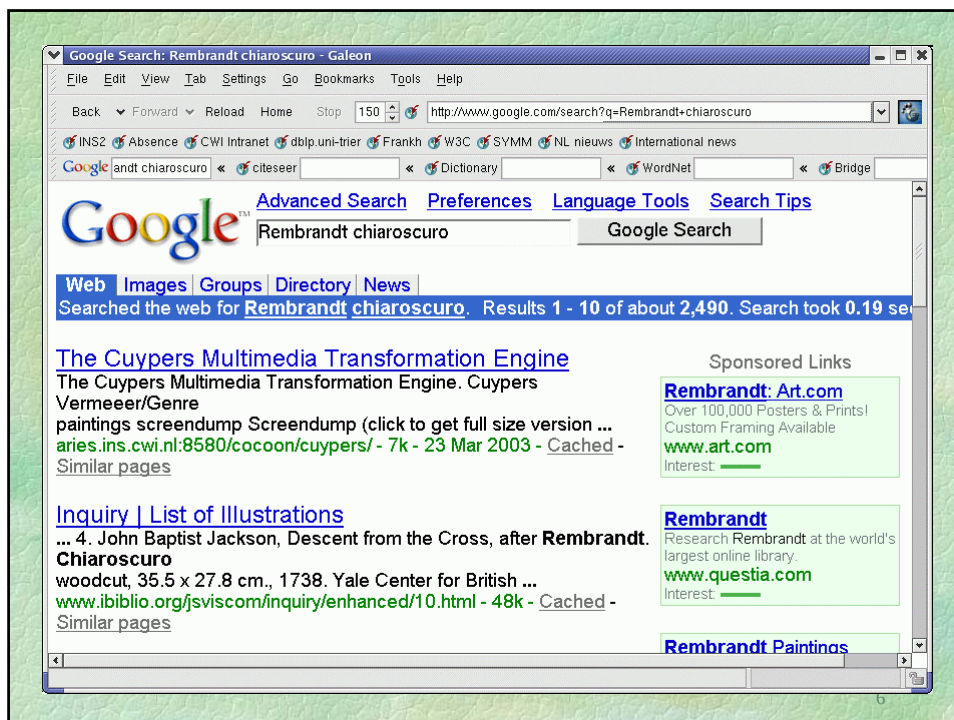
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Problems with current search engines

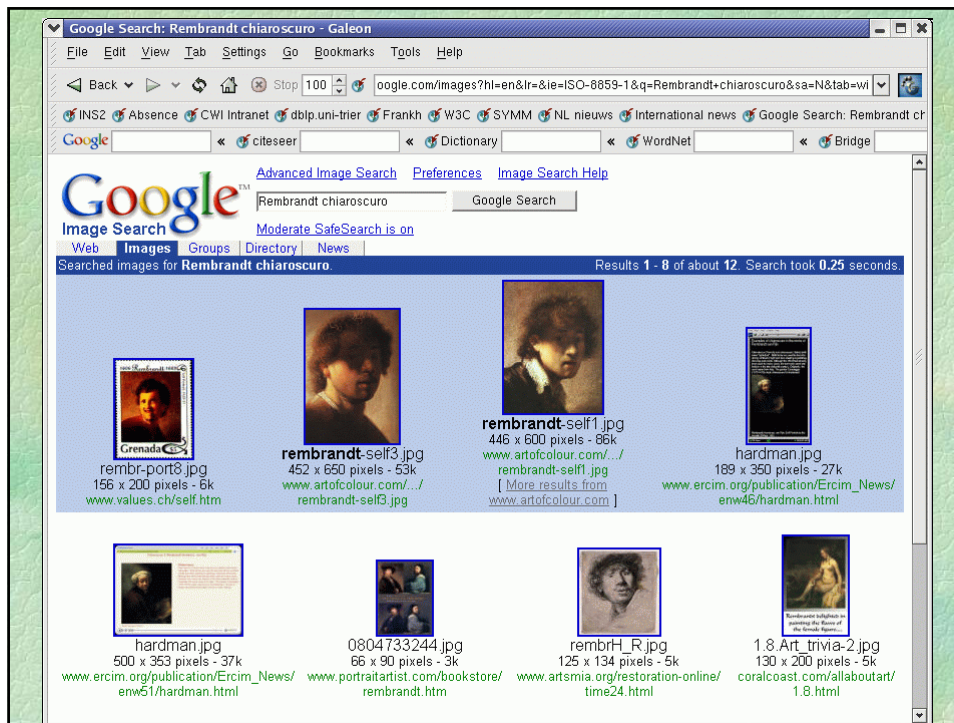
■ Current search engines = keywords:

