Enterprise architecture frameworks with semantic models as a foundation for complex networked operations

TUTORIAL

Semantic Days 2009, May 18th-20th,Stavanger, Norway

18.05.2009

Arne Jørgen Berre, SINTEF, Norway
Ulf Larsson, LFV, Norway
Dima Panfilenko, DFKI IWi, Germany

Agenda

- **(I) Enterprise Architecture, TOGAF, UPDM (Arne, Ulf, Dima)**
  - Zachman, TOGAF, MODAF/DODAF/NAF, MDA, UPDM - Arne
  - Saarstahl SHAPE - Dima
  - European ATM/SESAR - Ulf
- **(II) INFORMATION and ONTOLOGY MODELING (UML/ER, ODM/OWL with examples/tools) Arne (Ulf, Dima)**
  - Conceptual Modeling, Information Modeling, Ontologies - Ulf and Arne
  - ODM with OWL for semantic modeling (WSMT) - Dima
- **(III) PROCESS MODELING (EPC/BPMN with examples/tools) (Dima)**
  - ARIS/EPC (Event-Driven Process Chains) Dima
  - BPMN (Business Process Modeling Notation) Dima
- **(IV) SERVICE MODELING and Interoperability (SoaML with examples) (Arne)**
  - SoaML (Servic oriented architecture Modeling Language) Arne
  - Semantic annotations, SAWSDL, from existing system specifications to an ontology can support semantic interoperability Arne

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Information Modeling and Ontologies

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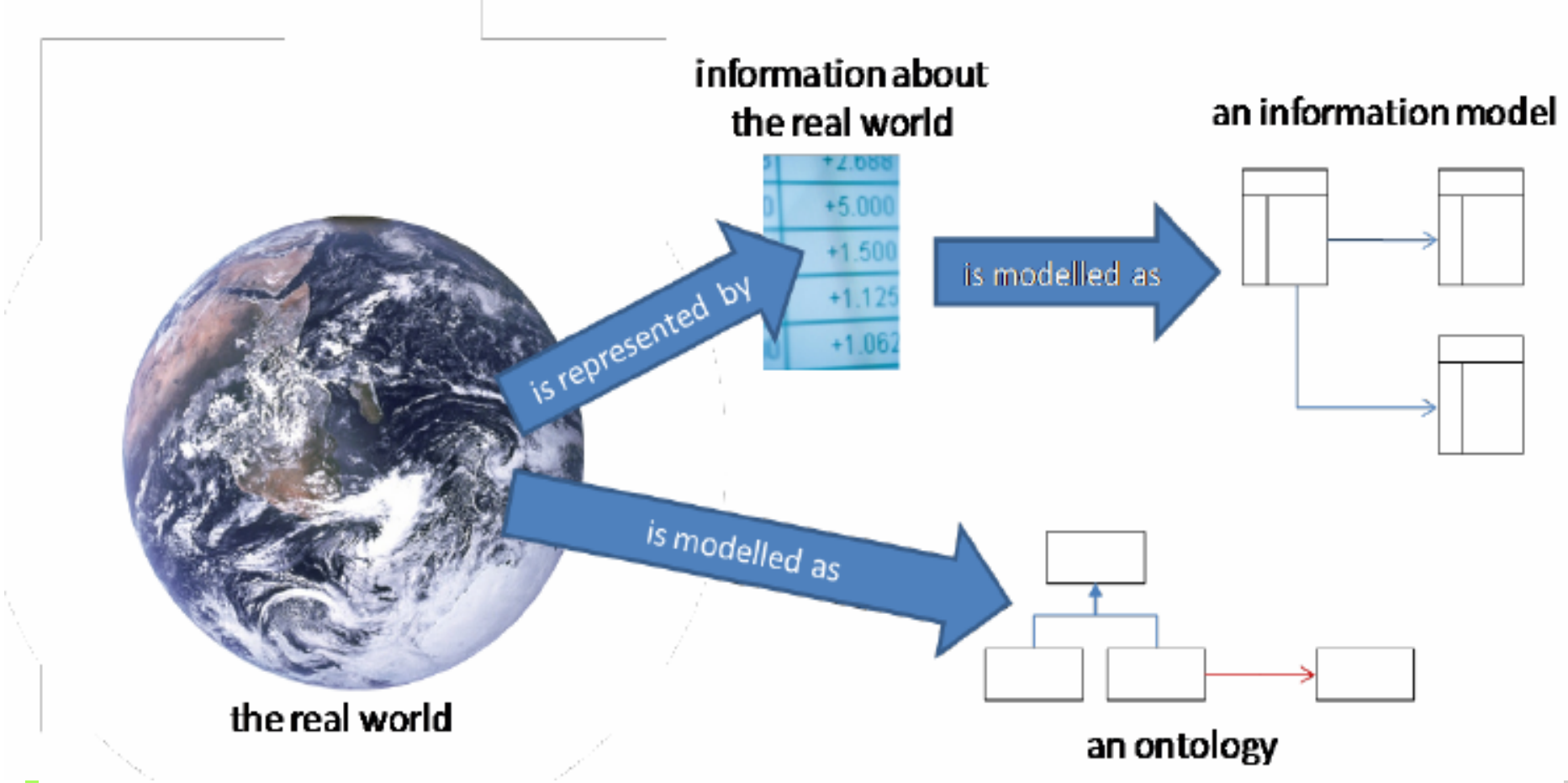
Ontology vs. Information Model



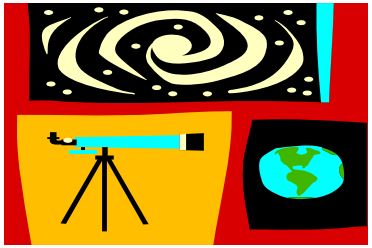
What is Ontology?

- Ontology is the study of what exists
  - Sounds a bit vague, but the intent is to remove the woolly thinking from how we describe our world
  - Ontology is about getting to an accurate representation of the things that are important to the enterprise.
- What ontology isn't
  - It's not a model of information or data. Rather, it is a model of the world
  - It's not a branch of artificial intelligence
  - It's not a "conceptual" model – if done properly an ontology can be implemented by a software system and can provide real business benefit

Information as a strategic resource within ATM – the history!

- ICAO started 1997 (SICIM ISO 10303-11)
- Eurocontrol AICM (a logical data model)
- SESAR (EC) discovered the needs for a Conceptual Information Model year 2006-2007
- LFV (NORACON) is responsible for the Information Management within SESAR Joint Undertaking
  - Information Management
  - Information Service

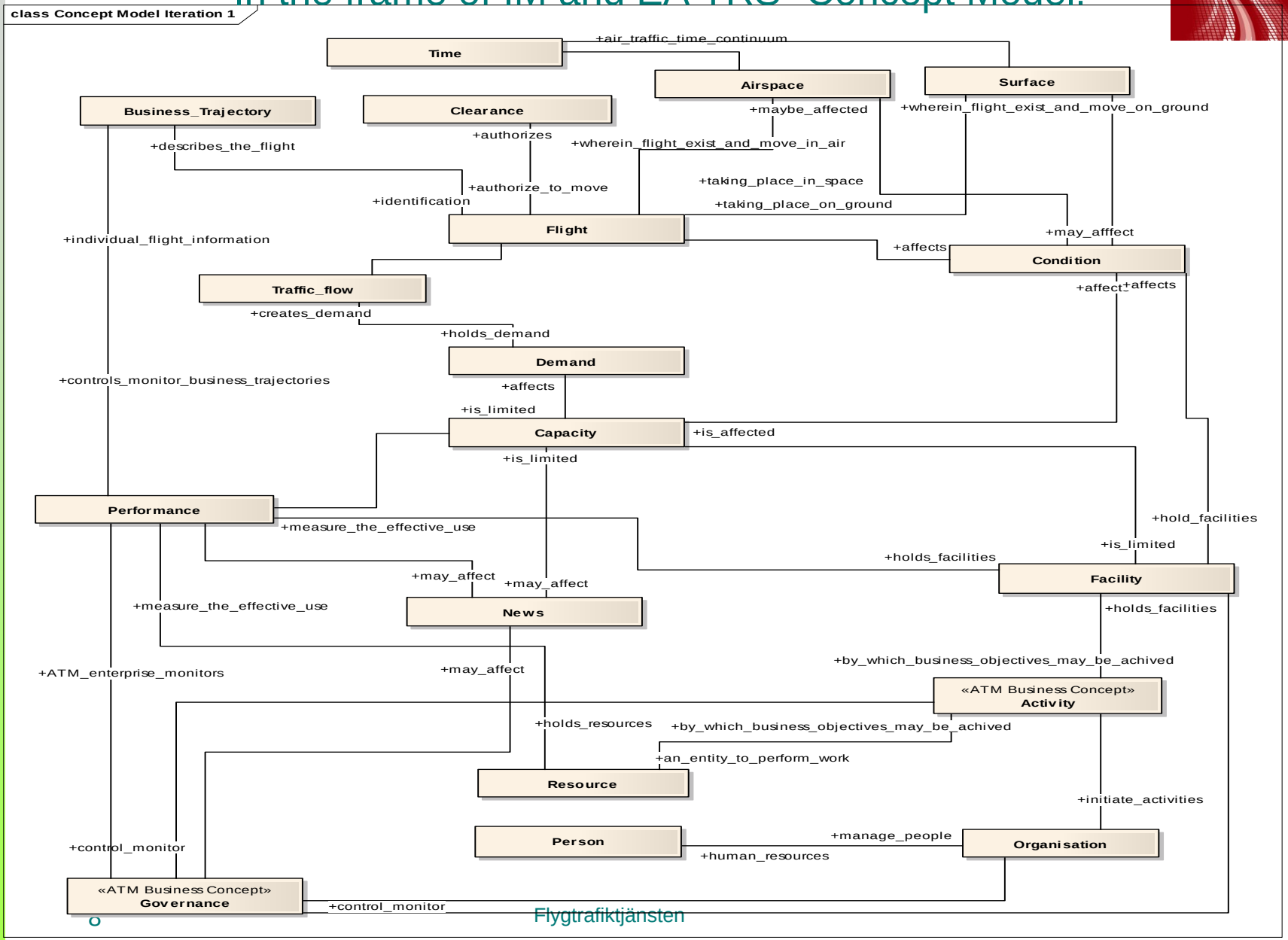
Where is ATM in this IM context?



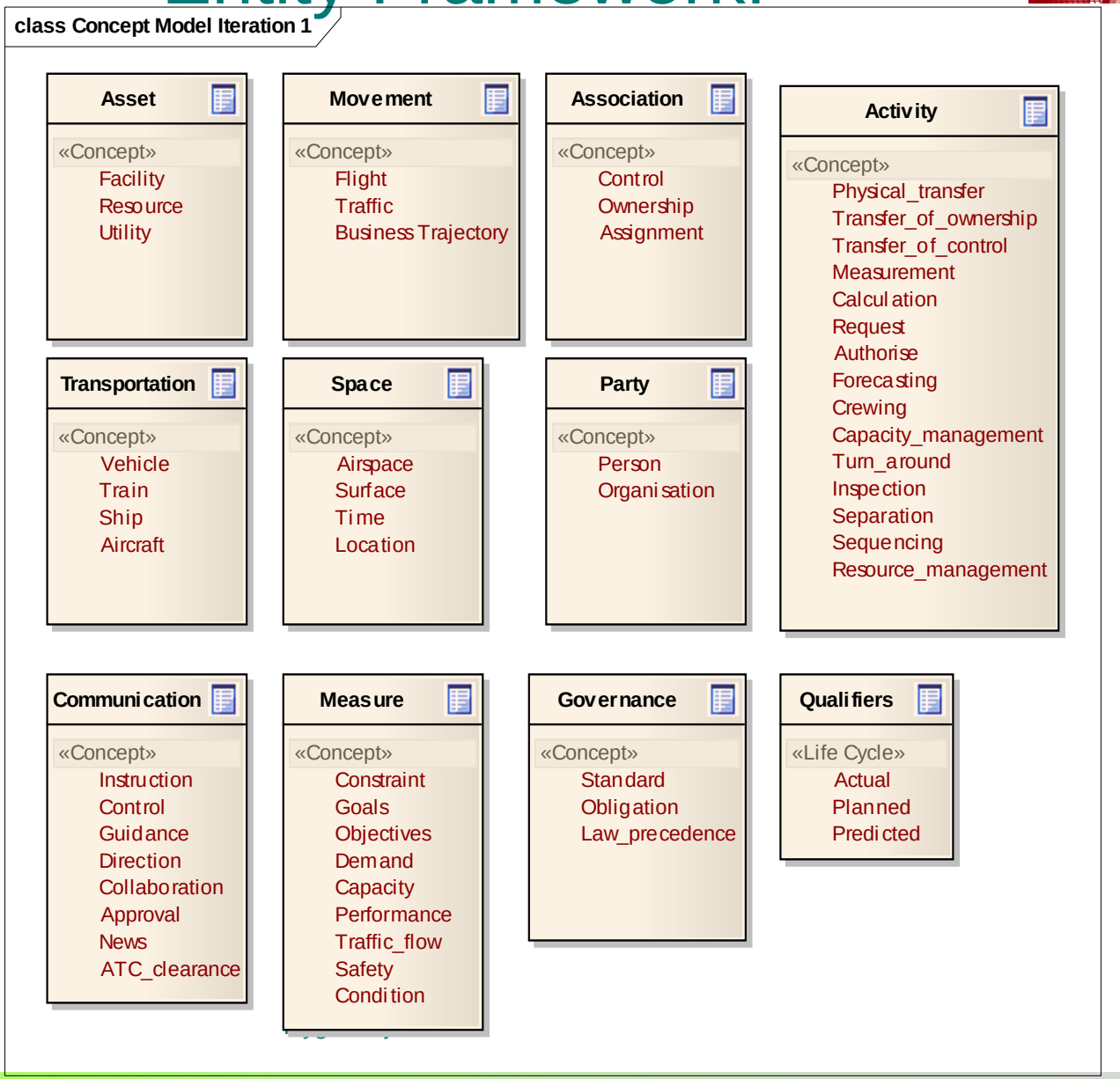
Service-Oriented Architecture the way forward within ATM