- high recall, low precision
- sensitive to vocabulary
- insensitive to implicit content

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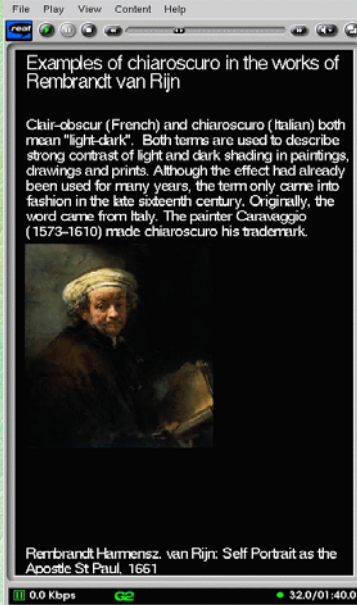
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Search engines on the Semantic Web

- concept search instead of keyword search
- semantic narrowing/widening of queries
- query-answering over >1 document
- document transformation operators

Tailored presentation



Student is taking an art class on Rembrandt and wants to know about the "*chiaroscuro*" technique

System responds with a textual and audio explanation of the technique and a number of example images of its application in Rembrandt's paintings

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Accessing information on the 2nd generation Web

- Students have access to material on the Web
 - Search problem
- Material is designed for "typical" student
 - No student is typical
- Some adaptivity is possible
 - Links revealed once material has been covered
- Student's knowledge level is implicit

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Accessing information on the Semantic Web

- Students would be able to find suitable courses
- Material can be tailored for the individual
- Material can be re-used
- Models can be made of
 - The domain
 - Learner profile
 - Learning strategies
- Student's knowledge level can be made explicit
 - in terms of the domain model
 - in terms of the learning strategy

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 - XML, RDF
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- 2nd generation multimedia
 - Cuyppers
- Towards 3rd generation multimedia

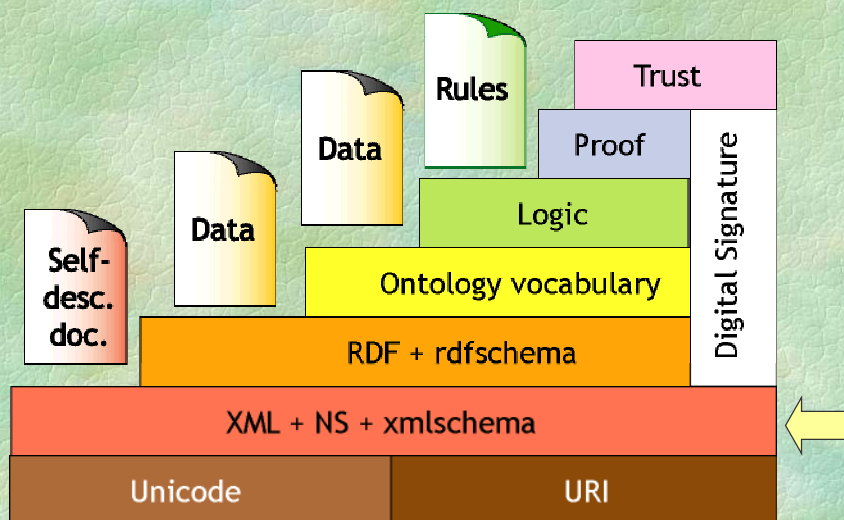
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So what is the Semantic Web?

- The “Semantic Web Wedding Cake”
- Crash course
 - XML
 - RDF
 - RDF Schema

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TBL talk at XML 2000



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Machine accessible meaning

(What it's like to be a machine)

林克昌 根留台灣 可能增高

name

education

work

private

CV

在國際音樂界走紅之下，華裔名指揮家林克昌根留台灣的可行性又提升了幾分。兩院院士李俊，國家音樂學院副院長黃炎明日前親赴林克昌，在聖荷西所拜會，並提出多場客席邀約。此外，台灣省立交響樂團團長陳澄雄也早先「下訂」，邀請林克昌赴台中指揮，從八月十日抵台開省交，為期長達一個月。

在台灣諸多公家機關中，陳澄雄是以實際行動表達對林克昌肯定的樂界人士之一，曾多次公開表示對林克昌指揮才華的欽佩，而且幾乎每個樂季都邀請林克昌客席演出。

此外，林克昌上個月赴俄羅斯聖彼得堡的「俄羅斯國家管弦樂團」灌錄了柴可夫斯基晚間三大交響曲以及「羅密歐與朱麗葉」、「斯拉夫進行曲」、「越天籟舞曲」，最佳的D A T母帶也在前兩天運回台灣，製作人楊忠衡與林克昌談話之後，都對錄音效果一尤其音質表現感到相當滿意，楊忠衡估計呈現了七分林克昌指揮神韻。