- The only possible way forward
- Requires a change in mindset
- Interoperable and Interchangeable Services (business and IT aligned)
- The Business must lead however it is not always in that way
- Top-down approach – Governance, reusability is key within SOA
- How to use the Service Bus and how to avoid a new “looked in position from an ANSP position” is a critical issue

In the frame of IM and EA TRS- Concept Model!

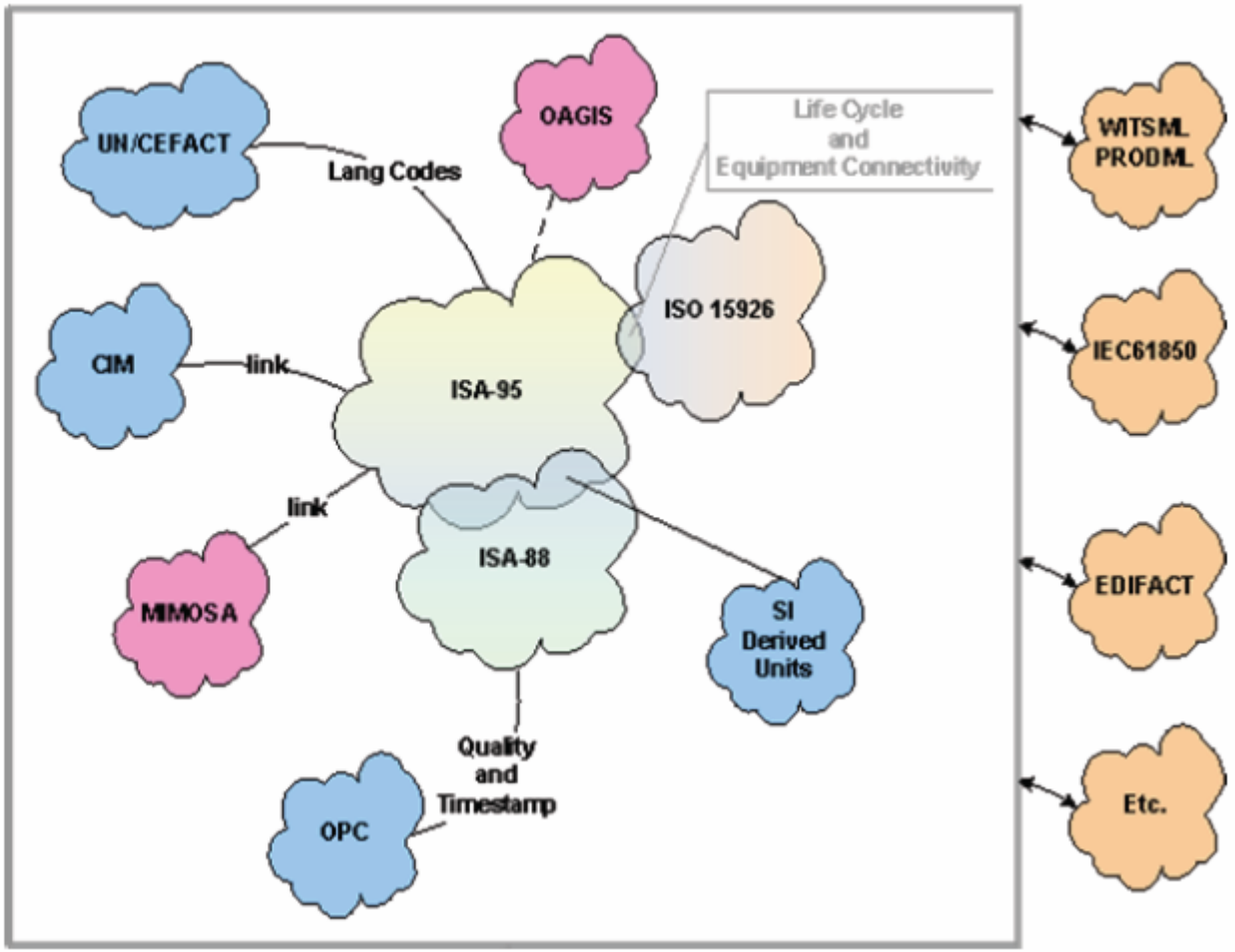


In the frame of IM and EA TRS-Entity Framework!



IBM's Reference Semantic Model (RSM) (Ref. later in Semantic Days)

- MIMOSA
- OAGi
- WBF
- Energistics
- ISA 88
- ISA 95
- POSC Caesar
- OPC
- OSIsoft
- DNV
- DOW
- SISCO
- IBM



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Semantic Interoperability

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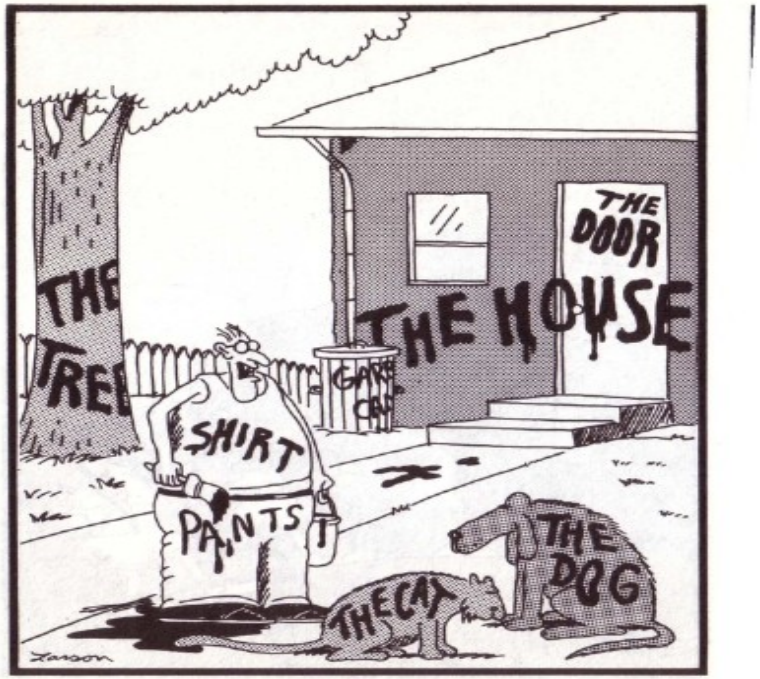
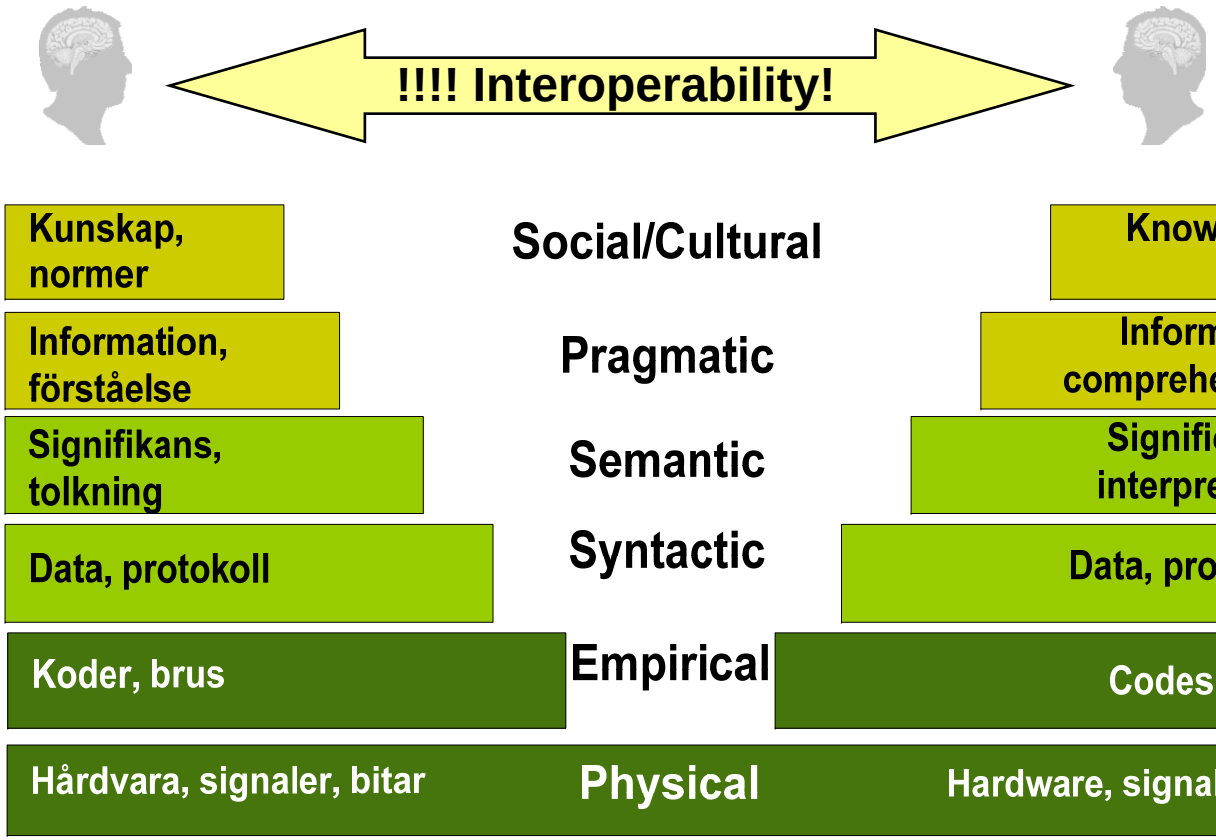
Semantic Interoperability (SI) - Definition

- The ability among two or more computerised systems to exchange information for a specific purpose and understand the meaning correct and automatically interpreted of the receiving system, in the light of the task that is performed.

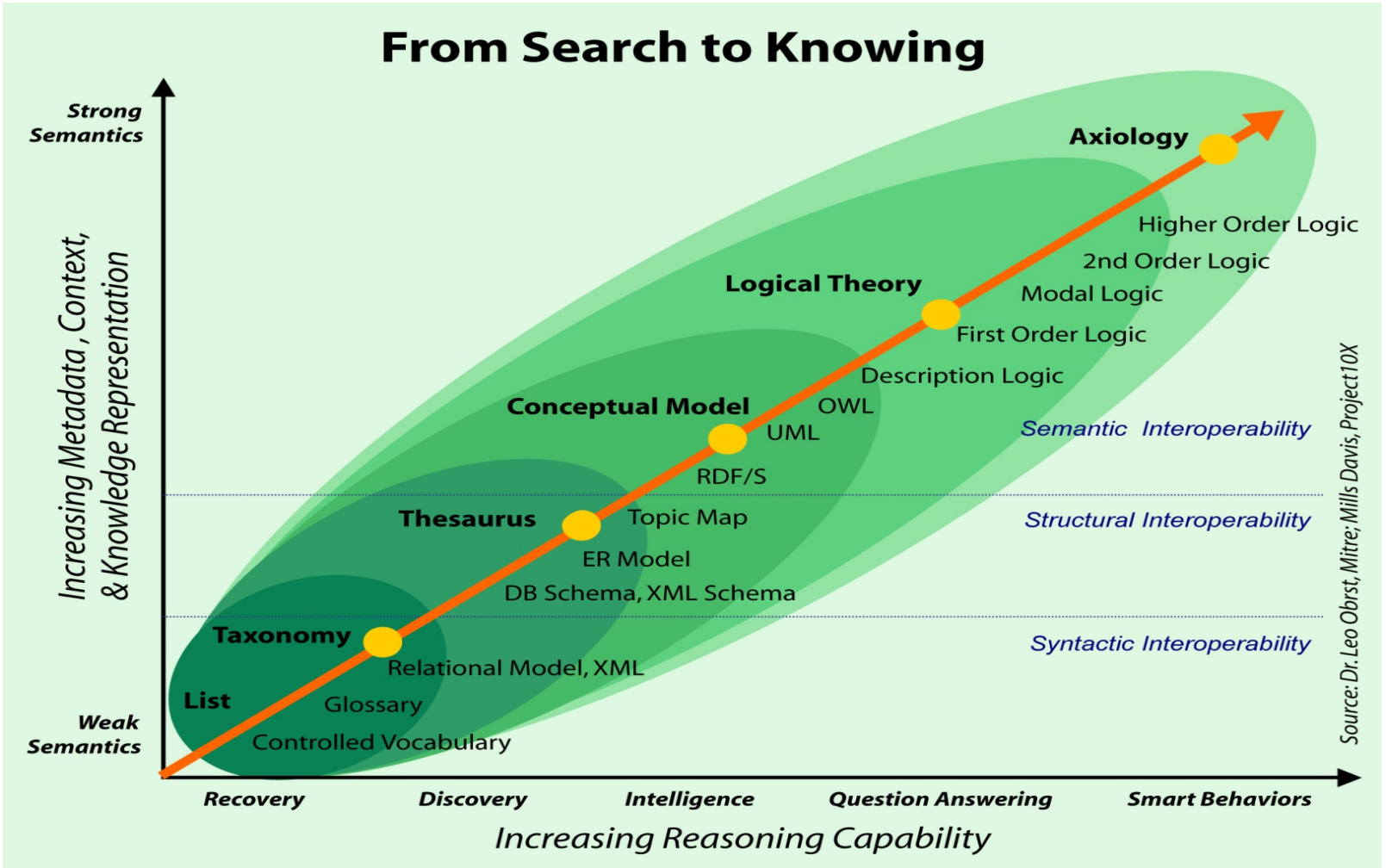


(SAF) How to create interoperability?



(SAF)The Future Focus

More metadata, semantic modeling & knowledge representation, more reasoning capability



Semantics

The teacher wrote on the black-board following words:

"Woman without her man is nothing" and asked the boys add punctuations.

The boys wrote:
"Woman, without her man, is nothing."

The girls wrote:
"Woman! Without her, man is nothing!"

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Model Driven Interoperability (principle)

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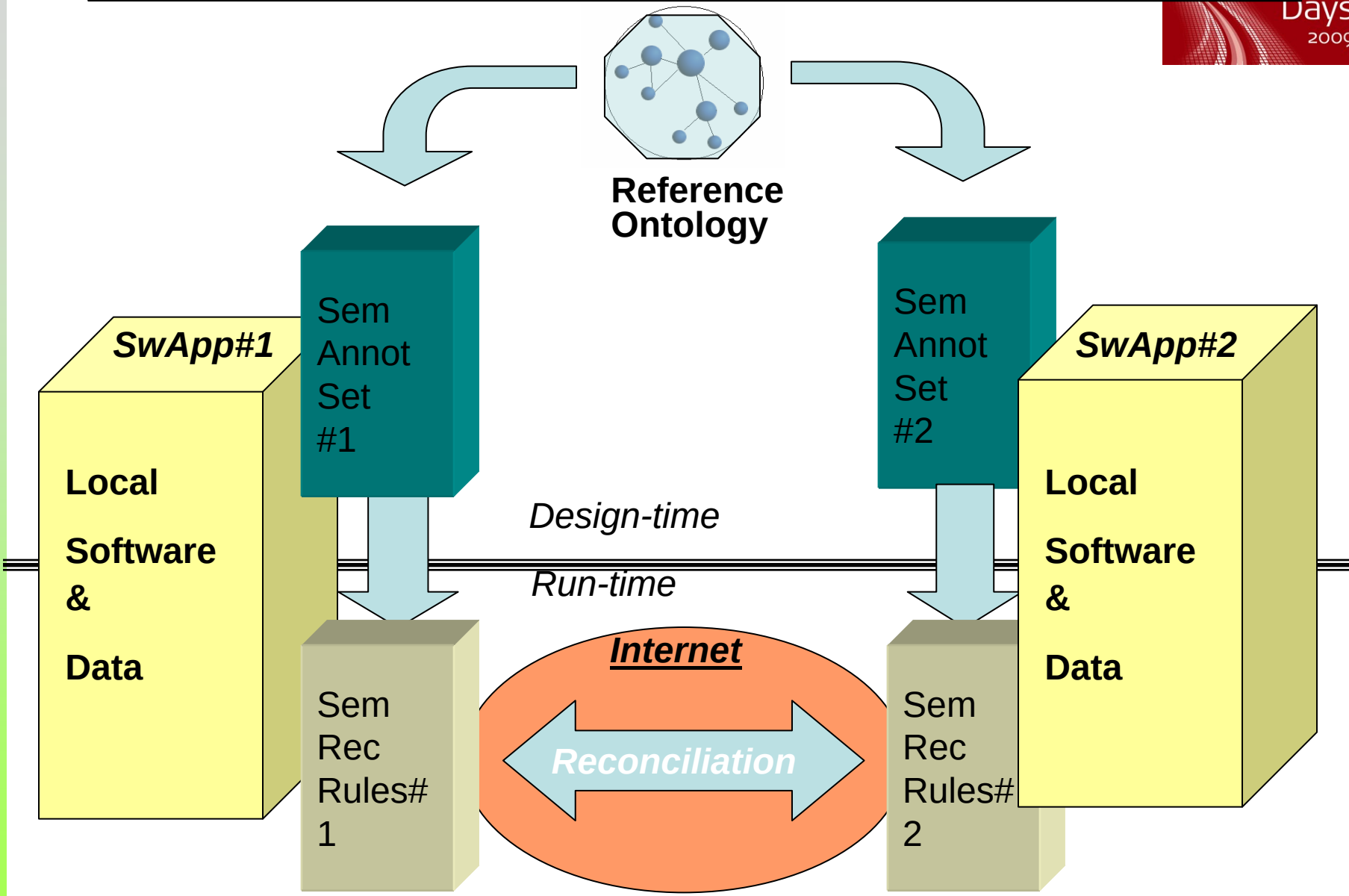
Architecture for semantic annotation and reconciliation



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Semantic Web

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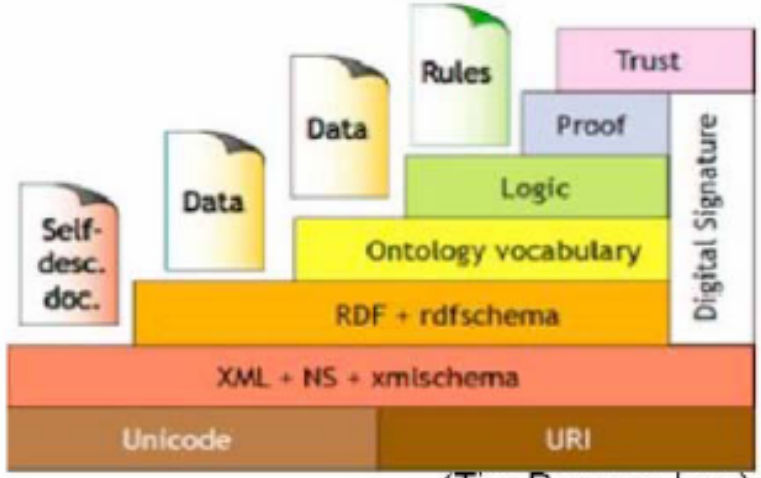
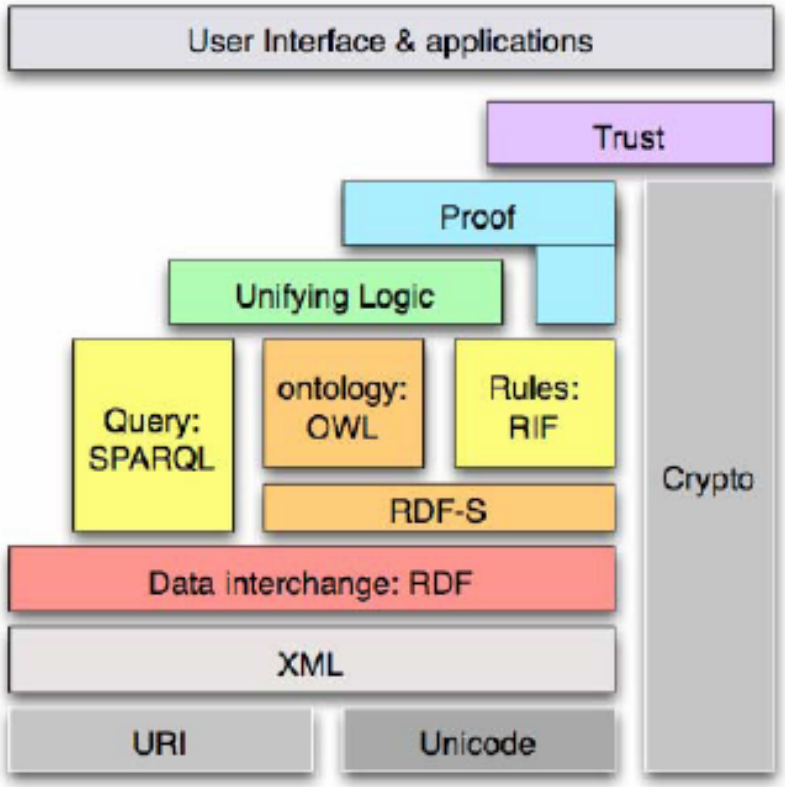
Evolution of the semantic web



(Tim Berners-Lee)