俄羅斯國家管弦樂團首席布魯尼日前也讚揚林克昌的指揮藝術有三大特點：一是控制自如的彈性速度；二是超強的動態對比；三是宛如呼吸歌喉的旋律處理。這些對錄音師而言都是極大挑戰，俄國錄音師雖然採用多軌錄音，但定位、場面都有可觀之處。

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XML: User definable and domain specific markup

HTML:

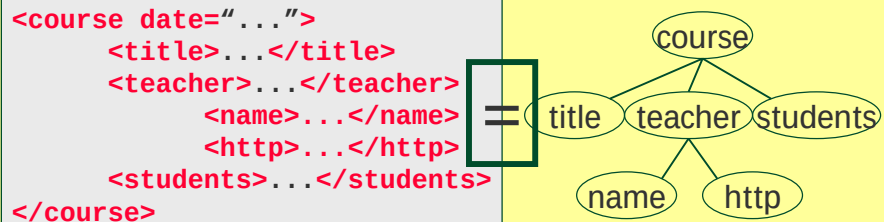
```
<H1>Introduction to AI</H1>
  <UL>
    <LI>Teacher: Frank van Harmelen
    <LI>Students: 1AI, 1I
    <LI>Requirements: none
  </UL>
```

XML:

```
<course>
  <title>Introduction to AI</title>
  <teacher>Frank van Harmelen</teacher>
  <students>1AI, 1I</students>
  <req>none</req>
</course>
```


XML: document = labelled tree

- node = label + attr/values + contents



- XML Schema: grammars for describing legal trees and datatypes
- So:
why not use XML to represent semantics?

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XML: limitations for semantic markup

- XML makes no commitment on:
 - ① Domain-specific ontological vocabulary
 - ② Ontological modeling primitives
- Requires pre-arranged agreement on ① & ②
- Only feasible for closed collaboration
 - agents in a small & stable community
 - pages on a small & stable intranet
- Not suited for sharing Web-resources



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XML ≠ machine accessible meaning

林克昌 擬留台灣 可能增高 < name >

< εδυσχαιτιον >

< ωορκ >

< πριωατε >

< Xς >

在臺灣熱心奔走之下，華裔名指揮家林克昌擬留台灣的可行性又提升了幾分。兩廳院掌櫃李俊，國家音樂廳樂團團長黃炎明日前親赴林克昌，右聖芳寓所拜會，並提出多場客席邀約。此外，台灣省立交響樂團團長陳漢強也早先「下訂」，邀請林克昌赴台中開峰，從八月十日租期開始，為期長達一個月。

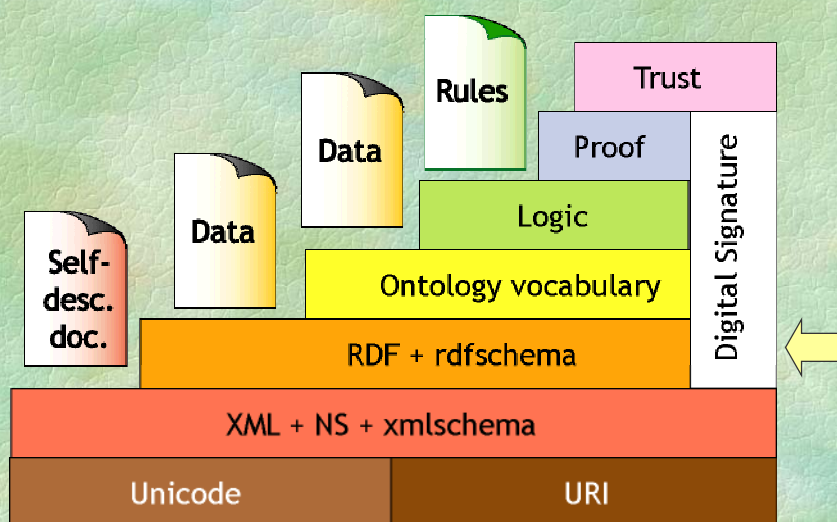
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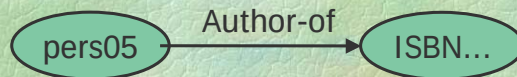
The semantic pyramid again