2001

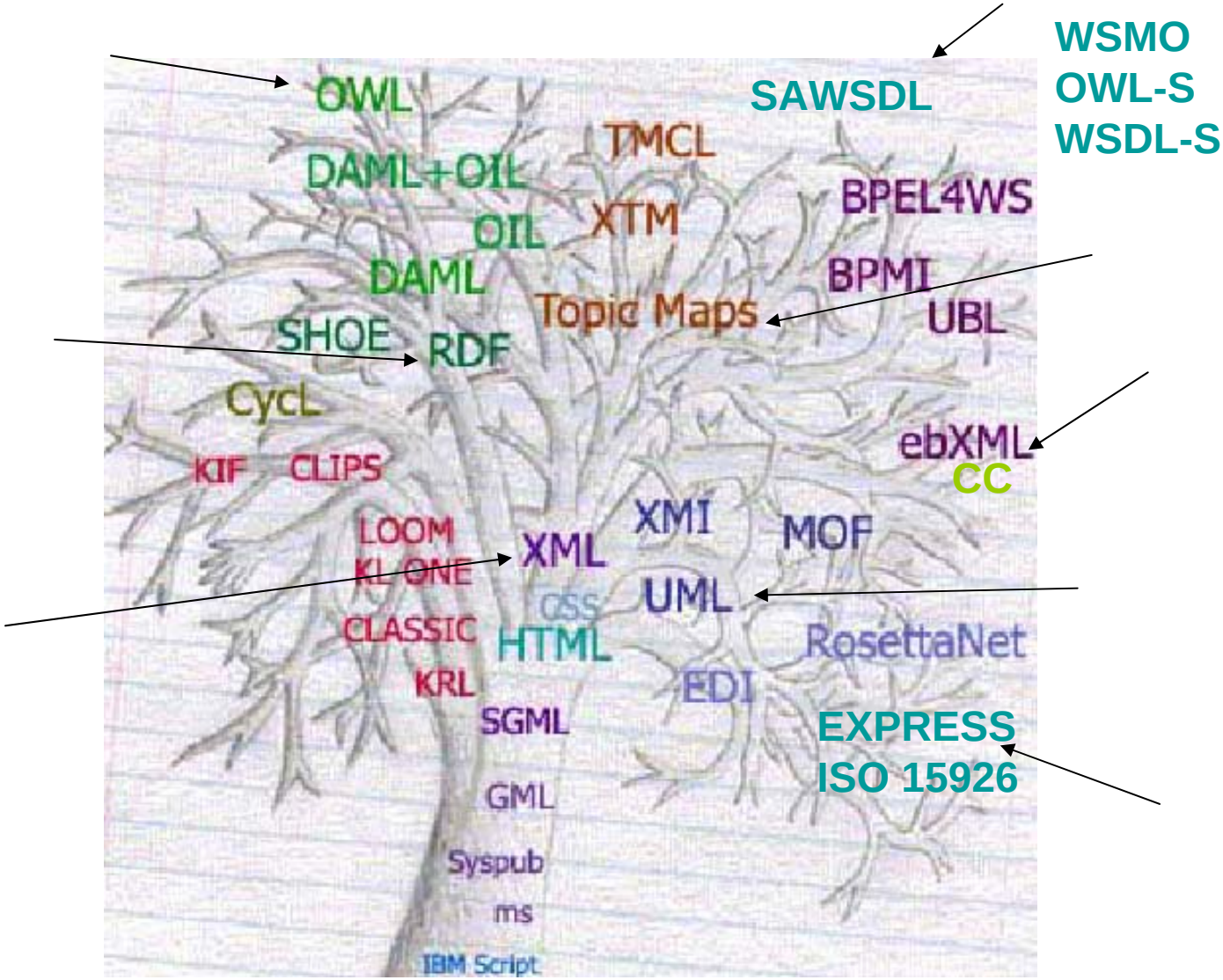


(Tim Berners-Lee)

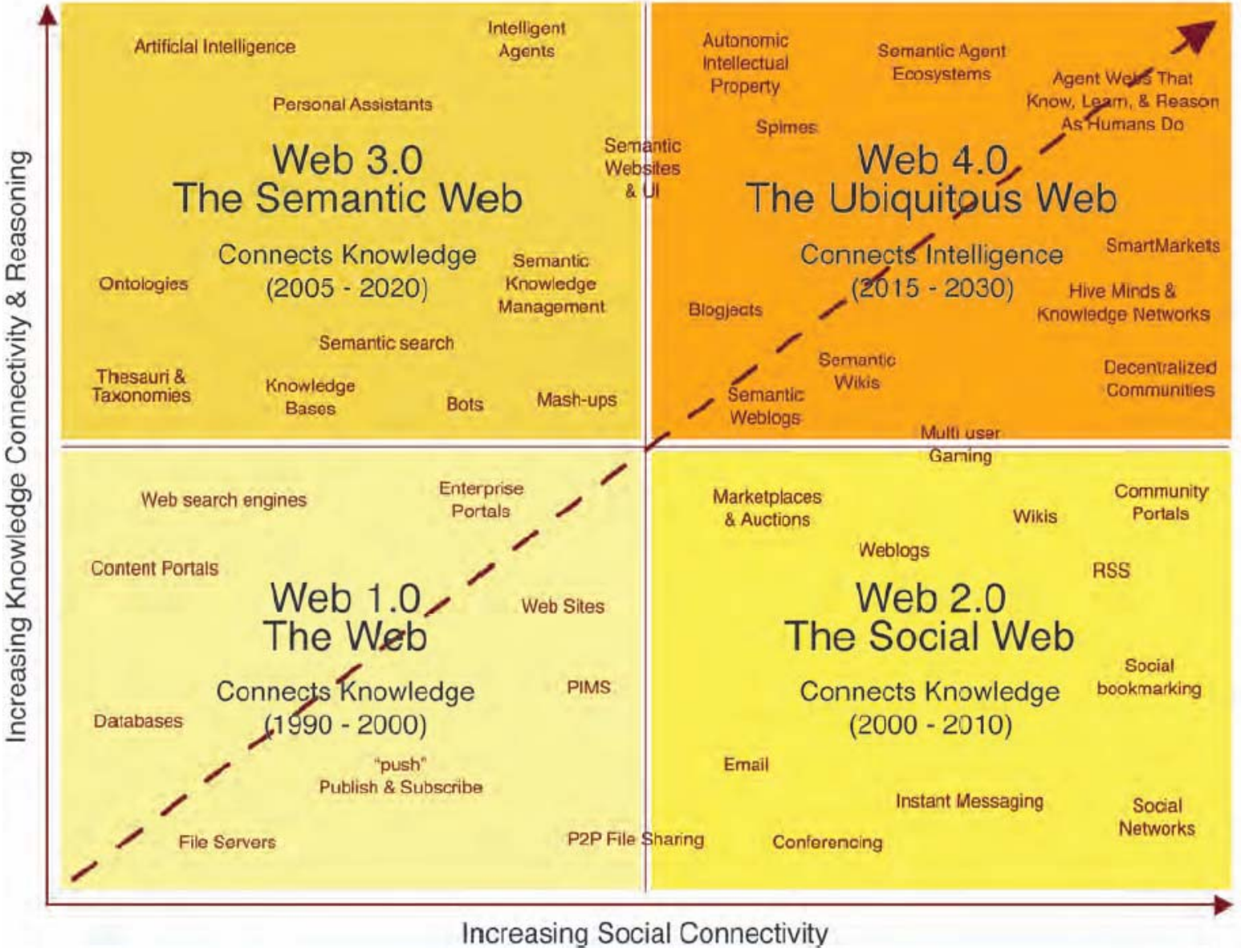
2006

The Tree of Knowledge Technologies

(Extended fromTop Quadrant)



Internet Evolution



Information Modeling languages

- ER
- BR – NIAM – ORM
- Logic based (First order predicate logic)
- EXPRESS (STEP), ISO 15926
- XML, DTD
- XML Schema
- RDF, RDFS
- OWL
- …
- UML
- ..
- Topic Maps

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Ontologies and Ontology languages (RDF, OWL)

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Comparison of different semantic technologies

- **RDF/ OWL**
- **Topic Maps**
- **Core Components**
- **ISO 15926**
- **UML**

- **SAWSDL – Semantic annotation of WSDL and XML**

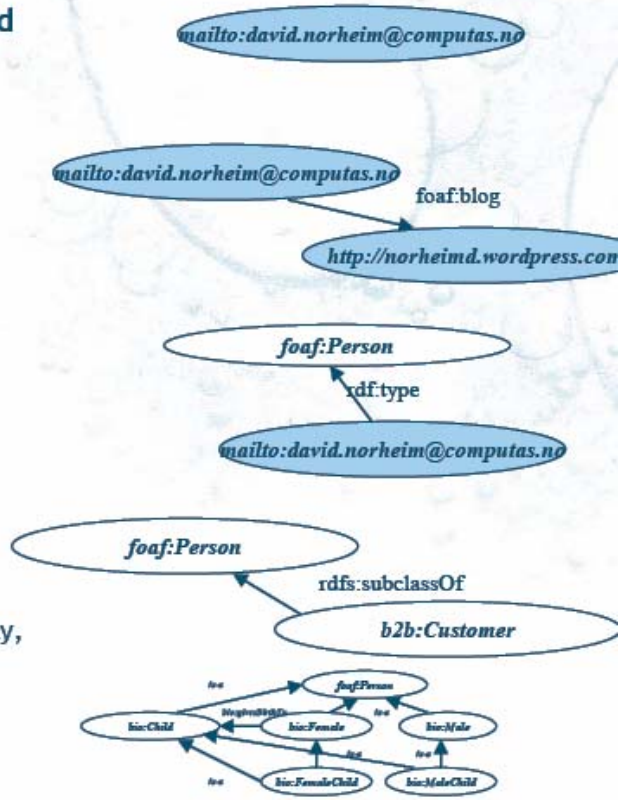
http://www.norstella.no/ - Interop utvalg

RDF/OWL

computas

Semantic building blocks

- **The URI provides unique identification of objects and conceps/classes and properties**
  - Namespaces used for efficient writing
  - The uri provides aggregation
- **The Triple in RDF provides the smallest possible statement**
  - Can be included in a html page (rdfa)
  - Extracted through transformations (grddl)
  - Queries from databases (sparql)
  - In a file (rdf/xml, n3)
- **The class allows typing**
- **OWL allows you to build vocabularies expressing**
  - Subclassing, subproperties, symmetry, transitivity, equality, disjunctness and more
  - Opens for shared meaning, reuse and reasoning
- **Reusable vocabularies exists in thousands**



Take-away: With the RDF and OWL building blocks your models can be tiny and huge, and all inbetween

RDF: Resource Description Framework

RDF is the simplest of the semantic languages. At the simplest level, the Resource Description Framework is an XML-based language to describe resources.

- Basic Idea #1: **RFD uses triples**
  - RDF is based on a subject-verb-object statement structure.
  - RDF subjects are called resources (classes).
  - Verbs (predicates) are called properties.
  - Objects (values) may be simple literals or other resources.

- Basic Idea #2: **Everything is a resource that is named with a URI**
  - RDF nouns, verbs, and objects are all labeled with URIs
  - A URI is just a name for a resource.
  - It may be a URL, but not necessarily.
  - A URI can name anything that can be described.
    - Web pages, telephone numbers, concepts, creators of web pages, organizations that the creator works for….

Resource Description Framework (RDF)

- A language for making simple statements about things (resources)
- Statements: *Subject* *Predicate* *Object* (triples)
  - *Item1* *isOrderFor* *Product1*
  - *Item1* *is-a* *Item*
  - *Product1* *hasName* *“Lawnmower”*

LineItem database table:

partNum	productName	quantity	USPrice	comment	shipDate
872-AA	Lawnmower	1	148,95	Confirm this is electric	21.05.1999
926-AA	Baby Monitor	1	39,98		

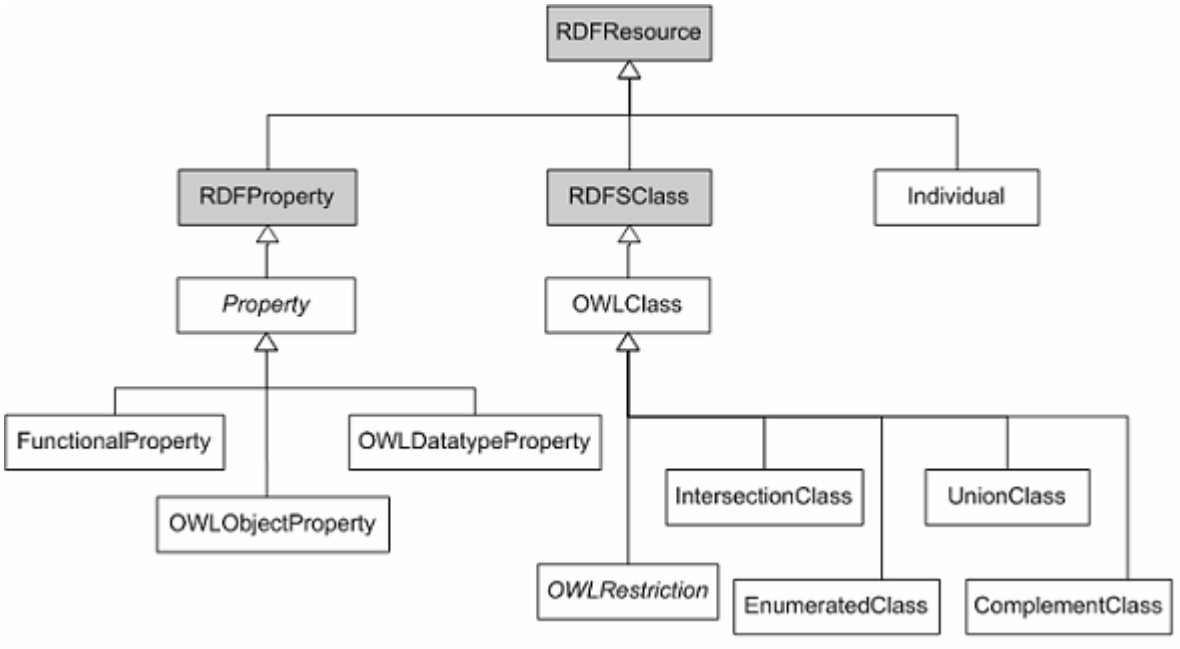
Ontology Web Language (OWL)

- A more expressive ontology language
- Concepts (classes) can be described or defined
  - described – necessary conditions given
  - defined – necessary and sufficient conditions given
- Builds on RDF and can be expressed in several ways:
  - RDF XML-based syntax
  - abstract syntax
  - graphic UML-like
- Has three sub-languages:
  - OWL Full
  - OWL Description Logic (DL) – maps to a DL, a subset of predicate logic
  - OWL lite – for simple taxonomies (class hierarchies)

OWL

- (Web Ontology language) is the most expressive language for representing and sharing ontologies over the Web. OWL is designed for use by applications that need to process the content of information instead of just presenting information. It facilitates greater machine interoperability of Web content than other description languages like XML, RDF and RDF-S by providing additional vocabulary along with a formal semantics.
- The OWL metamodel is implemented in by extending the RDFS metamodel. The figure below shows an excerpt of the class hierarchy present in OWL. An OWL Class is a kind of RDFS Class, like OWL Property are kind of RDF Property. OWL offers a richer semantic to express ontologies. With it we can define cardinalities on properties, defined classes with set operators like union, intersection, complement, etc. The notion of Individual in OWL is used to represent resources, i.e. class instances. Each element is identified by a unique URI identifier.

OWL Metamodel



Logical languages for the Semantic Web

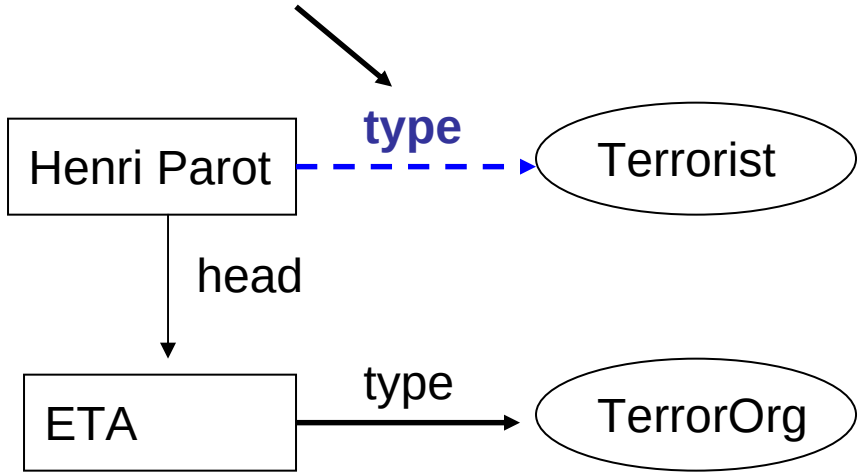
An example of the reasoning possibilities of the logical languages

```
<owl:Property rdf:ID="head">
  <rdf:subPropertyOf
        rdfs:resource="member" />
</owl:Property>

<owl:Class rdf:ID="Terrorist">
 <owl:sameClassAs>
   <owl:Restriction>
     <owl:onProperty
          rdf:resource="member" />
     <owl:someValuesFrom

rdf:resource="TerroristOrg" />
   </owl:Restriction>
  </owl:sameClassAs>
</owl:Class>
```

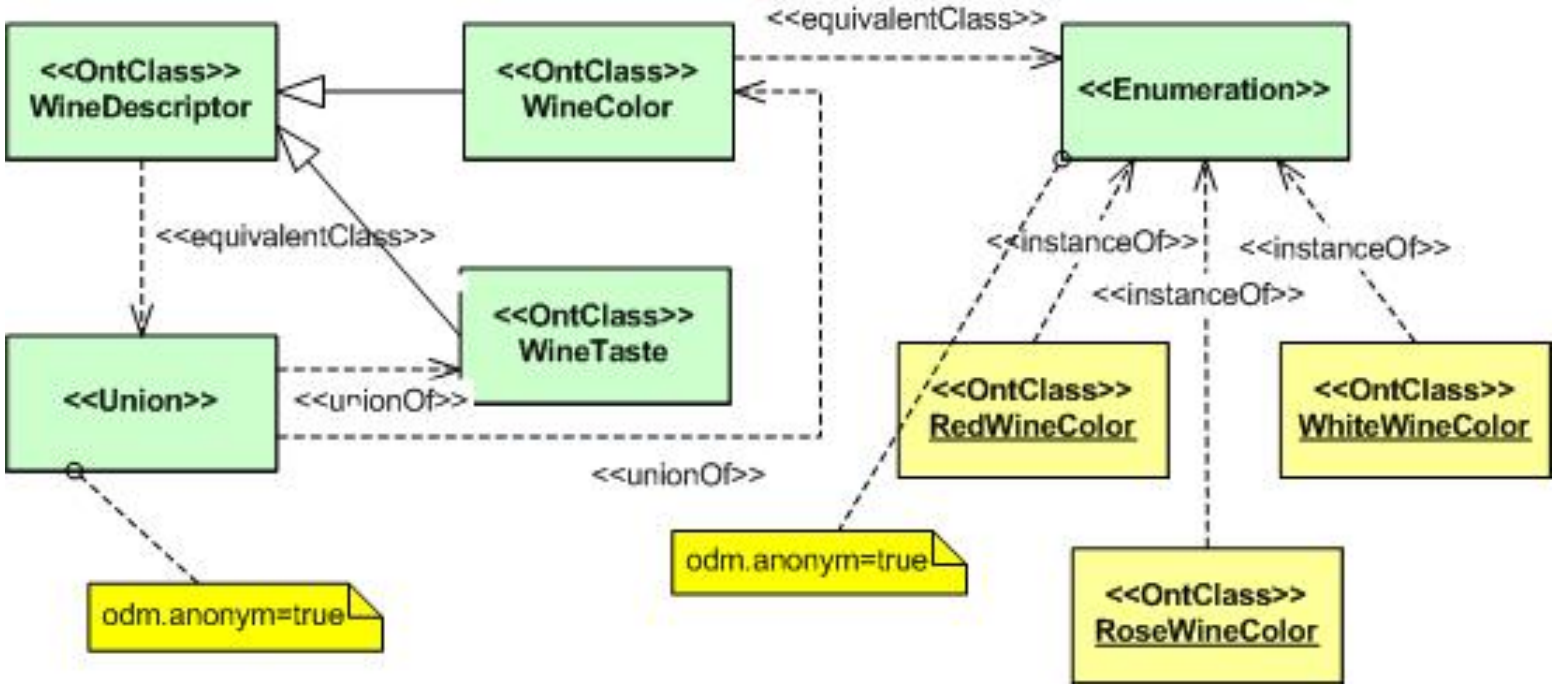
- The head of an organization is also a member of it
- A member of a terror organization is a terrorist
- Therefore, the head of a terror organization is a terrorist



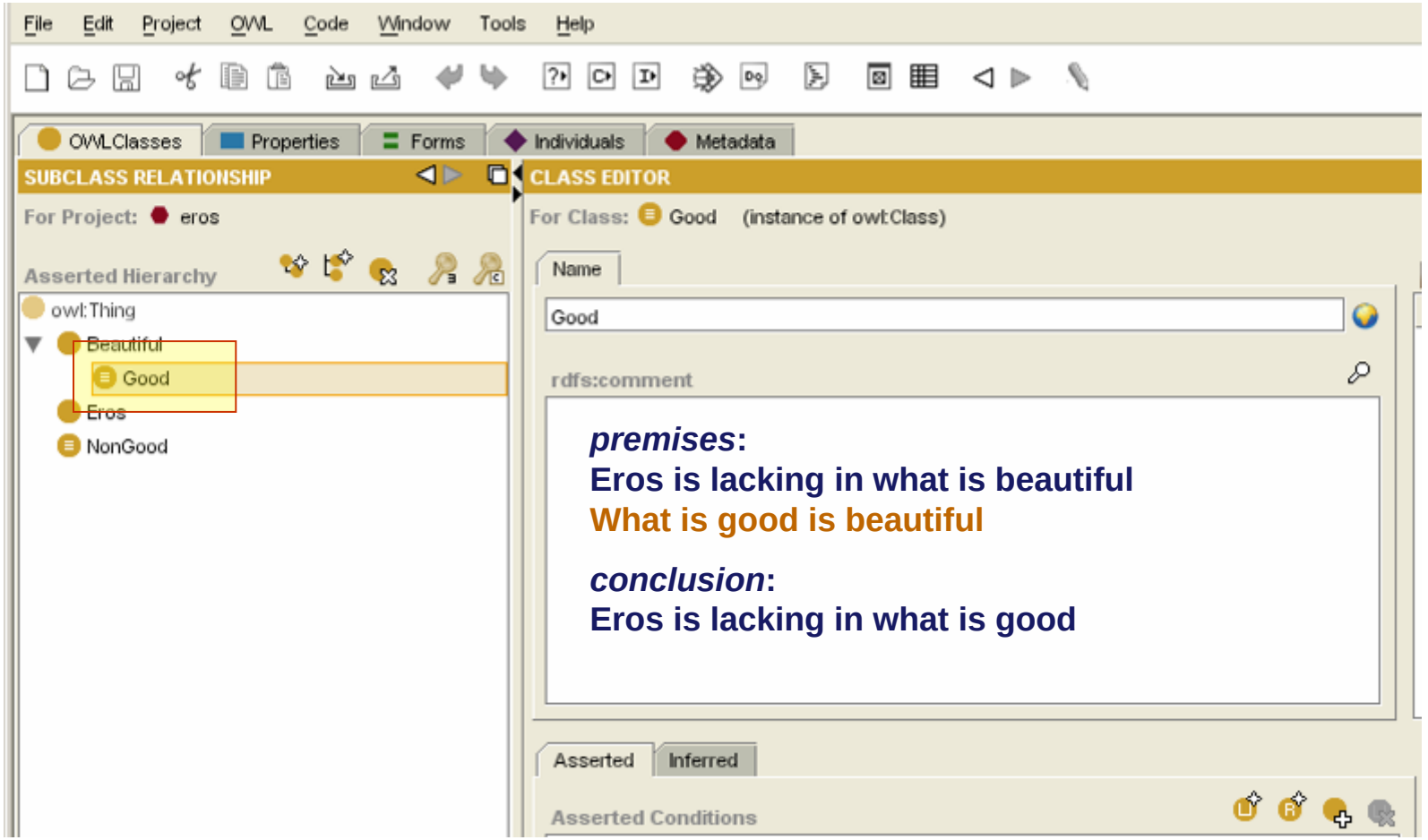
OWL versus UML

In OWL and not in UML	Explanation
Thing, global properties, autonomous individual	In OWL, instances as well as some relations (in owl, relations are called properties), can exist without being attached to certain class. This is due to the fact that OWL is based on sets while UML is based on types. Instances and relations in OWL can be a subset of the universal class *Thing* or binary relation between two Things.
Class-specific cardinality redefinition	As OWL properties can be declared independent of classes, they can have different cardinality definitions when applied to different classes.
allValuesFrom, some ValuesFrom	"In OWL, property can have its range restricted when applied to particular class, either that the range is limited to a class (subclass of range if declared) (**allValuesFrom**) or that range must intersect a class (**someValuesFrom**)." [28]
SymmetricProperty, TransitiveProperty	OWL allows properties to be declared symmetric or transitive. In both cases the domain and range must be type compatible.
Classes as instances	In UML or MOF defined languages, there is a strict separation of metalevels so that population of M1 classes is distinct from the population of M2 classes. In OWL full, one class can be an instance of another class, a characteristic inherited form RDF. In OWL DL, this usage is restricted.