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RDF: graphs of triples

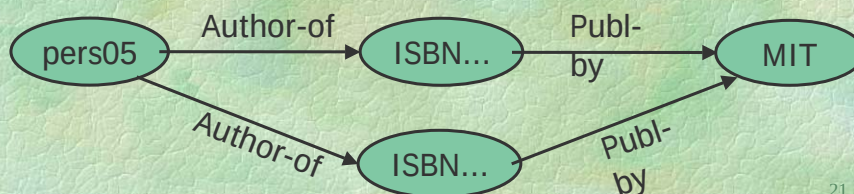
- Object -> Attribute -> Value triples



- Objects are web-resources

- Value is again an Object:

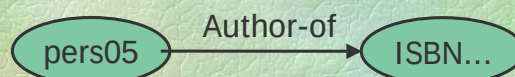
- triples can be linked
- data-model = graph



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RDF is part of the Web

- Every resource has a URI
= world-wide unique naming!



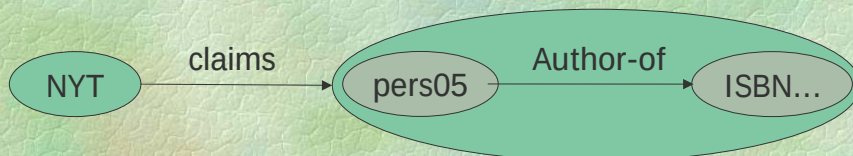
- Has XML syntax(es)

```
<rdf:Description rdf:about="#pers05">  
  <authorOf> ISBN...</authorOf>  
</rdf:Description>
```

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RDF can be nested

- Any statement can be an object
graphs can be nested - **reification**

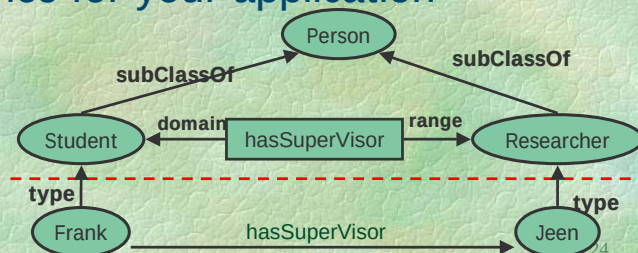


```
<rdf:Description rdf:about="# NYT">
  <claims>
    <rdf:Description rdf:about="# pers05">
      <authorOf> ISBN... </authorOf>
    </rdf:Description>
  </claims>
</rdf:Description>
```

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What does RDF Schema add?

- Defines small **vocabulary** for RDF:
 - Class, subClassOf, type
 - Property, subPropertyOf
 - domain, range
- Vocabulary can be used to define other vocabularies for your application domain



RDF Schema syntax in XML

```
<rdf:Description ID="MotorVehicle">
  <rdf:type resource="http://www.w3.org/...#Class"/>
  <rdfs:subClassOf rdf:resource="http://www.w3.org/...#Resource"/>
</rdf:Description>

<rdf:Description ID="Truck">
  <rdf:type resource="http://www.w3.org/...#Class"/>
  <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
</rdf:Description>

<rdf:Description ID="registeredTo">
  <rdf:type resource="http://www.w3.org/...#Property"/>
  <rdfs:domain rdf:resource="#MotorVehicle"/>
  <rdfs:range rdf:resource="#Person"/>
</rdf:Description>

<rdf:Description ID="ownedBy">
  <rdf:type resource="http://www.w3.org/...#Property"/>
  <rdfs:subPropertyOf rdf:resource="#registeredTo"/>
</rdf:Description>
```

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FOAF and WWW photos

- Friend of a Friend
- Alternative display of FOAF - pLink
- WWW photos
- Alternative display of WWW photos
- Experimental display

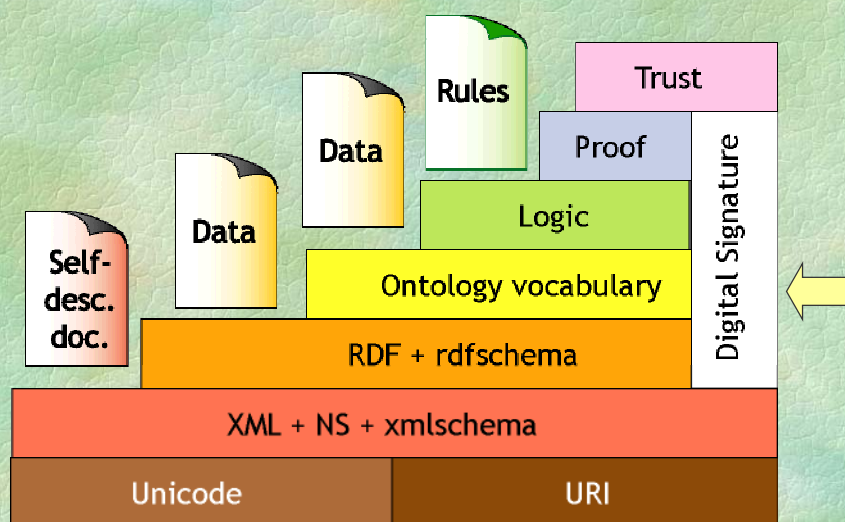
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Conclusions about RDF(S)