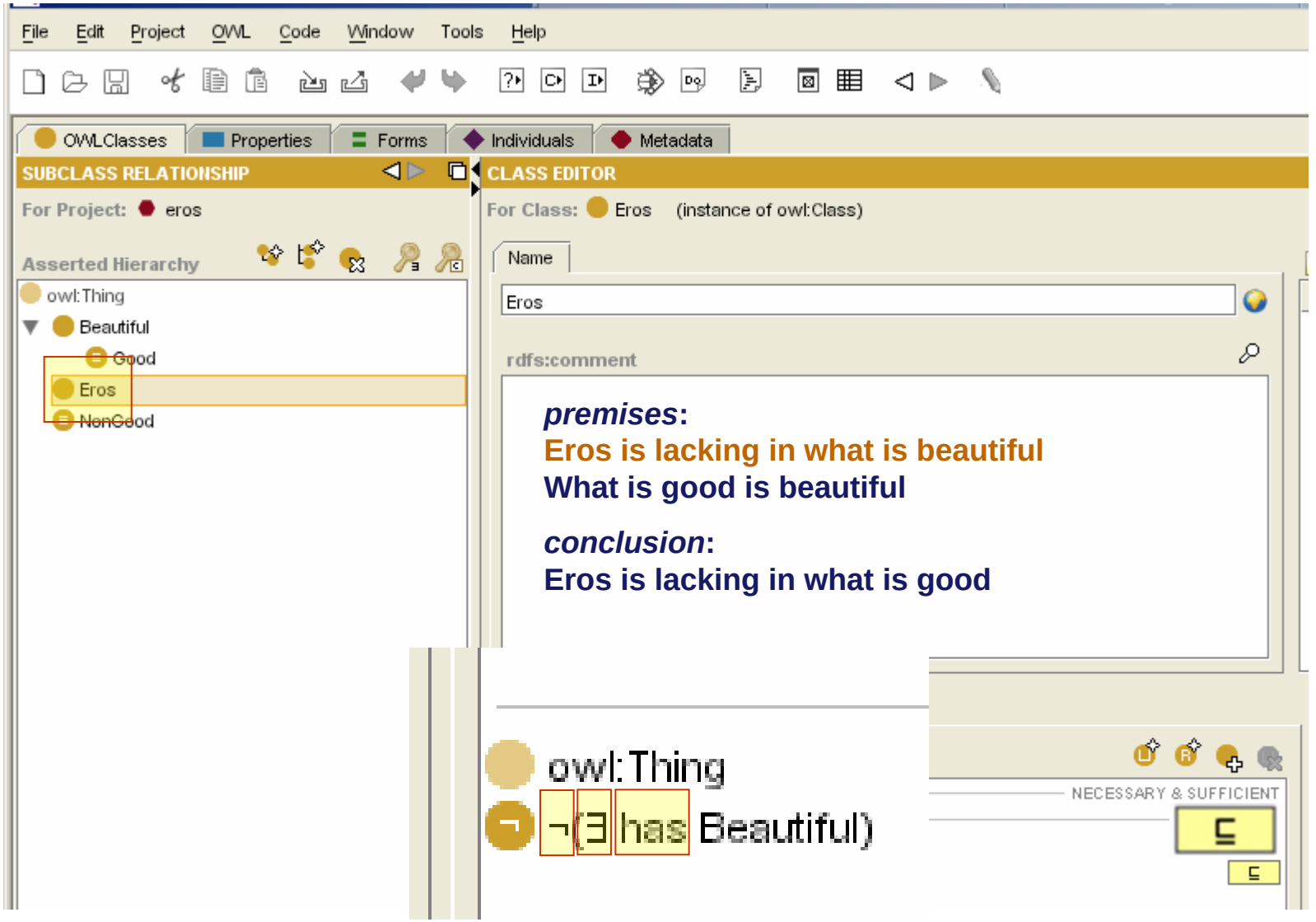
UML Ontology profile



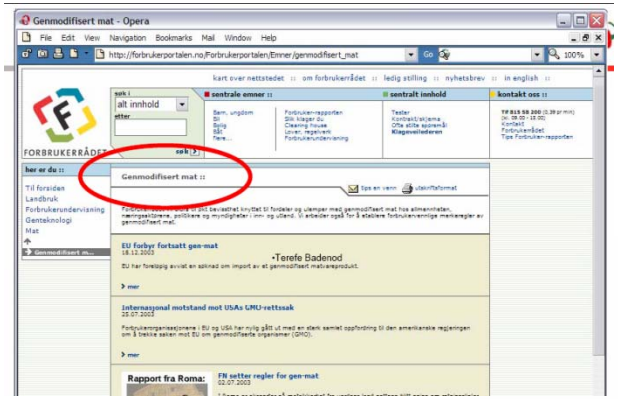
Protege: Good subclass of Beautiful

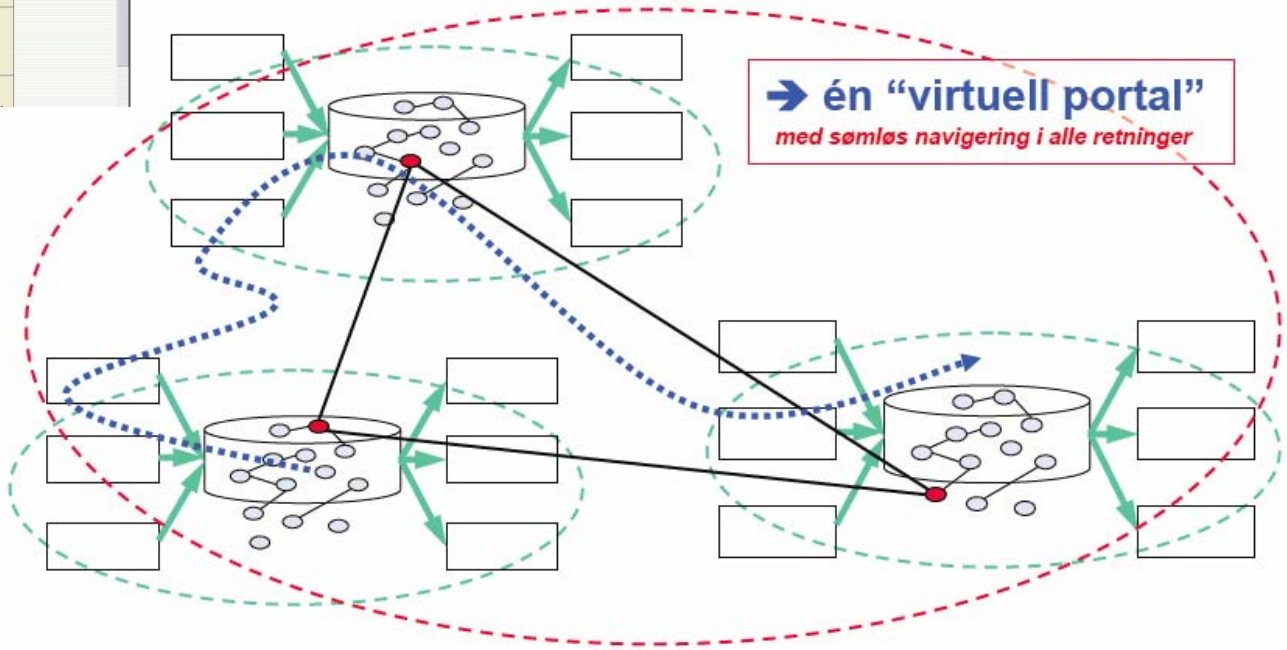


Protege: Eros described



Topic Maps, (Emnekart)

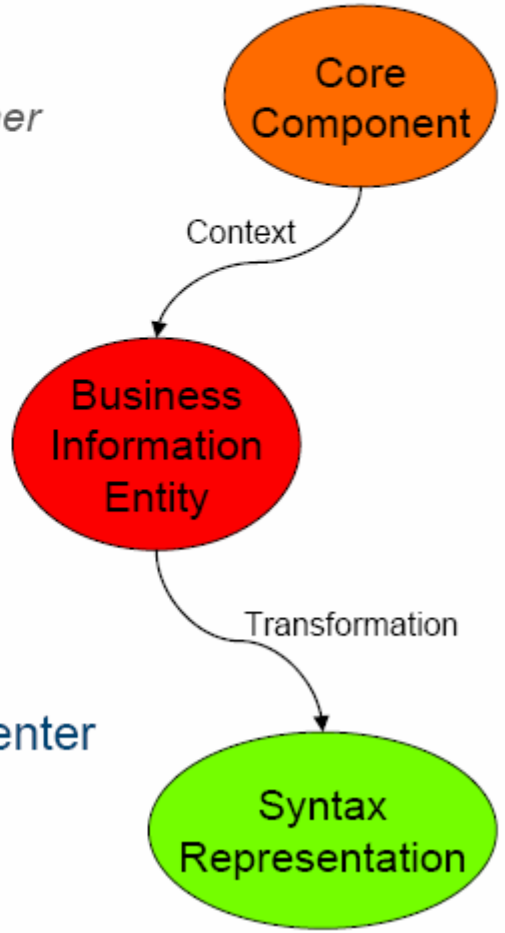




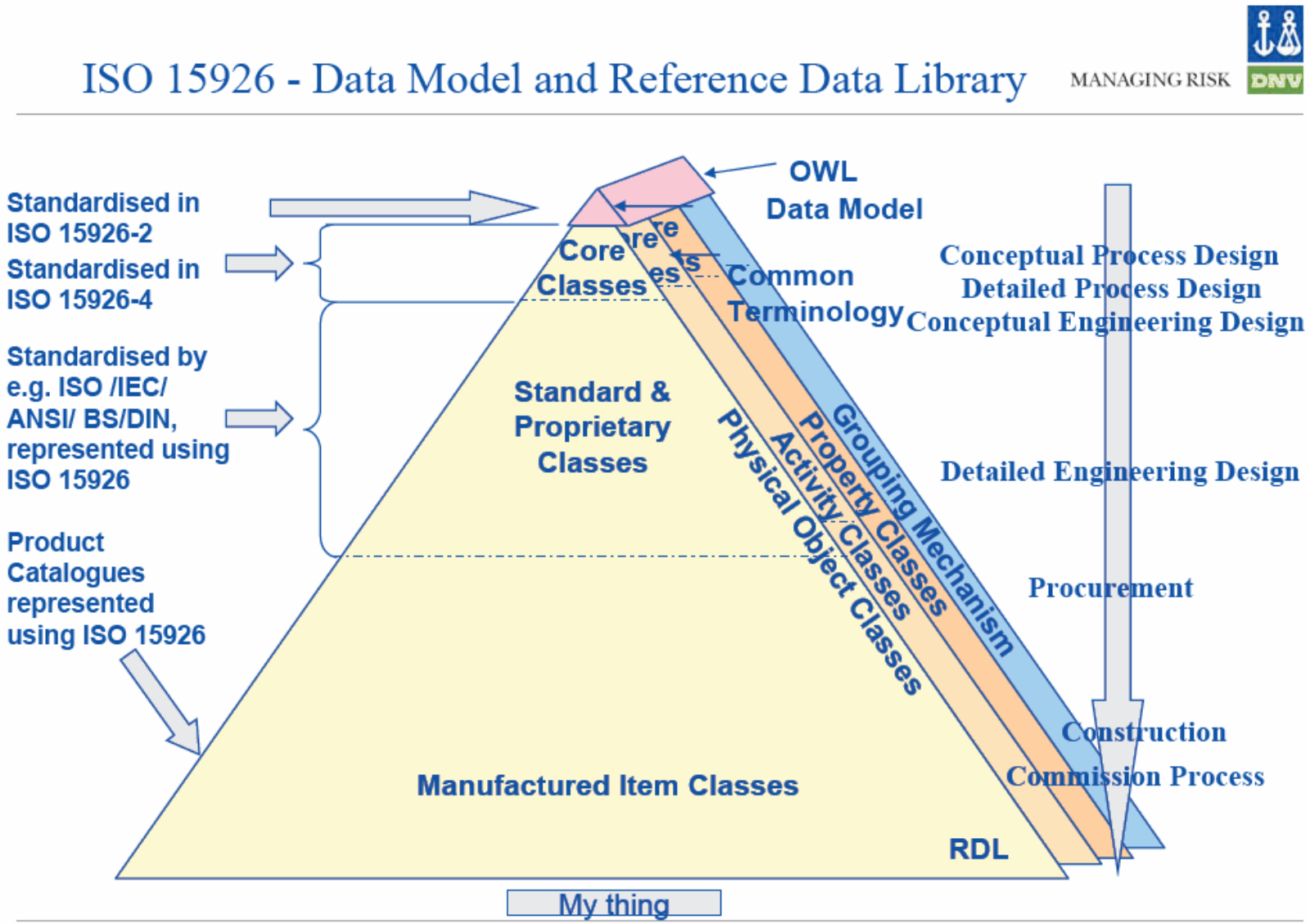
Core Components

ISO TS 15000 – 5: Core Component Technical Spesification – part 8 of the ebXML framework