- Next step up from plain XML ?
 - (small) ontological commitment to modeling primitives
 - possible to define vocabulary
- However:
 - no precisely described meaning
 - no inference model

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The semantic pyramid again



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Beyond RDF: OIL & DAML

- **OIL** extends RDF Schema to a fully-fledged knowledge representation language.
 - logical expressions
 - data-typing
 - cardinality
 - quantifiers
 - <http://www.ontoknowledge.org>
- **DAML** = US sister of OIL
- Merged as **DAML+OIL** in 2001
- Becomes **OWL** W3C standard in March '03

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WebOnt and OntoWeb

- W3C **WebOnt** working group Nov 2001–Mar 2003
Work continuing where DAML+OIL left off
<http://www.w3.org/2001/sw/WebOnt/charter>
- WebOnt is part of W3C Semantic Web activity
which also includes RDF
- **OntoWeb**
EU funded thematic network
> 80 partners, including CWI, UvA and VU
<http://www.ontoweb.org>

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Semantic Web: main players

Academic in Europe:

- VU, Amsterdam
- Karlsruhe
- Manchester
- INRIA
- SWI@UvA

Academic in US:

- Stanford
- Maryland
- MIT/W3C
- Florida
- CMU

Industrial:

- Lucent
- Philips
- Nokia
- HP
- Intel
- Daimler-Chrysler
- Fujitsu
- lots of start-ups (NL, UK, G, N, US)

DAML+OIL (by example)

```

class-def animal
class-def plant
  subclass-of NOT animal
class-def tree
  subclass-of plant
class-def branch
  slot-constraint is-part-of
    has-value tree
    max-cardinality 1
class-def defined carnivore
  subclass-of animal
  slot-constraint eats
    value-type animal
class-def defined herbivore
  subclass-of animal, NOT carnivore
  slot-constraint eats
    value-type plant OR (slot-constraint is-part-of has-value plant)
  
```

% animals are a class
 % plants are a class
 % that is disjoint from animals
 % trees are a type of plants
 % branches are parts of some tree
 % carnivores are animals
 % that eat any other animals
 % herbivores are animals
 % that are not carnivores, and
 % they eat plants or parts of plants

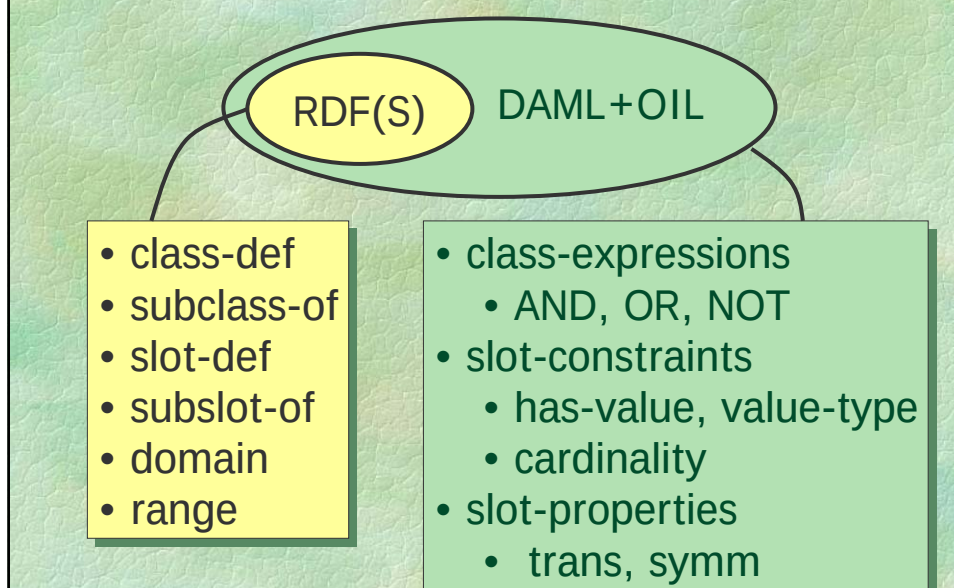
DAML+OIL as RDF(S) extension

```
<rdf:Class rdf:ID="herbivore">
  <rdf:type
    rdf:resource="http://www.ontoknowledge.org/#DefinedClass"/>
  <rdf:subClassOf rdf:resource="#animal"/>
  <rdf:subClassOf>

  </rdf:subClassOf>
</rdf:Class>
```

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DAML+OIL as RDFS extension



DAML+OIL: Classes

```
<daml:Class rdf:ID="Male">
  <rdfs:subClassOf rdf:resource="#Animal"/>
</daml:Class>

<daml:Class rdf:ID="Female">
  <rdfs:subClassOf rdf:resource="#Animal"/>
  <daml:disjointWith rdf:resource="#Male"/>
</daml:Class>

<daml:Class rdf:ID="Man">
  ^! <rdfs:subClassOf rdf:resource="#Person"/>
  <rdfs:subClassOf rdf:resource="#Male"/>
</daml:Class>
```

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Class-Building Operations

- Relation to other Classes
 - `rdfs:subClassOf`
 - `daml:disjointWith`
 - `daml:disjointUnionOf`
 - `daml:sameClassAs`
 - `daml:equivalentTo`
- Contained Elements:
 - `daml:oneOf`
- Boolean combinations:
 - `daml:intersectionOf`
 - `daml:unionOf`
 - `daml:complementOf`

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DAML+OIL: Properties

```
<daml:ObjectProperty rdf:ID="hasParent">
  <rdfs:domain rdf:resource="#Animal"/>
  <rdfs:range rdf:resource="#Animal"/>
</daml:ObjectProperty>

<daml:ObjectProperty rdf:ID="hasChild">
  <daml:inverseOf
    rdf:resource="#hasParent"/>
</daml:ObjectProperty>

<daml:UniqueProperty rdf:ID="hasMother">
  <rdfs:subPropertyOf
    rdf:resource="#hasParent"/>
  <rdfs:range rdf:resource="#Female"/>
</daml:UniqueProperty>
```

Property-Building Operations

- Basic Types
 - daml:ObjectProperty
 - daml:DataTypeProperty
- Special Types
 - daml:TransitiveProperty
 - daml:UniqueProperty
 - daml:UnambiguousProperty
- Further Restrictions
 - rdfs:subPropertyOf
 - rdfs:domain
 - rdfs:range
 - daml:samePropertyAs
 - daml:inverseOf

DAML+OIL: Property Restrictions

```
<daml:Class rdf:ID="Person">
  <rdfs:subClassOf rdf:resource="#Animal"/>
  <rdfs:subClassOf>
    <daml:Restriction>
      <daml:onProperty
        rdf:resource="#hasFather"/>
      <daml:toClass rdf:resource="#Man"/>
    </daml:Restriction>
    <daml:Restriction daml:cardinality="1">
      <daml:onProperty
        rdf:resource="#hasFather"/>
    </daml:Restriction>
  </rdfs:subClassOf>
</daml:Class>
```

DAML+OIL: Property Restrictions

```
<daml:Class rdf:ID="Person">
  <rdfs:subClassOf rdf:resource="#Animal"/>
  <rdfs:subClassOf>
    <daml:Restriction daml:cardinalityQ="1">
      <daml:onProperty
        rdf:resource="#hasFather"/>
      <daml:hasClassQ rdf:resource="#Man"/>
    </daml:Restriction>
  </rdfs:subClassOf>
</daml:Class>
```


Restrictions

■ General

- `daml:Restriction`
- `daml:onProperty`

■ Number Restrictions

- `daml:cardinality`
- `daml:maxCardinality`
- `daml:minCardinality`

■ Value and Type Restrictions

- `daml:toClass`
- `daml:hasValue`
- `daml:hasClass`

■ Combinations

- `daml:cardinalityQ`
- `daml:maxCardinalityQ`
- `daml:minCardinalityQ`

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DAML+OIL: Individuals

```
<rdf:Description rdf:ID="Asia">
  <rdf:type>
    <rdfs:Class rdf:about="#continent"/>
  </rdf:type>
  <daml:differnetIndividualFrom
    rdf:resource="#Europe"/>
</rdf:Description>

<continent rdf:ID="Asia"/>

<rdf:Description rdf:ID="India">
  <is_part_of rdf:resource="#Asia"/>
  <daml:sameIndividual
    rdf:resource="#IndianSubcontinent"/>
  <inhabitants>
    <xsd:integer rdf:value="700.000.000"/>
  </inhabitants>
</rdf:Description>
```