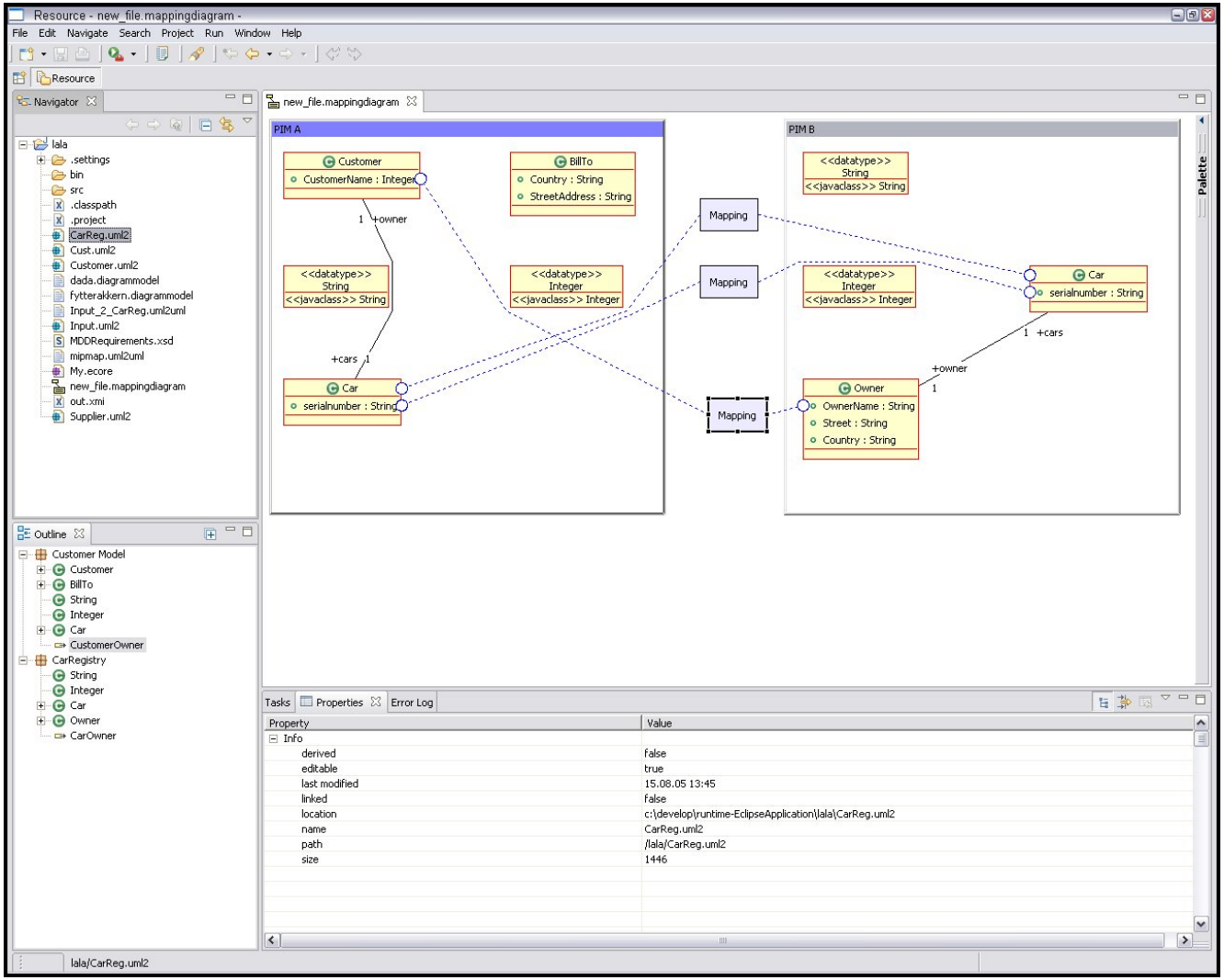
- En metodikk for
  - *å identifisere, beskrive og maksimere gjenbruk av forretningsinformasjon til støtte for semantisk interoperabilitet på tvers av ulike forretningsdomener*
  - *utvikling av et omforenet sett av semantiske byggeklosser*
- Tilrettelegger for
  - *semantisk interoperabilitet på tvers av forretningsdomener*
  - *konsistent bruk av felles semantiske enheter*
  - *konsistent bruk på tvers av ulike språk*
- Støttes av en rekke prosjekter/initiativ
  - *Rosetanet, OAG, SWIFT, EAN, UBL, ...*
- Det første biblioteket med harmoniserte komponenter er nå publisert



ISO 15926


ISO 15926 - Data Model and Reference Data Library
MANAGING RISK
DNV
Standardised in ISO 15926-2
Standardised in ISO 15926-4
Standardised by e.g. ISO /IEC/ ANSI/ BS/DIN, represented using ISO 15926
Product Catalogues represented using ISO 15926
OWL Data Model
Core Classes
Common Terminology
Standard & Proprietary Classes
Grouping Mechanism
Property Classes
Activity Classes
Physical Object Classes
Manufactured Item Classes
RDL
Conceptual Process Design
Detailed Process Design
Conceptual Engineering Design
Detailed Engineering Design
Procurement
Construction
Commission Process
My thing

UML


Resource - new_file.mappingdiagram -
File Edit Navigate Search Project Run Window Help
Navigator
lala
.settings
bin
src
.classpath
.project
CarReg.uml2
Cust.uml2
Customer.uml2
dada.diagrammodel
fytterakkern.diagrammodel
Input_2_CarReg.uml2uml
Input.uml2
MDDRequirements.xsd
mipmap.uml2uml
My.ecore
new_file.mappingdiagram
out.xmi
Supplier.uml2
new_file.mappingdiagram
PIM A
Customer
CustomerName : Integer
BillTo
Country : String
StreetAddress : String
1
+owner
<<datatype>>
String
<<javaclass>> String
<<datatype>>
Integer
<<javaclass>> Integer
+cars
1
Car
serialnumber : String
Mapping
Mapping
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PIM B
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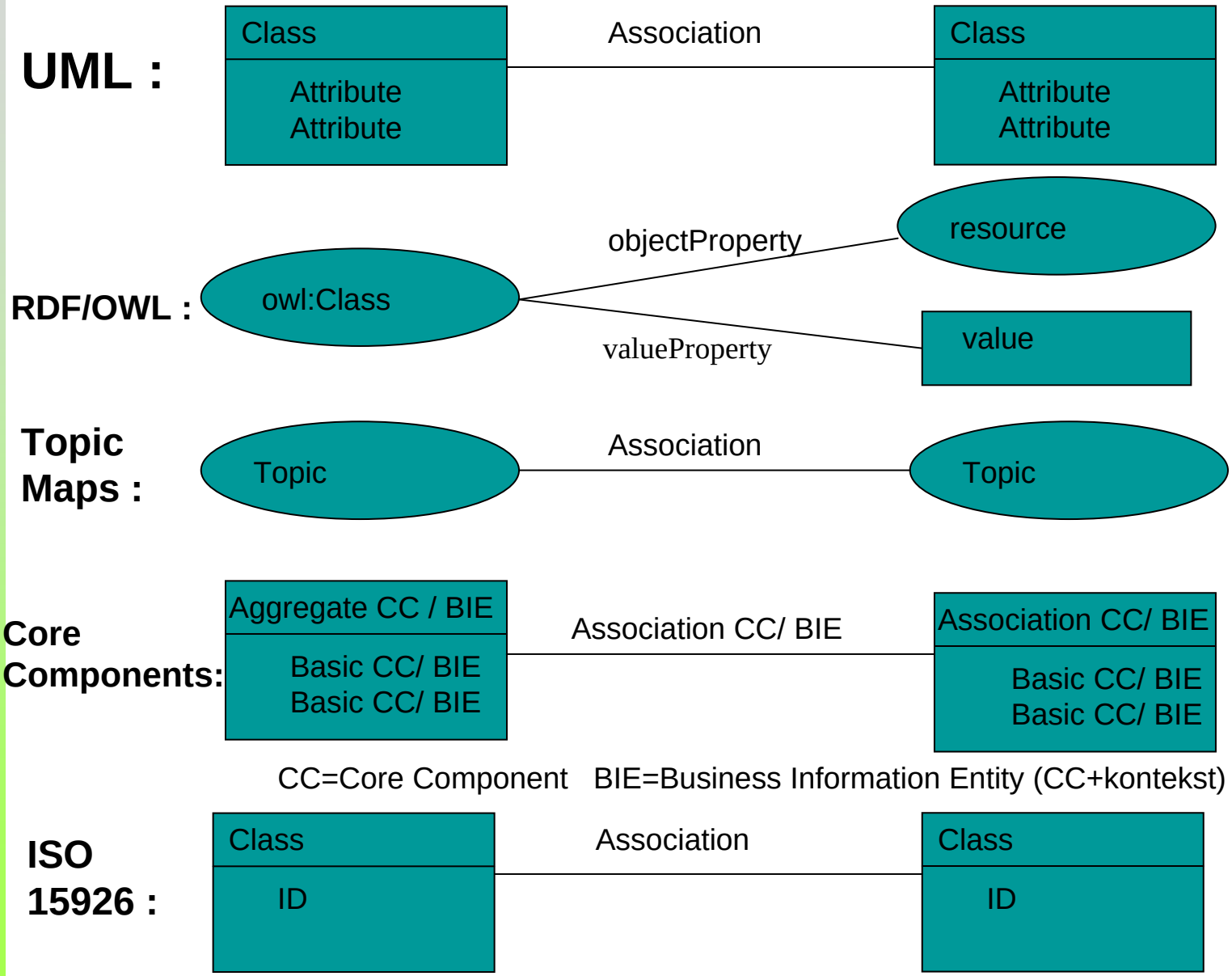
Integer
<<javaclass>> Integer
Car
serialnumber : String
1
+cars
+owner
1
Owner
OwnerName : String
Street : String
Country : String
Palette
Outline
Customer Model
Customer
BillTo
String
Integer
Car
CustomerOwner
CarRegistry
String
Integer
Car
Owner
CarOwner
Tasks
Properties
Error Log
Property
Value
Info
derived
false
editable
true
last modified
15.08.05 13:45
linked
false
location
c:\develop\runtime-EclipseApplication\lala\CarReg.uml2
name
CarReg.uml2
path
/lala/CarReg.uml2
size
1446
lala/CarReg.uml2

Representation of Class concepts



Typical usage areas

- **RDF/ OWL**

  Extend the web from today to more explicit represent meaning

- **Topic Maps**, Emnekart

  Strucutre and navigation in web portals.

- **Core Components**

  B2B transacations in business systemns. Example> Purchase Order, Invoice

- **ISO 15926**

  B2B, B2G for Product Lifecycle Data.