DAML+OIL: Defined Datatypes

```
<xsd:simpleType name="over17">
  <xsd:restriction
    base="xsd:positiveInteger">
    <xsd:minInclusive value="18"/>
  </xsd:restriction>
</xsd:simpleType>

<daml:Class rdf:ID="Adult">
  <daml:intersectionOf
    rdf:parseType="daml:collection">
    <daml:Class rdf:about="#Person"/>
    <daml:Restriction>
      <daml:onProperty
        rdf:resource="#age"/>
      <daml:hasClass
        rdf:resource="#over17"/>
    </daml:Restriction>
  </daml:intersectionOf>
</daml:Class>
```

DAML+OIL: more info.

- DAML+OIL home page
<http://www.daml.org/>
- Language tutorial
<http://www.daml.org/2001/03/daml+oil-walkthru.html>
- OWL
<http://www.w3.org/2001/sw/WebOnt/>
<http://www.w3.org/TR/owl-ref/>

SW isn't just KR in XML/RDF

- the Web is large
- it's even larger
- no referential integrity
- many authors, distributed authority, trust
- high variability in quality of knowledge
- diverse vocabularies
- decentralized
- high change rate, time-dependent content
- local containment of inconsistencies
- justifications as first order citizens

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- **2nd generation multimedia**
 - **Cuypers**
- Towards 3rd generation multimedia

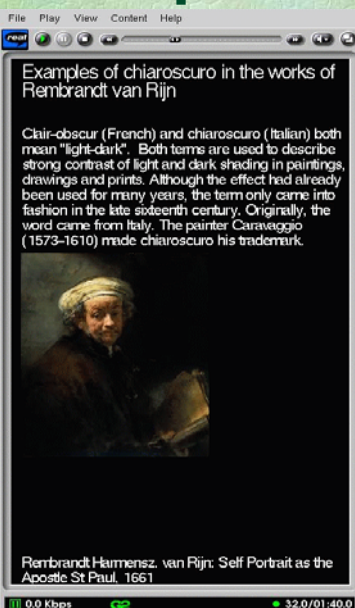
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Multimedia on the Web

- Real multimedia Web content is still rare
 - Mostly bells & whistles to enhance HTML text ...
 - ... or mono-media AV-streams
- Virtually all presentations are hand-authored
 - proprietary formats that are hard to generate
 - limited support for dynamic content and multichanneling
 - most Web technology is text/page-oriented ...
 - ... with SMIL as one of the few exceptions
- Conclusion:
Multimedia has hardly caught up with the 1st generation Web!

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Example scenario



- User is interested in Rembrandt and wants to know about about the “chiaroscuro” technique
- System responds with textual explanation of the technique and a number of example images of its application in Rembrandt’s paintings

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2nd generation multimedia

- Adapt to end-user's platform capabilities
 - PC, PDA, mobile, voice-only, ...
- Adapt to the network resources available
 - bandwidth and other quality of service parameters
- Personalization
 - language, abilities, level of expertise, ..
- Problem: current 2nd generation Web tools
do not work for multimedia

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Multimedia differs from text

- Different document and presentation abstractions
 - hard to separate style from structure
- Formatting is not based on text flow
 - no pages or scrollbars, no line-breaking or hyphenation
 - templates often do not work well either
- Feedback from the formatting back-end required
 - need to check whether proposed layout is feasible
 - layout of media items is less flexible than text layout
- Transformations are hard in a functional language
 - need to try out designs and backtrack when necessary

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Cuypers multimedia generation engine

■ Demo time



■ Acknowledgements:

- Demonstrator developed in the context of the ToKeN2000 project
- Media database used with permission, courtesy Rijksmuseum Amsterdam.