- **UML**

  Design of IT systems – including visualisation of models (also OWL etc)

- **SAWSDL – Semantic annotation of WSDL and XML**

  Rerences from services and data to ontologies, with lifting and lowering operations to support semantic interoperability

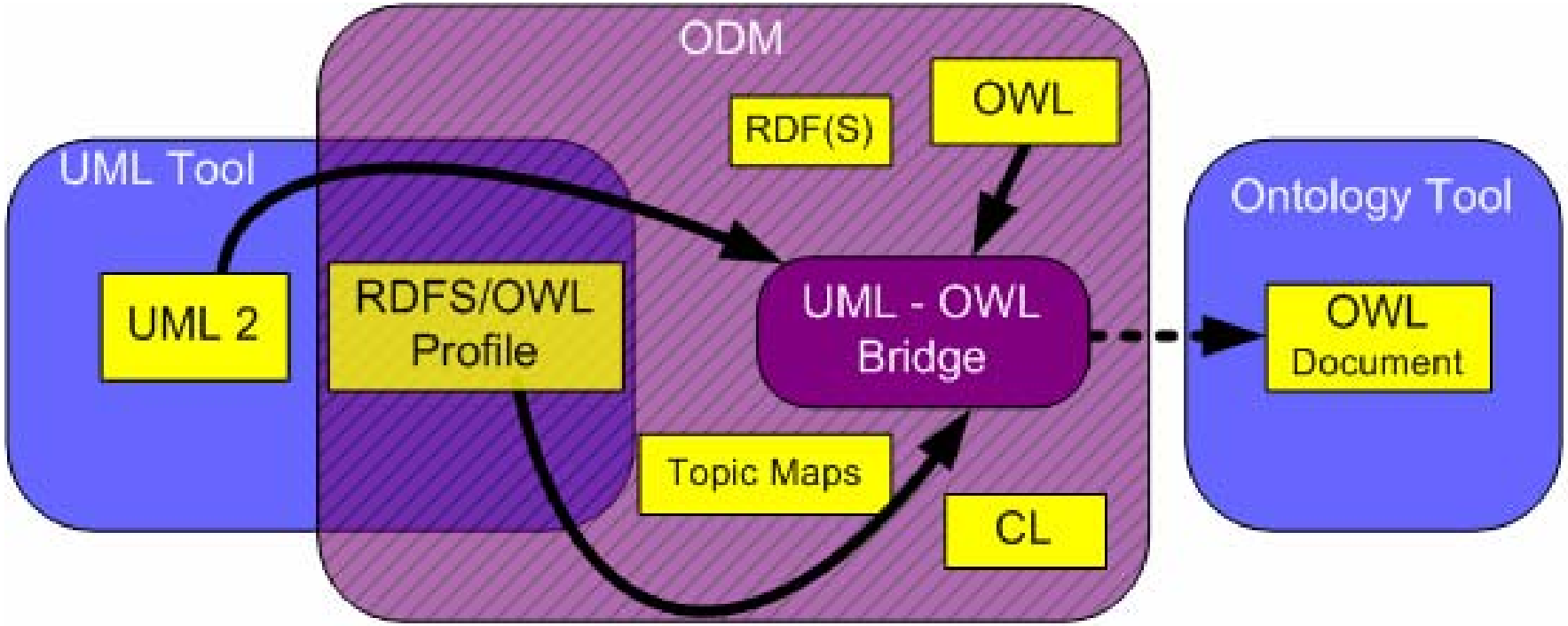
ODM Standard

- **ODM** (OMG Ontology Definition Metamodel) defines five metamodels (RDFS, OWL, Topic Maps, Common Logic and Description Logic), two UML Profiles (RDFS/OWL Profile, Topic Maps Profile) and a set of QVT mappings from UML to OWL, Topic Maps to OWL and RDFS/OWL to Common Logic.
- Open source metamodels and mappings for these exists. (Eclipse Galileo, June 2009)

UML-OWL Bridge

- This use case presents an implemented solution to the OMG Ontology Definition Metamodel (ODM) specification. ODM offers a set of metamodels and mappings for bridging the metamodeling world and the ontologies. The present solution supports the UML 2.0 metamodel and the OWL metamodel as defined in ODM.
- The ODM is a recently adopted standard from the Object Management Group that supports ontology development and conceptual modeling in several standard representation languages. It provides a coherent framework for ontology creation based on MOF (Meta Object Facility) and UML (Unified Modeling Language). In this way it plays a central role for bridging Model Driven Architecture based standards and Semantic Web technologies.

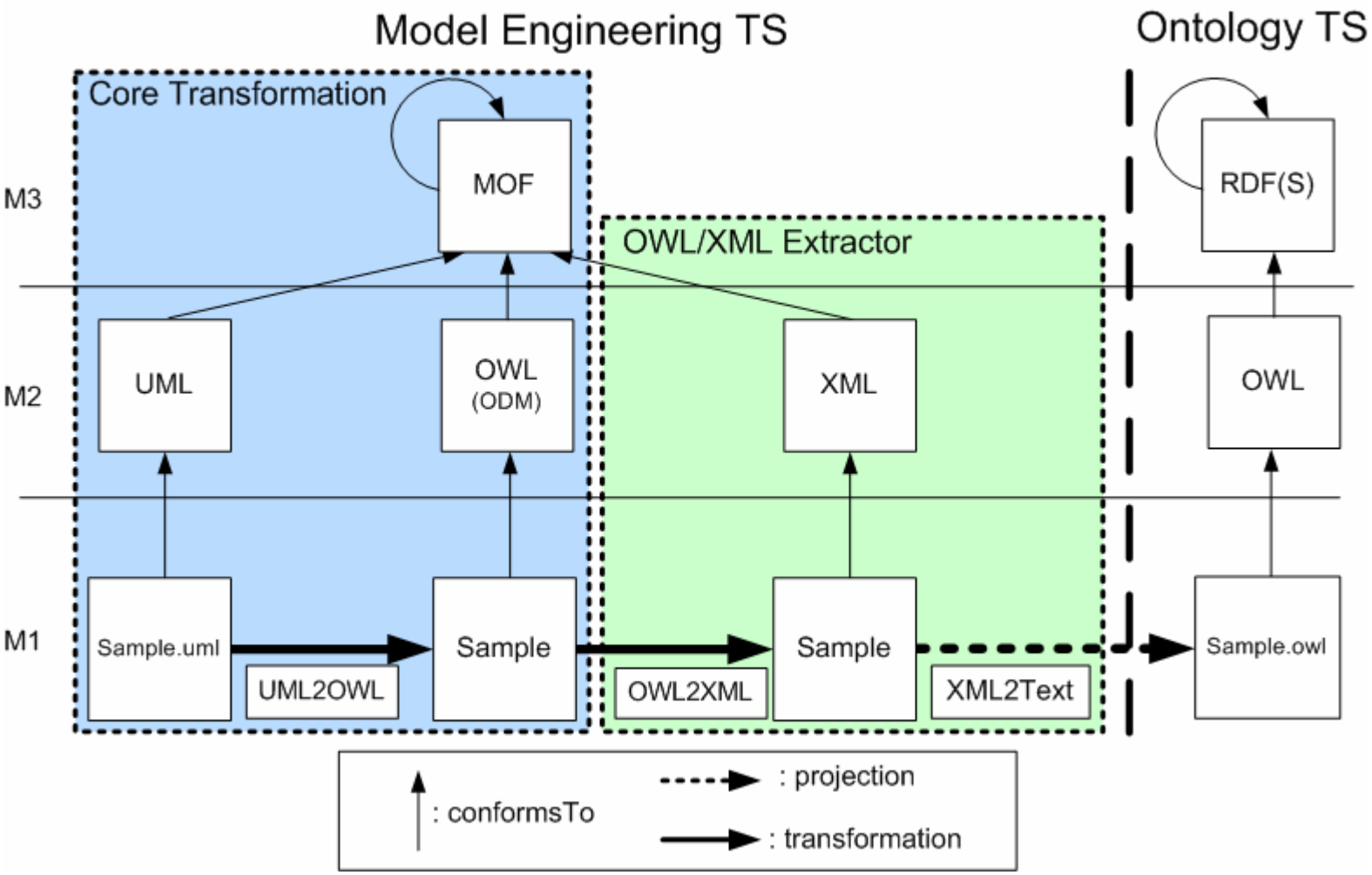
UML-OWL Bridge



UML2OWL Concept

- The ATL transformation **UML2OWL** has been implemented according to the ODM specification, i.e. corresponding QVT mapping. This transformation made possible the conversion of an arbitrary UML model into OWL ontology. The complete scenario of this transformation is given in figure below.

UML2OWL Overview



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Ulf Larsson, LFV, Norway
Dima Panfilenko, DFKI IWi, Germany

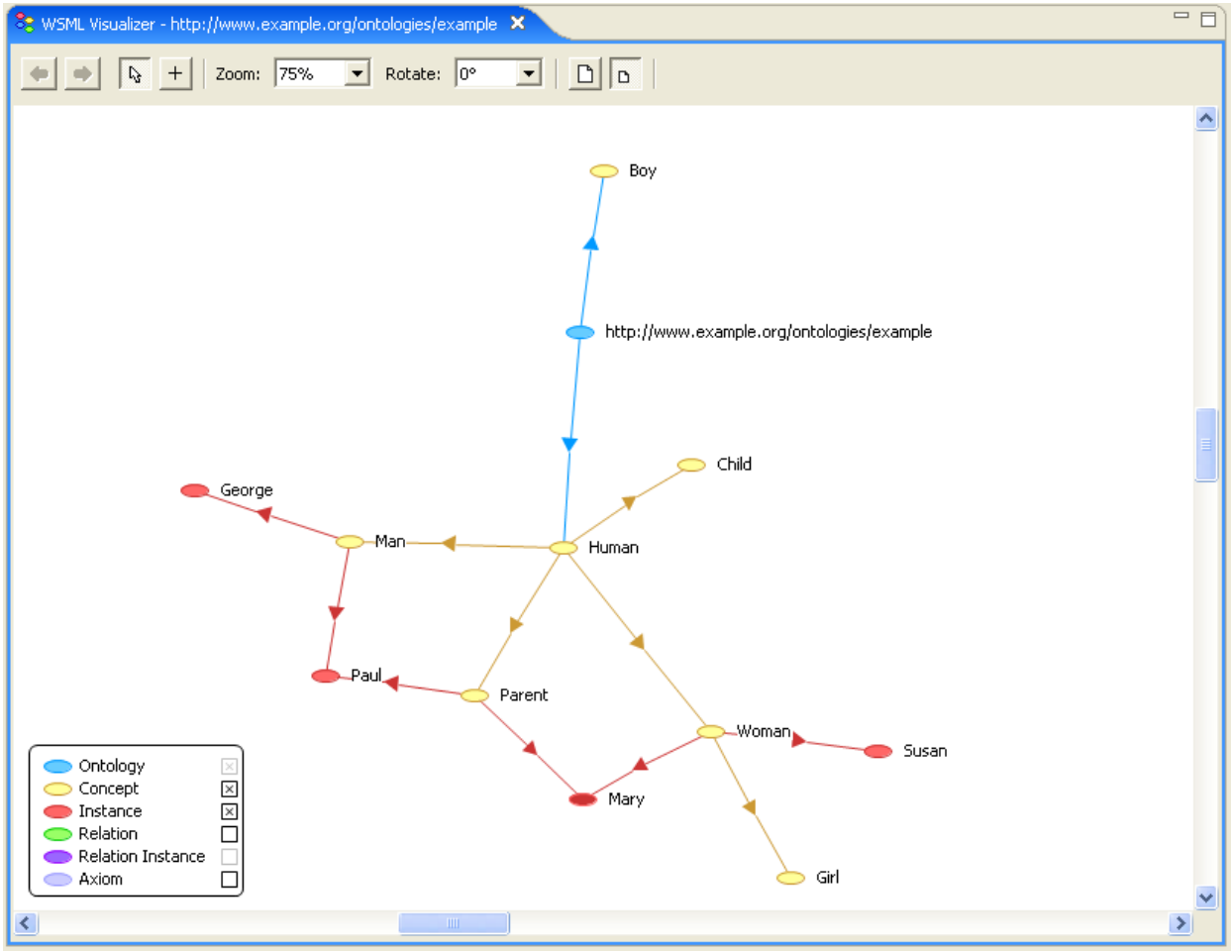
Agenda

- ODM standard for ontology development support
- OWL language for ontologies on the Web
- WSMT Tool for modeling and sharing ontologies

WSMT

- The Web Service Modeling Toolkit (WSMT) is an Integrated Development Environment for Semantic Web services creation, validation and testing, to deployment on a Semantic Execution Environment.
- WSML Artefacts: The Web Service Modeling Ontology (WSMO) is made up of four top level elements, namely Ontologies, Web services, Mediators and Goals.
- Mediation Mappings: The WSMT provides the Mapping perspective within which mediation mappings between two or more ontologies can be created at design time, such that they can later be executed at runtime.
- Interfacing with Semantic Execution Environments: The SEE Perspective provides functionality for interfacing with SEE like the Web Service Execution Environment (WSMX) and IRSIII.

WSMT Visualizer



Arne Jørgen Berre, SINTEF, Norway
Ulf Larsson, LFV, Norway
Dima Panfilenko, DFKI IWi, Germany

ODM and OWL

Thank you very much
for your kind attention…

Questions, please?