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Cuypers – the bad news

Currently all our design knowledge is:

- implicit and hidden in the generation rules
- lost in the generated Web presentation
- not reusable for other Web applications/sites

We need the Semantic Web

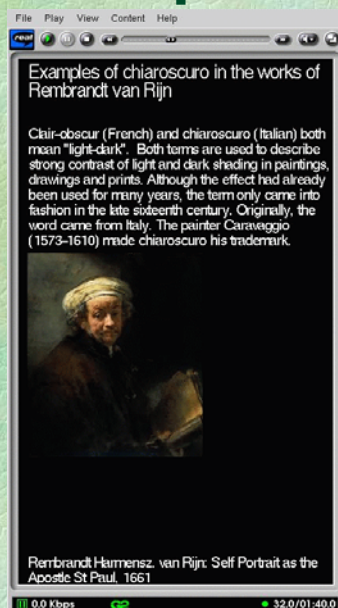
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- **Towards 3rd generation multimedia**

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Example - Annotated SMIL



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Using an existing ontology

See <http://www.cwi.nl/~media/semantics/>

```
<?xml version="1.0"?>
<!-- taken from
http://www.ics.forth.gr/proj/isst/RDF/RQL/rql.html
-->
<rdf:RDF xml:lang="en"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/TR/2000/CR-rdf-schema-20000327#"
  xmlns="">

  <rdfs:Class rdf:ID="Artist"/>
  <rdfs:Class rdf:ID="Artifact"/>
  <rdfs:Class rdf:ID="Museum"/>
  <rdfs:Class rdf:ID="Painter">
    <rdfs:subClassOf rdf:resource="#Artist"/>
  </rdfs:Class>
  <rdfs:Class rdf:ID="Painting">
    <rdfs:subClassOf rdf:resource="#Artifact"/>
  </rdfs:Class>

  ...
</rdf:RDF>
```

Embedding RDF in SMIL - I

```
<smil xmlns="http://www.w3.org/2000/SMIL20/CR">
  <head>
    <meta name="generator" content="CWI/Cuyper 1.0"/>
    <metadata>
      <rdf:RDF xml:lang="en"
        xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
        xmlns:oil="http://www.ontoknowledge.org/oil/"
        xmlns:museum="http://ics.forth.gr/.../museum.rdf">

        <museum:Museum rdf:ID="Rijksmuseum" />

        <museum:Painter rdf:ID="Rembrandt">
          <museum:fname>Rembrandt</museum:fname>
          <museum:lname>Harmenszoon van Rijn</museum:lname>
          <museum:paints rdf:resource="#apostlePaul" />
        </museum:Painter>

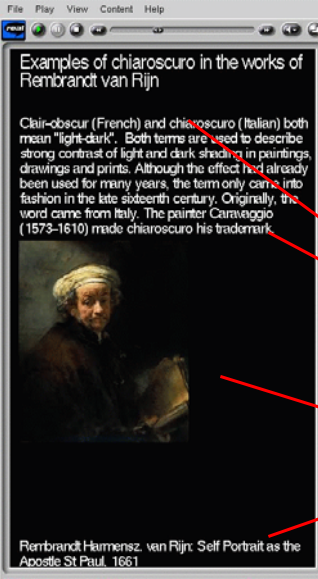
        <museum:Painting rdf:about="#apostlePaul">
          <museum:exhibited rdf:resource="#Rijksmuseum" />
          <museum:technique>chiaroscuro</museum:technique>
        </museum:Painting>
      </rdf:RDF>
    </metadata>
    ...
  </head>
```


Embedding RDF in SMIL - II

```
<museum:Painting rdf:about="#apostlePaul">
  <museum:exhibited rdf:resource="#Rijksmuseum" />
  <museum:technique>chiaroscuro</museum:technique>
  <token:painting-by rdf:resource="#Rembrandt" />
</museum:Painting>
</rdf:RDF>
</metadata>

...
</head>
<body>
  <par>
    <text region="title" src="...query to MM DBMS..." />
    <text region="descr" src="..." />
    <seq>
      <par dur="10"> ... 1st painting+title ... </par>
      <par dur="10"> ... 2nd painting+title ... </par>
      <par dur="10"> ... 3rd painting+title ... </par>
      <par dur="10"> ... 4th painting+title ... </par>
      <par dur="10" id="apostlePaul">
        
        <text region="ptitle" src=".." />
      </par>
    </seq>
  </par>
</body>
</smil>
```

Marked-up presentation



```
<museum:Painting rdf:about="#apostlePaul">
  <museum:exhibited rdf:resource="#Rijksmuseum" />
  <museum:technique>chiaroscuro</museum:technique>
  </museum:Painting>
</rdf:RDF>
</metadata>

...
</head>
<body>
  <par>
    <text region="title" src="..." />
    <text region="descr" src="..." />
    <seq>
      <par dur="10"> ... </par>
      <par dur="10"> ... </par>
      <par dur="10"> ... </par>
      <par dur="10"> ... </par>
      <par dur="10" id="apostlePaul">
        
        <text region="ptitle" src=".." />
      </par>
    </seq>
  </par>
</body>
</smil>
```